HGTC – CONWAY COSMETOLOGY EXPANSION
BLDG. 500/600

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SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section describes the common work requirements for the plumbing work included in Division 22 and applies to all sections of Division 22.

B. Related Sections:
   1. Section 013150 “Coordination Drawings” for coordination drawing requirements.

1.3 EQUIPMENT LIST

A. Provide a spreadsheet list of all equipment provided with the drawing tag number or designation, name, manufacturer, model number, serial number and full electrical characteristics.

B. This list shall be provided to the TAB agent, Commissioning Agent, BAS providers and to the Owner prior to beginning TAB work and as soon after all equipment is received on site.

1.4 EQUIPMENT START-UP AND INITIAL OPERATION

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

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

C. It is the Contractor's responsibility to place each item of equipment, installed by him, in operating condition. This responsibility includes all auxiliaries, piping, wiring, etc., the start up of each unit, and a check of its performance.

1.5 PROTECTION

A. Protect piping and equipment from moisture, construction debris and dust, and other foreign materials.
   1. Open ends on stored, completed and in-progress work, as well as overnight work-in-progress, shall be sealed.

2. Protective coverings shall only be removed immediately before installation or new work, and inspected to determine if additional wipe down is necessary.

1.6 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Refer to Section 017900 "Demonstration and Training"

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

C. Contractor shall instruct the Owner's representative fully in the operation, adjustment, and maintenance of all equipment furnished.

1.7 SITE VISIT

A. Prior to preparing the bid, it is recommended that the Contractor and subcontractors shall visit the site and familiarize themselves with all existing conditions, make all necessary investigations as to locations of utilities, and all other matters which can affect the work.

B. No additional compensation will be made to the Contractor as a result of his failure to familiarize himself with the existing conditions under which the work must be performed.

1.8 DRAWINGS

A. The Contract Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. Any offsets, rises, or transitions not shown on the drawings and required to provide a complete system shall be provided at no additional contract cost. Do not scale the drawings. Consult the Architectural and Structural drawings and details for exact location of structure and equipment; where same are not definitely located, obtain this information from the Architect.

B. In the event of ambiguities within or between parts of the Contract Documents, the contractor shall 1) provide the better quality or greater quantity of work, or 2) comply with the more stringent requirement, either or both in accordance with the Architect's interpretation.

1.9 SINGULAR NUMBER

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

1.10 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For plumbing systems and specialties to include in emergency, operation, and maintenance manuals.

B. Plumbing Submittals/Shop Drawings

C. Plumbing Warranties

D. Water Quality Test Report

E. Pressure Test Reports

PART 2 - PRODUCTS

2.1 MATERIALS

A. For each specified product, provide from single manufacturer. Do not mix and match various manufactures for a single product. If various manufacturers are required for a single product, indicate reason and locations where each will be installed.

B. All component parts of each items of equipment or device shall bear the manufacturers' name plate; giving name of manufacturer, description, size, type, serial or model number, electrical characteristics, etc., in order to facilitate the maintenance or replacement. The name plate of a subcontractor or distributor will not be acceptable. Where Underwriters' Laboratories standards apply, material and equipment shall be approved by them and shall bear the UL Label.

C. In specifying materials, three (3) general procedures are used. The three (3) classifications are as follows:
   1. GROUP 1: When a material or equipment is specified by brand name or other identifying information and three (3) or more brands are named it is considered that any one (1) of the brands so named will perform as desired, and the Contractor shall base his proposal on one (1) of the named brands. The first brand named or identified basis of design shall be used as a standard. The other brands named shall be equal to the specified brand in all respects. If one (1) of the other brands named is used it shall be the Contractor's responsibility to verify proper clearances and fit of the substituted equipment.
   2. GROUP 2: When the material or equipment is specified with the phrase "...or approved equal..." after a brand name and other identifying information, it is intended that the brand name is used for the purpose of establishing a minimum acceptable standard of quality and performance and Contractor may base his bid proposal on any item which is in all respects equal to that specified and presents essentially the same appearance. It shall be the Contractor's responsibility to ensure proper fit and clearances of all substituted equipment.
   3. GROUP 3: When material is specified as complying with the requirements of published "Standard Specification" of trade associations, American Society of Testing and Materials, government specifications, etc. the Contractor shall base

his proposal on any item which can be shown to comply in all respects to the referred "Standard Specification".

D. It is distinctly understood: (1) that the Architect will use his own judgment in determining whether or not any materials, equipment or methods offered in substitution are equal to those specified; (2) that the decision of the Architect on all such questions of equality is final; and (3) that all substitutions will be made at no increase in cost to the Owner.

E. Upon receipt of written approval from Architect, Contractor may proceed with substitution providing Contractor assumes full responsibility for, and makes, at his own expense, any changes or adjustments in construction or connection with other work that may be required by the substitution of such materials, equipment or methods. In the event of any adverse decisions by the Architect no claim of any sort shall be made or allowed against the Owner.

F. All pipe and fittings shall be from a United States domestic manufacturer.

2.2 FIRE-RATED PENETRATIONS

A. Provide UL Listed fire penetration systems in openings in rated floors, walls, and other elements of construction. Provide UL listed fire penetration systems at all new and existing pipe penetrations of new and existing rated construction within the area of work. Coordinate work of this section with all other trades necessary for the proper installation of the fire rated penetration systems.

B. Submit shop drawings showing each condition requiring penetration seals in dictating proposed UL systems materials, anchorage, methods of installation, and actual adjacent construction. Submit a copy of UL illustration of each proposed system indicating manufacturer approved modifications. Submit copies of manufacturer's specifications, recommendations, inspection requirements, installation instructions, and maintenance data for each type of material required. Include letter indicating that each material complies with the requirements and is recommended for the applications shown.

C. All fire penetration systems shall reference ASTM E814/UL 1479 - Fire Test of Through - Penetration Fire Stops.

D. All systems shall be UL tested and listed in the UL Fire Resistance Directory.

E. Submit copies of written guarantee agreeing to repair or replace joint sealers which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated. The guarantee period shall be one (1) year from date of substantial completion.

F. 3M products have been specified as the penetration fire stop basis of design. Other manufacturer's systems are acceptable providing they meet the requirements set forth in this specification. The fire rated penetration systems shall be the products of one

manufacturer to the maximum extent possible. The products of more than one manufacturer shall not be used as a combined seal.

G. Provide materials classified by UL to provide fire stopping equal to time rating, both "F" and "T" ratings, of construction being penetrated. Provide asbestos free materials that comply with applicable codes and have been tested under positive pressure in accordance with UL 1479 or ASTM E814. Systems shall be smoke and air tight.

H. Deliver material undamaged in manufacturer's clearly labeled, unopened containers identified with brand, type, grade, and UL label where applicable. Coordinate delivery with scheduled installation date to allow minimum storage time at site. Store material in clean, dry ventilated location. Protect from soiling, abuse, and moisture. Follow manufacturer's instruction.

I. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.

J. Furnish adequate ventilation if using solvent. Furnish forced air ventilation during installation if required by manufacturer. Keep flammable materials away from sparks or flame. Provide masking and drop cloths to prevent contamination of adjacent surfaces by fire stopping resistance.

K. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose, materials, rust, or other substances that may affect proper fitting, adhesion of the required fire resistance.

L. Install penetration seal materials in accordance with printed instructions of the UL Fire Resistance Directory and in accordance with manufacturer's instructions. Seal holes or voids made by penetrations to ensure an effective smoke barrier. Where floor openings without penetrating items are more than four (4) inches in width and subject to traffic or loading, install fire stopping materials capable of supporting same loading as floor. Protect materials from damages on surfaces subject to traffic.

M. Clean up spills of liquid components. Neatly cut and trim materials as required. Remove equipment, materials, and debris, leaving area in undamaged, clean condition.

N. Examine penetration sealed areas to ensure proper installation before concealing or enclosing areas. Keep areas of work accessible until inspection by applicable code authorities. Perform under this section patching and repairing of fire stopping caused by cutting or penetration by local inspectors and other trades.

PART 3 - EXECUTION

3.1 WORKMANSHIP

A. The quality of workmanship required, for each trade, in the execution of work shall be the finest and highest obtainable in that trade working with the materials specified.

Workmanship shall be satisfactory to the Architect and his decision as to acceptable quality is final.

B. Workmanship proven to be of poor quality or unsatisfactory in the commissioning phase of the project as deemed by the Architect shall be removed and replaced to the satisfaction of the Architect.

3.2 EQUIPMENT CONNECTIONS

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

3.3 CUTTING AND PATCHING

A. Cutting and patching associated with the work shall be performed in a neat and workmanlike manner. Existing surfaces, which are damaged by the Contractor, shall be repaired or provided with new materials. All patching shall be done with materials and methods similar to existing adjacent work, subject to approval of the Architect. Structural members shall not be cut or penetrated. Holes cut through concrete and/or masonry to accommodate new work shall be cut by reciprocating or rotary, non-percussive methods.

B. Patching of areas disturbed by installation of new work shall match existing adjacent surfaces in material, texture, and color.

3.4 PROTECTION OF EXISTING WORK

A. When working in and around the building, extreme care shall be exercised with regard to protection of the structure and plumbing services. Repair or replace, to the satisfaction of the Architect, any existing work damaged in the performance of the new work.

3.5 SURVEYS AND MEASUREMENTS

A. Base all measurements (both horizontal and vertical) from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at site and check correctness of same as related to the work. Verify locations of existing utilities and inverts of same prior to the start of any systems shown connecting to existing utilities.

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

3.6 HANDLING AND STORAGE OF MATERIAL

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

B. All equipment delivered to the job site shall be stored on pedestals, above the ground and under roof or other approved covering. All enclosures for equipment shall be weatherproof. All motors, drives, switchgear, panels, etc. which are not totally enclosed, that are involved in the work, shall be stored in a heated, dry, water protected area with a minimum temperature of fifty degrees (50) Fahrenheit. All valves shall be stored under roof on wood pedestals, above ground. All insulation shall be stored under roof or in trailers, adequately protected from the weather. The Contractor shall follow all written instructions and recommendations of the manufacturer and all requirements of the Architect in oiling, protection and maintenance of equipment during storage. It shall be the Contractor's complete responsibility for the storage and care of the equipment and materials.

C. If any equipment and/or materials are found to be in poor condition at the time of installation the Architect may, at his discretion, order the Contractor to furnish and install new equipment and/or material at no cost to the Owner.

3.7 COOPERATION WITH OTHER TRADES

A. Plumbing trades shall give full cooperation to other trades and shall furnish in writing, with copies to Architect any information necessary to permit the work of all trades to be installed satisfactorily and with least possible interference or delay. Exact location of all plumbing and equipment, devices, etc. in finished spaces shall be coordinated with Architectural reflected ceiling plans, elevations and details.

3.8 CLEANING AND PATCHING

A. Thoroughly clean all exposed surfaces of equipment and material and leave in a neat, clean condition.

B. Restore and touch-up factory finishes which have been damaged during construction.

3.9 ACCESSIBILITY

A. Equipment shall be installed per manufacturer’s recommended clearance guidelines with sufficient space for maintenance personnel service, operate, and maintain equipment.

B. Locate all above ceiling equipment which must be serviced, operated, or maintained, in fully accessible positions to eliminate the need for access panels and doors. Equipment shall include, but not be limited to, valves, clean-outs, motors, controllers, dampers, drain points, etc.

C. Where overhead equipment cannot be located above spaces with either no ceilings or removable acoustical ceiling tiles, contractor shall provide, as part of the contract and no expense to the Owner, fourteen (14) gauge painted steel access doors where required and/or where directed (color shall match ceiling).
   1. Access doors shall be Milcor or approved equal to suit material in which installed.
   2. Access doors installed in fire rated walls or shafts shall be labeled and shall match rating of the construction.
   3. Doors shall be of sufficient size to allow access to all components; minimum size shall be eighteen (18) inches by eighteen (18) inches.
   4. Doors in Toilet Rooms and Janitor's Closets shall be Type 304 stainless steel.
   5. All doors shall have cylinder locks operable from same key.
   6. Submit shop drawings for approval. Locations shall be coordinated with the Architect and indicated on the composite installation and coordination drawings

D. Equipment deemed inaccessible by the Architect shall be reworked by the Contractor at no expense to the Owner.

3.10 EXCAVATION AND BACKFILL

A. Definitions:
   1. Backfill: Soil material or controlled low-strength material used to fill an excavation.
      a. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
      b. Final Backfill: Backfill placed over initial backfill to fill a trench.
   2. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
   3. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
   4. Fill: Soil materials used to raise existing grades.
   5. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
   6. Utilities: On-site underground pipes, as well as underground services within buildings.

B. Soil Materials:
   1. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487, Groups A-1, A-2-4, A-2-5, and A-3 according to AASHTO M 145, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter
   2. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M 145, or a combination of these groups.
      a. Unsatisfactory soils include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
   3. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M;

with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

4. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.
5. Sand: ASTM C 33/C 33M; fine aggregate.

C. Subgrade Inspection
1. Notify Architect when excavations have reached required subgrade.
2. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
3. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

D. Compaction of Soil Backfills and Fills
1. Following inspection as specified above, approved backfill material shall be deposited in the trench with hand shovels, not by means of wheelbarrows, carts, trucks, bulldozers, or similar equipment.
2. Place backfill and fill soil materials in layers not more than 4 inches in loose depth for material compacted by hand-operated tampers until the pipe has a cover of not less than two (2) feet. The remainder of the backfill material shall then be deposited in the trench in eight (8) inch layers and compacted.
3. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
4. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698 and ASTM D 1557:
    a. For utility trenches, compact each layer of initial and final backfill soil material at 95 percent of dry weight compaction.
5. Mechanical tampers, for compacting backfill, shall be tampers capable of exerting a blow equal to 250 foot-pounds per square foot (FT2) of area of the tamping face.
6. Work broken or ruptured by improperly placed backfill shall be removed and replaced by the Contractor at no additional cost to the Owner.
7. Any trenches improperly backfilled shall be reopened, then refilled and compacted to the required grade and smoothed off.

E. Field Quality Control
1. Test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
    a. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 100 feet or less of trench length but no fewer than two tests.
2. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.11 DEMOLITION

A. All existing piping, conduit, equipment and materials not required for re-use or re-installation shall be removed. Any existing materials and equipment which are removed and are desired by the Owner or are indicated to remain the property of the Owner, shall be delivered to him on the premises by the Contractor where directed by the Architect. All other materials and equipment which are removed shall become the property of the Contractor and shall be removed by him from the premises.

B. Existing piping that remains concealed, buried, or otherwise contained in the remaining slabs and walls shall be capped, plugged, or otherwise sealed. All pipes shall be cut so that their capped or plugged ends will be below the finished floors or behind finished surfaces.

C. Existing wiring, where possible, shall be removed or pulled through conduits. Wiring remaining shall be cut back behind the termination of conduits so that conduits can be adequately capped, plugged, or sealed.

3.12 CONNECTIONS AND ALTERATIONS TO EXISTING WORK

A. When existing plumbing work is removed, all pipes, valves and materials shall be removed to a point below the finished floors or behind finished walls and capped. Such points shall be far enough behind finished surfaces to allow for the installation of the normal thickness of finished material.

B. When the work specified hereinafter connects to existing equipment or piping, the Contractor shall perform all necessary alterations, cuttings, or fitting of existing work as may be necessary or required to make satisfactory connections between the new and existing work and to leave the completed work in a finished and workmanlike condition, to the entire satisfaction of the Architect.

C. When the work specified hereinafter or under other divisions of the contract necessitates relocation of existing equipment, piping, or ductwork, the Contractor shall perform all work and make all necessary changes to existing work as may be required to leave the completed work in a finished and workmanlike condition, to the satisfaction of the Architect. All work resulting in an extra to the contract shall be approved by the Owner and Architect before proceeding.

D. All cutting and patching necessary for the installation of the plumbing work shall be done under this Division. Any damage done to the work already in place shall be repaired at the Contractor's expense. Patching shall be uniform in appearance and shall match the surrounding surface.

E. When the work specified hereinafter connects to existing piping, to avoid possible cross-connection of supply and return lines, the Contractor shall field verify the configuration of supply and return lines, using an appropriate temperature sensing or pressure device, before making final connections. Any discrepancy between construction documents and field verification should be promptly reported to the Architect before completing piping installation, so proper piping configuration can be verified.

3.13 INTERRUPTION OF EXISTING UTILITIES

A. Notify the Owner in writing at least ten (10) calendar days in advance of any required shutdown of water, sewage, gas, electrical service or other utility. Upon written receipt of approval from Owner, shutdowns shall be performed between the hours of six (6) p.m. and six (6) a.m. including clean-up or as directed otherwise and shall be accomplished at no additional cost.

B. At the end of each interruption, all services shall be restored so that normal use of the building can continue.

END OF SECTION 220500

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Sleeve-seal systems.
   3. Sleeve-seal fittings.
   4. Grout.

B. Related Requirements:
   1. Division 07 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc
   2. CALPICO, Inc
   3. GPT; an EnPro Industries company

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

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

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

2.2 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc
   2. CALPICO, Inc
   3. GPT; an EnPro Industries company
   4. Metraflex Company (The)
   5. Proco Products, Inc

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

2.3 GROUT

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

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

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

B. Fasten sleeves securely in floors and walls so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials from being forced into space between pipe and sleeve during construction

C. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

D. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

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

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

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

3.2 SLEEVE-SEAL-FITTING INSTALLATION

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

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

C. Secure nailing flanges to concrete forms.

D. Use grout to seal the space around outside of sleeve-seal fittings.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

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

C. Prepare test and inspection reports.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves or sleeve-seal fittings.
   b. Piping NPS 6 and Larger: Steel pipe sleeves or sleeve-seal fittings.

2. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal fittings.
   b. Piping NPS 6 and Larger: Steel pipe sleeves with sleeve-seal fittings.

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

END OF SECTION 220517

SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. BrassCraft Manufacturing Co.; a Masco company
   2. Dearborn Brass
   3. Keeney Manufacturing Company (The)
   4. Mid-America Fittings, Inc.
   5. ProFlo; a Ferguson Enterprises, Inc. brand

2.2 ESCUTCHEONS

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

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

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

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

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

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

2.3 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install escutcheons on bare piping to be compatible with pipe material:
   1. Copper Piping: Brass
   2. Ferrous Piping: Steel.
   3. Plastic Piping: Steel.
   4. Stainless Steel Piping: Stainless Steel.

C. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
   1. Escutcheons for New Piping and Relocated Existing Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
      b. Chrome-Plated Piping: One-piece or split-plate, with concealed hinge with polished, chrome-plated finish.
      c. Insulated Piping: One-piece or split-plate with concealed hinge with polished, chrome-plated finish.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece or split-plate with concealed hinge with polished, chrome-plated finish.
      e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-plate with concealed hinge with polished, chrome-plated finish.
      f. Bare Piping in Unfinished Service Spaces: One-piece or split-plate with concealed hinge with polished, chrome-plated finish.
      g. Bare Piping in Equipment Rooms: One-piece or split-plate with concealed hinge with polished, chrome-plated finish.
   2. Escutcheons for Existing Piping to Remain:
      a. Chrome-Plated Piping: Split-plate with concealed hinge with polished, chrome-plated finish.

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

D. Install floor plates for exposed piping penetrations of floors in finished areas with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
1. New Piping and Relocated Existing Piping: One-piece, floor plate.
2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 220518

SECTION 220523 - VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Ball valves.
   2. Butterfly valves.
   3. Check valves.
   4. Gate valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

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

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.
   1. Certification that products comply with NSF 61 Annex G and NSF 372 for products that come in contact with potable water.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, and soldered ends.
   3. Set ball valves open to minimize exposure of functional surfaces.
   4. Set butterfly valves closed or slightly open.

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles for applications of valves.

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

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

D. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable-water service.

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

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

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

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

I. Ball Valve Actuator Types:
   1. Handlever: For quarter-turn valves smaller than NPS 4.

J. Valves in Insulated Piping:
   1. Include 2-inch stem extensions with protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
   2. For valves used for throttling or balancing, include memory stops that are fully adjustable after insulation is applied.

2.2 BALL VALVES

A. Brass Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Apollo Flow Controls; Conbraco Industries, Inc.
      b. Crane; Crane Energy Flow Solutions
      c. Hammond Valve
      d. Milwaukee Valve Company
      e. NIBCO INC.
      f. Viega
      g. WATTS
   2. Description:
      a. Standard: MSS SP-110.
      b. CWP Rating: 600 psig.
      c. Body Design: Two piece.
      d. Body Material: Lead free brass.
      e. Ends: Threaded or soldered.
         1) Press joint ends shall be acceptable only if also approved for the associated piping system connections.
      f. Seats: PTFE.
      g. Stem: Stainless steel.
      h. Ball: Stainless steel, vented.
      i. Port: Full.

B. Iron Ball Valves, Class 125:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Valve, Inc
      b. Apollo Flow Controls; Conbraco Industries, Inc.
      c. WATTS
      d. Zurn Industries, LLC
   2. Description:
      a. Standard: MSS SP-72.
      b. CWP Rating: 200 psig.
      c. Body Design: Split body.
      d. Body Material: ASTM A 126, gray iron.
      e. Ends: Flanged or threaded.
      f. Seats: PTFE.
      g. Stem: Stainless steel.
      h. Ball: Stainless steel.
      i. Port: Full.

2.3 CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 125:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Apollo Flow Controls; Conbraco Industries, Inc.
      b. Crane; a Crane brand

c. Hammond Valve
d. Jenkins Valves; a Crane brand
e. Milwaukee Valve Company
f. NIBCO INC.
g. Stockham; a Crane brand
h. WATTS

2. Description:
3. Standard: MSS SP-80, Type 3.
4. CWP Rating: 200 psig.
5. Body Design: Horizontal flow.
6. Body Material: ASTM B62, bronze.
7. Ends: Threaded or soldered. See valve schedule articles.
8. Disc: Bronze.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Flow Controls; Conbraco Industries, Inc.
   b. Crane; a Crane brand
   c. Hammond Valve
   d. Jenkins Valves; a Crane brand
   e. KITZ Corporation
   f. Milwaukee Valve Company
   g. NIBCO INC.
   h. Stockham; a Crane brand
   i. WATTS
2. Description:
3. Standard: MSS SP-71, Type I.
4. CWP Rating: 200 psig.
5. Body Design: Clear or full waterway.
6. Body Material: ASTM A126, gray iron with bolted bonnet.
7. Ends: Flanged or threaded. See valve schedule articles.
8. Trim: Bronze.
9. Disc: Cast iron
10. Gasket: Asbestos free.

C. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 150:

1. Description:
   a. Standard: MSS SP-125.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
   c. NPS 14 to NPS 24, CWP Rating: 250 psig.
   d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: Bronze.

2.4 GATE VALVES

A. Bronze Gate Valves, RS, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Flow Controls; Conbraco Industries, Inc.
   b. Crane; Crane Energy Flow Solutions
   c. Hammond Valve
   d. Jenkins Valves; Crane Energy Flow Solutions
   e. Milwaukee Valve Company
   f. NIBCO INC.
   g. Stockham; Crane Energy Flow Solutions
   h. WATTS
2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   c. Body Material: Bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded or solder joint.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron, bronze, or aluminum.

B. Iron Gate Valves, OS&Y, Class 125:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Flow Controls; Conbraco Industries, Inc.
   b. Crane; Crane Energy Flow Solutions
   c. Hammond Valve
   d. Jenkins Valves; Crane Energy Flow Solutions
   e. Milwaukee Valve Company
   f. NIBCO INC.
   g. Stockham; Crane Energy Flow Solutions
   h. WATTS
2. Description:
   a. Standard: MSS SP-70, Type I.
   b. CWP Rating: 200 psig.
   c. Body Material: Gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Disc: Solid wedge.
   g. Packing and Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

A. Valves shall be provided where indicated on the drawings and as herein specified.

B. Install shut-off valves in piping where shown and where listed below:
   1. To isolate all items of equipment.
   2. To isolate motorized flow control valves.
   3. To isolate branch lines and riser at mains.

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

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

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

F. Install valves in position to allow for handwheel operation, full stem movement and stuffing maintenance.

G. Install chainwheels on operators for butterfly valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

H. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
   3. Lift Check Valves: With stem upright and plumb.

I. Install valve tags.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Use gate valves for shutoff service only.

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

C. Select valves with the following end connections:
   1. NPS 2 and Smaller: Threaded or soldered.
   2. NPS 2-1/2 to NPS 4: Flanged or threaded.
   3. NPS 5 and Larger: Flanged.

3.5 DOMESTIC WATER VALVE SCHEDULE

A. Ball Valves:
   1. Pipe NPS 3 and Smaller: Brass ball valves, two-piece with full port and stainless-steel trim.

B. Check Valves:
   1. Pipe NPS 3 and Smaller: Bronze swing check valves with bronze disc, Class 125, with soldered end connections.

C. Gate Valves:
   1. Pipe NPS 2 and Smaller: Bronze gate valves, RS, Class 125 with soldered ends.
   2. Pipe NPS 2-1/2 and Larger: Iron gate valves, OS&Y, Class 125 with flanged ends.

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

B. Related Requirements:
   1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Section 220516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
   3. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. It shall be the responsibility of the Contractor to provide an adequate pipe hanger and support system for all pipe systems and equipment in accordance with recognized engineering practices, using standard, commercially accepted pipe hangers and suspension equipment.

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

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
   3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

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

C. Copper Pipe and Tube Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.3 TRAPEZE PIPE HANGERS

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

2.4 THERMAL HANGER-SHIELD INSERTS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Pipe Shields Inc or comparable product by one of the following:
   1. Carpenter & Paterson, Inc
   2. Clement Support Services
   3. ERICO International Corporation
   4. Insulation Components, Inc.
   5. National Pipe Hanger Corporation
   6. Pipe Shields Inc.
   7. Piping Technology & Products, Inc
   8. Rilco Manufacturing Co., Inc

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

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

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

E. For Clevis or Band Hangers: Insert shall cover entire circumference of pipe. Shield shall cover lower 180 degrees of pipe.

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

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hilti, Inc.
      b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
      c. MKT Fastening, LLC
      d. Simpson Strong-Tie Co., Inc.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. B-line, an Eaton business
      b. Hilti, Inc.
      c. ITW Ramset/Red Head; Illinois Tool Works, Inc.
      d. MKT Fastening, LLC

2. Indoor Applications: Zinc-coated or stainless steel.
3. Outdoor Applications: Stainless steel.

C. Per IBC and ACI 318 Appendix D, all concrete anchors within the scope of ACI 318 require approved anchors for crack concrete. Attachment devices shall have certified load test data from an independent test laboratory and shall be capable of carrying a minimum of five times the design load. The concrete anchors for the following supported items need to meet the crack concrete requirements:
1. Any suspended pipe, larger than 2", regardless of material.
2. All components with an Ip 1.5.
3. All components required to function after a seismic event.
4. Anywhere required by ASCE 7.

2.6 PIPE STANDS

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

B. Compact Pipe Stand:
1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Hardware: Galvanized steel or polycarbonate.
4. Accessories: Protection pads.

C. Low-Profile, Single-Base, Single-Pipe Stand:
1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Vertical Members: Two galvanized-steel, continuous-thread, 1/2-inch rods.
4. Horizontal Member: Adjustable horizontal, galvanized-steel pipe support channels.
5. Pipe Supports: Roller or strut clamps.
6. Hardware: Galvanized steel.
7. Accessories: Protection pads.
8. Height: 12 inches above roof, unless otherwise noted.

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

1. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Single vulcanized rubber or molded polypropylene.
3. Vertical Members: Two galvanized-steel, continuous-thread, 1/2-inch rods.
4. Horizontal Member: One adjustable-height, galvanized-steel, pipe-support slotted channel or plate.
5. Pipe Supports: Roller, clevis hanger or swivel hanger.
6. Hardware: Galvanized steel.
7. Accessories: Protection pads, 1/2-inch, continuous-thread, galvanized-steel rod.
8. Height: 36 inches above roof, unless otherwise noted.

E. High-Profile, Multiple-Pipe Stand:
   1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
   2. Bases: Two or more; vulcanized rubber or molded polypropylene.
   3. Vertical Members: Two or more, galvanized-steel channels.
   4. Horizontal Members: One or more, adjustable-height, galvanized-steel pipe support.
   5. Pipe Supports: Roller, strut clamps, clevis hanger or swivel hanger.
   6. Hardware: Galvanized steel.
   7. Accessories: Protection pads, 1/2-inch, continuous-thread rod.
   8. Height: 36 inches above roof, unless otherwise noted.

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

2.7 PIPE-POSITIONING SYSTEMS

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

2.8 EQUIPMENT SUPPORTS

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

2.9 MATERIALS

A. Aluminum: ASTM B 221.

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

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

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

E. Grout: ASTM C 1107/C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

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

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported operating components with a design safety factor of not less than five.

3.2 HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
   3. The use of cable ties, zip ties and/or tie wraps for attaching piping to metal trapeze pip-hanger is prohibited. Provide appropriate strut clamps, brackets and/or similar attachments to properly secure piping to trapeze pipe-hangers.

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

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

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

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

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

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

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

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

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

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

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

N. Insulated Piping:
   1. Attach clamps and spacers to piping.
      a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
      d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
      e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
   5. Pipes NPS 2-1/2 and Larger: Include thermal hanger shield inserts of length at least as long as protective shield. Insert thickness shall be the same thickness as piping insulation. Fill interior voids with insulation that matches adjoining insulation and seal as appropriate.

O. In no case shall wire or perforated strap be used for pipe or conduit support.

3.3 EQUIPMENT SUPPORTS

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

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

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

3.4 METAL FABRICATIONS

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

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

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections, so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to maximum 1-inch.

3.6 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

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

3.7 HANGER AND SUPPORT SCHEDULE

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

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

C. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications with field-applied finish.

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

E. Use hot dip galvanized pipe hangers and stainless-steel attachments for exterior applications. Zinc plated hangers and attachments are not acceptable for exterior use.

F. Use stainless-steel pipe hangers and stainless-steel attachments for corrosive environment applications. Zinc plated hangers and attachments are not acceptable for corrosive use.

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

H. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

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

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

K. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
   4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
   5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
   6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
   7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
   8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
   9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.

10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction occurs.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction occurs.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction occurs and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation, in addition to expansion and contraction, is required.

L. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

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

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

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

O. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.

P. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.

4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

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

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

END OF SECTION 220529

SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The International Building Code and ASCE/SEI 7 Standard apply to all work associated with the seismic installation of all new mechanical piping and equipment. Refer to Structural drawings and ASCE/SEI 7 for seismic and wind loads and additional information.

1.2 SUMMARY

A. Section Includes:
1. Elastomeric hangers.
2. Spring hangers.
3. Snubbers.
4. Restraints - rigid type.
5. Restraints - cable type.
6. Restraint accessories.
7. Post-installed concrete anchors.
8. Concrete inserts.

B. Related Requirements:

1. Section 230548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

1.3 DEFINITIONS

A. ASCE/SEI: American Society of Civil Engineers/Structural Engineering Institute.

B. IBC: International Building Code.

C. ICC-ES: ICC-Evaluation Service.

D. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Include load rating for each wind-force-restraint fitting and assembly.
   3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic- and wind-force-restraint component.
   4. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction.
   5. Annotate to indicate application of each product submitted and compliance with requirements.
   6. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
   1. Detail fabrication and assembly of equipment bases.
   2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal:
   1. For each seismic-restraint and wind-load protection device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, concrete anchor and insert, and restrained isolation roof-curb rail that is required by this Section or is indicated on Drawings, submit the following:
      a. Seismic and Wind-Load Restraint, and Vibration Isolation Base Selection: Select vibration isolators, seismic and wind-load restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.
      b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.
      c. Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
      d. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
      e. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
      f. Qualified Professional Engineer: All designated-design submittals for seismic- and wind-restraint calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.

2. Seismic- and Wind-Restraint Detail Drawing:
   a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.
3. All delegated-design submittals for seismic- and wind-restraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.
4. Product Listing, Preapproval, and Evaluation Documentation: By an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and basis for approval (tests or calculations).
5. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
6. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Air-Spring Isolator Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

E. Field quality-control reports.

F. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in ASCE/SEI 7 Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.
   1. Provide equipment manufacturer's written certification for each designated active mechanical seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270, including shake table testing per ICC-ES AC156 or

a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction or experience data as permitted by ASCE/SEI 7.

2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7.
3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.

G. Wind-Force Performance Certification: Provide special certification for components subject to high wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-force performance certification.
1. Provide equipment manufacturer's written certification for each designated device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.
2. Provide manufacturer's written certification for each designated louver, damper, or similar device, stating that it will remain in place and protect opening from penetration of windborne debris and comply with all requirements of authorities having jurisdiction.
3. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-spring isolators and restrained-air-spring isolators to include in operation and maintenance manuals.

B. Manufacturer’s Inspection Report: Contractor shall submit factory-authorized service representative’s final report indicating all restraints and isolation devices as being properly installed or requiring correction.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7, and be acceptable to authorities having jurisdiction.

B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic- and Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.

1.8 COORDINATION

A. Coordinate with vibration isolation restraint manufacturer and the structural contractor/engineer of record to locate and size structural supports underneath vibration isolated restrained equipment (e.g. roof curbs and other similar equipment).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic and wind- load control system.
   1. Seismic and Wind-Load Performance: Equipment shall withstand the effects of earthquake motions and high wind events determined in accordance with ASCE/SEI 7.

B. Seismic Design Calculations:
   1. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to is the currently adopted edition.
      a. Data indicated below to be determined by Delegated-Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.
      b. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.

C. Wind-Load Design Calculations:
   1. Perform calculations to obtain force information necessary to properly select wind-load-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to is the currently adopted edition.
      a. Data indicated below that are specific to individual pieces of equipment must be obtained by Contractor and must be included in individual component submittal packages.
      b. Coordinate design wind-load calculations with seismic load calculations for equipment requiring both seismic and wind-load reinforcement. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.

D. Fire/Smoke Resistance: Seismic- and wind-load-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.

E. Component Supports:
   1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
   2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7.

2.2 GENERAL

A. Select vibration isolating units for the lowest operating speed of equipment, so designed that natural frequency of equipment and base mass is not less than 1.5 times the lowest operating frequency of the moving equipment, but not a multiple or harmonic of the base frequency. Furnish vibration isolation producing a uniform loading and deflection even when equipment weight is not evenly distributed, vibration isolation shall be stable during starting and stopping of equipment without excessive traverse and eccentric movement of equipment.

B. The installed vibration isolation system for each floor or ceiling mounted item of equipment shall have a maximum lateral motion under equipment start up and shut down conditions of 1/4 inch. Motions in excess shall be restrained by approved spring type mounting.

C. The type of isolation, base, and minimum static deflection shall be as required for each specific equipment application, but not less than that specified herein when supported on a solid concrete structural slab having a thickness of not less than four (4) inches.
   1. Should vibration isolators installed for the equipment prove inadequate to prevent transmission of equipment vibrations to the building structure or limit equipment vibration originated noise in the building spaces to acceptable levels, the isolators shall be replaced with units having the largest deflection that can be practicably installed.

D. All springs installed out-of-doors shall be cadmium-plated, zinc electroplated or powder-coated after fabrication. Hardware and other metal parts shall be cadmium-plated or galvanized. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14.

E. All isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.

2.3 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- thick neoprene.
   1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.4 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. California Dynamics Corporation
      b. Isolation Technology, Inc
      c. Kinetics Noise Control, Inc.
      d. Mason Industries, Inc.
      e. The VMC Group
      f. Vibration Eliminator Co., Inc.
      g. Vibration Isolation Co., Inc.
      h. Vibration Mountings & Controls/Korfund.
      i. Vibro-Acoustics, Inc.
   2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
   3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.5 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. California Dynamics Corporation
      b. Isolation Technology, Inc
      c. Kinetics Noise Control, Inc.
      d. Mason Industries, Inc.
      e. The VMC Group
      f. Vibration Eliminator Co., Inc.
      g. Vibration Isolation Co., Inc.
      h. Vibration Mountings & Controls/Korfund.
      i. Vibro-Acoustics, Inc.
   2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod (where required).

9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.6 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Kinetics Noise Control, Inc
   2. Mason Industries, Inc.
   3. Novia; A Division of C&P
   4. Vibration Mountings & Controls, Inc

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
   1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be seismically prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318.
   2. Preset Concrete Inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
   3. Anchors in Masonry: Design in accordance with TMS 402.
   4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
   5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.7 RESTRAINTS - RIGID TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business
   2. California Dynamics Corporation
   3. Hilti, Inc.
   4. Mason Industries, Inc.
   5. Unistrut; Part of Atkore International

B. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.8 RESTRAINTS - CABLE TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Gripple Inc.
   2. Kinetics Noise Control, Inc.
   3. Mason Industries, Inc.
   4. Novia; A Division of C&P
   5. Vibration & Seismic Technologies, LLC

6. Vibration Mountings & Controls, Inc.

B. Seismic-Restraint Cables: ASTM A603 galvanized-steel or ASTM A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

C. Restraint cable assembly with cable fittings must comply with ASCE/SEI 19. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.9 RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Novia; A Division of C&P
5. TOLCO
6. Vibration & Seismic Technologies, LLC

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.10 POST-INSTALLED CONCRETE ANCHORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Simpson Strong-Tie Co., Inc.
5. Unistrut; Atkore International.

B. Mechanical Anchor Bolts:

1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

C. Adhesive Anchor Bolts:
1. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

D. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7, Ch. 13.
1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

2.11 CONCRETE INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Simpson Strong-Tie Co., Inc.
5. Unistrut; Atkore International.

B. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC466 testing.

C. Comply with ANSI/MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction.

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

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

3.3 INSTALLATION OF VIBRATION-CONTROL, WIND-LOAD CONTROL, AND SEISMIC-RESTRAINT DEVICES

A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Devices Schedules, where indicated on Drawings, or where Specifications indicate they are to be installed on specific equipment and systems.

B. Provide seismic-restraint and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Seismic-Restraint Devices Schedules, where indicated on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

C. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

D. Installation of vibration isolators, wind-load restraints, must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

E. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

F. Equipment Restraints:
   1. Install seismic snubbers on equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
   2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   3. Install seismic-restraint, and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

G. Piping Restraints:
   1. Comply with requirements in MSS SP-127.
   2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.

3. Brace a change of direction longer than 12 feet.

H. Install seismic- and wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.

I. Equipment Bases:
   1. Fill concrete inertia bases, after installing base frame, with 3000-psi concrete; trowel to a smooth finish.
      a. Cast-in-place concrete materials and placement requirements are specified in Division 3.
   2. Concrete Bases: Anchor equipment to concrete base according to supported equipment manufacturer's written instructions for seismic codes at Project site.
      a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
      b. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base and anchor into structural concrete floor.
      c. Place and secure anchorage devices. Use Setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      d. Install anchor bolts to elevations required for proper attachment to supported equipment.
      e. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
      f. Cast-in-place concrete materials and placement requirements are specified in Division 3.

J. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

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

L. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

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

N. Mechanical Anchor Bolts:

   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Provide flexible connections in piping systems where they cross structural seismic joints, expansion joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in other sections for piping flexible connections.

3.5 ADJUSTING

A. Adjust isolators after system is at operating weight.

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

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:
1. Perform tests and inspections with the assistance of a factory-authorized service representative.
2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
3. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
5. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
6. Test to 90 percent of rated proof load of device.
7. Measure isolator restraint clearance.
8. Measure isolator deflection.

9. Verify snubber minimum clearances.

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

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare testing agency test and inspection reports.

F. Manufacturer’s Inspection:
1. A representative of the isolation materials manufacturer shall inspect the completed system and report in writing any installation errors, improperly selected isolation or restraint devices, or other faults that could affect the performance of the system.
2. Contractor shall submit manufacturer's representative’s final report indicating all isolation as being properly installed or requiring correction. If corrections are required, include steps to be taken to properly complete the isolation work.

3.7 VIBRATION ISOLATION AND SEISMIC-RESTRAINT SCHEDULE

A. Suspended Inline Pumps:
1. Isolation Type: Spring Hanger
2. Deflection: 0.25”

B. First Four (4) Pipe Hangers near Isolated Equipment:
1. Isolation Type: Spring Hanger
2. Deflection:
a. Piping 3-inches and smaller: 0.75”
b. Piping 4-inches to 6-inches: 1.5”
c. Piping Larger than 6-inches: 2.5”

END OF SECTION 220548

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Pipe labels.
   3. Valve tags.
   4. Underground Warning Labels.
   5. Warning tags.

1.3 ACTION SUBMITTALS

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

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Pipe Label Schedule: Include a listing of all piping to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals. Include Service Abbreviation, Number Sequence, Valve Location and Valve Function.

1.4 QUALITY ASSURANCE

A. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
   1. ANSI / ASME A13.1: “Scheme for the Identification of Piping Systems”
   2. ANSI Z535.1: “Safety Color Code”
   3. NFPA-99C; CGA C-9-2002 "Standard Industry Color Coding Recommendations for Medical Gases."

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Labels for Equipment:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Brady Corporation
      b. Brimar Industries, Inc.
      c. Carlton Industries, LP
      d. Craftmark Pipe Markers
      e. Kolbi Pipe Marker Co.
      f. LEM Products Inc.
      g. Seton Identification Products
   2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
   3. Letter and Background Color: As indicated for specific application under Part 3.
   4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
   5. Minimum Label Size: Length and width vary for required label content, but not less than 4 by 2-1/2 inch.
   6. Minimum Letter Size: 3/4 inch.
   7. Fasteners: Stainless-steel rivets or self-tapping screws, or double face adhesive.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number as indicated on the mechanical drawings and schedules.

2.2 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation
   2. Brimar Industries, Inc.
   3. Carlton Industries, LP
   4. Craftmark Pipe Markers
   5. Kolbi Pipe Marker Co.
   6. LEM Products Inc.
   7. Seton Identification Products

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

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic
   1. For Pipes With an Overall Pipe Diameter of 8” or less: Formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
   2. For Pipes With an Overall Pipe Diameter Larger Than 8”: Formed to partially cover circumference of pipe and to attach to pipe with no less than two nylon strap-on fasteners.

D. Self-Adhesive Pipe Labels:
   1. For Pipes With an Overall Pipe Diameter of 3/4" or less: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.3 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation
   2. Brimar Industries, Inc.
   3. Carlton Industries, LP
   4. Craftmark Pipe Markers
   5. Kolbi Pipe Marker Co.
   6. LEM Products Inc.
   7. Seton Identification Products

B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 1-1/2 diameter, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware. If necessary, to accommodate longer abbreviations or number sequences increase tag size to 2" in diameter.
   2. Fasteners: Brass wire-link chain or beaded chain.

C. Valve Markers: Engraved phenolic plastic nameplates with 3/4-inch white surface and 1/4-inch tall black lettering.
   1. Fasteners: Epoxy.

D. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

   1. Valve-tag schedule shall be included in operation and maintenance data.

2.4 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation
   2. Brimar Industries, Inc.

3. Carlton Industries, LP
4. Craftmark Pipe Markers
5. Kolbi Pipe Marker Co.
6. LEM Products Inc.
7. Seton Identification Products

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

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

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

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of plumbing equipment.

B. Locate equipment labels where accessible and visible.

C. For equipment located above the ceiling, in addition to a label on the equipment, equipment markers are to be permanently affixed to the ceiling grid framing as near to the item as possible using epoxy glue. Where hard ceilings are used, the label is to be affixed to the frame of the access panel for the unit.

3.4 PIPE COLOR CODING

A. Paint exposed and insulated piping in finished areas and mechanical rooms.
1. Finished Areas: Color shall be the same as the adjacent surface. Color by Architect.

2. Mechanical Rooms: Color shall be the same as the pipe label background color.
3. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
4. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Exterior non-insulated piping shall be painted with two coats of rust inhibitive paint. Colors shall be approved by the Owner after a sample is provided for each service. Do not paint aluminum jackets.

C. Do not paint exposed copper piping or galvanized piping.

D. Do not paint aluminum or stainless-steel jackets.

E. Painting of piping is specified in Division 09.

3.5 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, crawl spaces and plenums; and exterior exposed locations as follows:
1. Spaced at maximum intervals of 20 feet along each straight run.
2. Near each valve and control device.
3. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
4. Near each change in direction.
5. Above and below every floor penetration and on either side of every wall penetration.
6. At least one pipe marker per pipe in every room.
7. At access doors, manholes, and similar access points that permit view of concealed piping.
8. Near major equipment items and other points of origination and termination.
9. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Vertical Piping: Provide strip of adhesive on the inside of pretensioned pipe labels to further secure the marker in a permanent position.

D. Pipe Label Color Schedule:
1. Domestic Water Piping
   a. Background: Safety green.
   b. Letter Colors: White.
   c. Designation: COLD WATER, HOT WATER, HOT WATER RECIRC.
2. Sanitary Waste and Vent Piping:
   a. Background Color: Safety black.
   b. Letter Color: White.
   c. Designation: SANITARY DRAIN, VENT.
3. Storm and Overflow Drainage Piping:

a. Background Color: Safety black.
b. Letter Color: White.
c. Designation: STORM DRAIN, OVERFLOW DRAIN.

4. Natural Gas:
a. Background Color: Safety Yellow.
b. Letter Color: Black.
c. Designation: NATURAL GAS.

3.6 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve Tags for Shutoff Valves in Medical Gas and Vacuum Systems: Tag shall contain the name or chemical symbol of the specific system, the room served, and a caution to not close or open the valve except in emergency. The operating pressure of the gas system shall be included on the tag if the system operates at pressures other than the standard gauge pressure of 50psi to 55 psi, 15 in to 30 in HgV (Vacuum) or 160-185 psi (Nitrogen or Instrument Air).

C. Ceiling valve markers shall be provided for valves above ceilings. Attach valve marker to ceiling grid directly below the valve.

3.7 WARNING-TAG INSTALLATION

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

END OF SECTION 220553

SECTION 220593 - TESTING, ADJUSTING, AND BALANCING FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. TAB of plumbing equipment:
   2. Pipe-leakage test verification.
   3. Testing, adjusting, and balancing of existing plumbing systems and equipment.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

F. TDH: Total dynamic head.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Submit the Contract Documents review report as specified in Part 3.

C. System Readiness Checklists: Submit system readiness checklists as specified in "Preparation" Article.

D. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

E. Certified TAB reports.

F. Sample report forms.

G. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC or NEBB.
   1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB.
   2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB as a TAB technician.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. ASHRAE 188 Compliance: Comply with balancing and report requirements, Section 8.3 "Balancing."

D. Code and Authorities Having Jurisdiction Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.6 COORDINATION

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

B. Coordinate efforts with the project Commissioning Agent. Refer to commissioning specifications for additional information.

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

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

1.7 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.8 WARRANTY

A. Performance Warranty:
   1. If AABC standards are used, provide a warranty on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.
   2. If NEBB standards are used, provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.

B. Warranty includes the following provisions:
   1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
   2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, available TAB specialists that may be engaged include, but are not limited to, the following:
   1. Carolina Air & Water Balancing Company, Inc.
   2. Hall Technology, Inc.
   3. KLG Jones, LLC.
   4. Palmetto Air & Water Balance, Inc.

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing valves and fittings. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine approved submittals for plumbing systems and equipment.

D. Examine design data, including plumbing system descriptions.

E. Examine equipment performance data.
   1. Relate performance data to Project conditions and requirements.

F. Examine system and equipment installations.

G. Examine operating safety interlocks and controls on plumbing equipment.

H. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

A. Prepare a TAB plan that includes the following:
   1. Strategies and step-by-step procedures for balancing the systems.
   2. Instrumentation to be used.
   3. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of plumbing systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
   1. Domestic Water System:
      a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed in accordance with applicable code and authority having jurisdiction.
      b. Water heaters are installed and functioning.
      c. Piping is complete and all points of outlet are installed.
      d. Water treatment is complete.
      e. Systems are flushed, filled, and air purged.
      f. Strainers are clean.
      g. Shutoff and balance valves are 100 percent open.
      h. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in ASHRAE 111 and in this Section.

B. Cut insulation, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
   1. Where holes for probes are required in piping or equipment, install pressure and temperature test plugs to seal systems.
   2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 220700 “Plumbing Insulation."

C. Mark equipment and balancing devices, including valve position indicators and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

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

3.5 GENERAL PROCEDURES FOR PLUMBING EQUIPMENT

A. Test, adjust, and balance plumbing equipment indicated on Drawings, including, but not limited to, the following:

3.6 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
   1. Measure and record flows, temperatures, and pressures of each piece of equipment. Compare the values to design or nameplate information, where information is available.
   2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
   3. Check the condition of filters.
   4. Check bearings and other lubricated parts for proper lubrication.
   5. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. TAB After Construction: Before performing testing and balancing of renovated existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished in accordance with renovation scope indicated by Contract Documents. Verify the following:
   1. New filters are installed.
   2. Bearings and other parts are properly lubricated.
   3. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
   1. Compare the indicated system flows of the renovated work to the measured flows and determine the new pump speed.
   2. Verify that the indicated system flows of the renovated work result in velocities and pump speeds that are within the acceptable limits defined by equipment manufacturer.
   3. If calculations increase or decrease the system flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.

3.7 TOLERANCES

A. Set plumbing system's flow rates within the following tolerances:
   1. Domestic Hot-Water Rate: Plus 10 percent.

3.8 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
   1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   2. Include a list of instruments used for procedures, along with proof of calibration.
   3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Manufacturers' test data.
   2. Field test reports prepared by system and equipment installers.
   3. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:
   1. Title page.
   2. Name and address of the TAB specialist.
   3. Project name.
   4. Project location.
   5. Architect's name and address.
   6. Engineer's name and address.
   7. Contractor's name and address.
   8. Report date.
   9. Signature of TAB supervisor who certifies the report.
   10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   11. Summary of contents, including the following:
      a. Indicated versus final performance.
      b. Notable characteristics of systems.
      c. Description of system operation sequence if it varies from the Contract Documents.
   12. Nomenclature sheets for each item of equipment.
   13. Notes to explain why certain final data in the body of reports vary from indicated values.

D. System Diagrams: Include schematic layouts of distribution systems. Present each system with single-line diagram and include the following:
   1. Flow rates.
   2. Pipe and valve sizes and locations.
   3. Balancing stations.
   4. Position of balancing devices.

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

3.9 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of the Architect, Owner’s representative, or Commissioning authority.

B. Architect, Owner’s representative, or Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:
   1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
   2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

F. Prepare test and inspection reports.

END OF SECTION 220593

SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulation for the following plumbing services:
   1. Plumbing equipment.
   2. Plumbing piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail insulation application at pipe expansion joints for each type of insulation.
   4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   5. Detail removable insulation at piping specialties, equipment connections, and access panels.
   6. Detail removable insulation at equipment connections and access panels.
   7. Detail application of field-applied jackets.
   8. Detail application at linkages of control devices.
   9. Detail field application for each equipment type.

C. Samples:
   1. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and

adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Piping Mockups:
   a. One 10-foot section of NPS 2 straight pipe.
   b. One each of a 90-degree threaded, welded, and flanged elbow.
   c. One each of a threaded, welded, and flanged tee fitting.
   d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.
   e. Four support hangers including hanger shield and insert.
   f. One threaded strainer and one flanged strainer with removable portion of insulation.
   g. One threaded reducer and one welded reducer.
   h. One pressure temperature tap.
   i. One mechanical coupling.
2. Equipment Mockups: One tank or vessel.
3. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
4. Notify Architect seven days in advance of dates and times when mockups will be constructed.
5. Obtain Architect's approval of mockups before starting insulation application.
6. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
7. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
8. Demolish and remove mockups when directed.

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

1. ICC - International Energy Conservation Code (ICC-IECC)
2. ANSI/ASHRAE/IES Standard 90.1-2016 -- Energy Standard for Buildings Except Low-Rise Residential Buildings
3. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in PART 3 - EXECUTION articles for where insulating materials shall be applied.

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

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

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

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

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Pittsburgh Corning Corporation
   2. Block Insulation: ASTM C 552, Type I.
   3. Special-Shaped Insulation: ASTM C 552, Type III.
   4. Preformed Pipe Insulation with Factory-Applied ASJ or ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
   5. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Aeroflex USA, Inc.
      b. Armacell LLC
      c. K-Flex USA

H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation
      b. Johns Manville; a Berkshire Hathaway company
      c. Knauf Insulation
      d. Manson Insulation Inc.
      e. Owens Corning

I. Mineral-Fiber, Preformed Pipe Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Johns Manville; a Berkshire Hathaway company
      b. Knauf Insulation
      c. Manson Insulation Inc.
      d. Owens Corning
   2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ or ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation
      b. Johns Manville; a Berkshire Hathaway company
      c. Knauf Insulation
      d. Manson Insulation Inc.
      e. Owens Corning

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

2.3 ADHESIVES

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

B. For indoor applications, use adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aeroflex USA, Inc.
2. Armacell LLC
3. Childers Brand; H. B. Fuller Construction Products
4. Dow Corning Corporation
5. Eagle Bridges - Marathon Industries
6. Foster Brand; H. B. Fuller Construction Products.
7. Johns Manville; a Berkshire Hathaway company
8. K-Flex USA
9. P.I.C. Plastics, Inc.
10. Mon-Eco Industries, Inc.
11. Speedline Corporation
12. Vimasco Corporation.

D. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

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

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

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

H. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

I. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. For indoor applications, use mastics that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Childers Brand; H. B. Fuller Construction Products
   2. Eagle Bridges - Marathon Industries
   3. Foster Brand; H. B. Fuller Construction Products.
   4. Knauf Insulation
   5. Mon-Eco Industries, Inc.
   6. Vimasco Corporation

D. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
   1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.
   3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
   4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.
   3. Solids Content: 60 percent by volume and 66 percent by weight.
   4. Color: White.

2.5 LAGGING ADHESIVES

A. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Childers Brand; H. B. Fuller Construction Products
   2. Foster Brand; H. B. Fuller Construction Products.
   3. Vimasco Corporation

C. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
   1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
   2. Service Temperature Range: 0 to plus 180 deg F.
   3. Color: White.

2.6 SEALANTS

A. Use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24)

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

1. Childers Brand; H. B. Fuller Construction Products
2. Eagle Bridges - Marathon Industries
3. Foster Brand; H. B. Fuller Construction Products.
4. Knauf Insulation
5. Mon-Eco Industries, Inc.
6. Pittsburgh Corning Corporation
7. Vimasco Corporation

C. Joint Sealants for Cellular-Glass Products:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F.
4. Color: White or gray.

D. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

E. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Alpha Associates, Inc

2.9 FIELD-APPLIED JACKETS

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

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 30 mils thick; roll stock ready for shop or field cutting and forming.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Johns Manville; a Berkshire Hathaway company
      b. P.I.C. Plastics, Inc.
      c. Proto Corporation
      d. Speedline Corporation
   2. Adhesive: As recommended by jacket material manufacturer.
   3. Color: White
   4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Metal Jacket:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ITW Insulation Systems; Illinois Tool Works, Inc.
      b. RPR Products, Inc.
   2. Aluminum Jacket: Comply with ASTM B 209, ASTM C 1729, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
      a. Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.
      c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
      d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
      e. Factory-Fabricated Fitting Covers:
         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

   3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
      a. Factory cut and rolled to size.
      b. Material, finish, and thickness are indicated in field-applied jacket schedules.

c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:
    1) Same material, finish, and thickness as jacket.
    2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    3) Tee covers.
    4) Flange and union covers.
    5) End caps.
    6) Beveled collars.
    7) Valve covers.
    8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

D. Underground Direct-Buried Jacket: 125-mil- thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Pittsburgh Corning Corporation
    b. Polyguard Products, Inc

E. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Polyguard Products, Inc.
2. Warranty: Minimum 10-year warranty that water will not leak directly through membrane as a result of deterioration of the membrane caused by ordinary wear and tear.

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Width: 3 inches.
2. Thickness: 6.5 mils.

3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

2.11 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.

B. Insulation Pins and Hangers:
1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Aluminum, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Aluminum, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

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

2.12 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

2.13 PROTECTIVE SHIELDING GUARDS

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

e. Oatey
f. Plumberex Specialty Products, Inc.
g. Truebro
h. Zurn Industries, LLC

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

B. Protective Shielding Piping Enclosures:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Truebro
b. Zurn Industries, LLC
2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
1. For exterior, above-grade piping: Before insulating, apply a corrosion coating to insulated surfaces as follows:
a. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
b. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below-ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

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

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

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

P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

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

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

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.

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

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF PIPE INSULATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe

insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

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

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

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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

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

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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

B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.
   2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.
   4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

E. Provide latex-based, UV resistant protective coating for outdoor applications.

3.8 INSTALLATION OF MINERAL-FIBER INSULATION

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

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

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

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

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
   2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
   3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
   5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

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

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

3.10 FIELD QUALITY CONTROL

A. If workmanship is of questionable quality, the contractor shall perform tests and inspections as directed by the Architect.

B. Tests and Inspections:

   1. Inspect field insulated equipment, pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation.

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

3.11 INSULATION SCHEDULE, GENERAL

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

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

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

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:
1. NPS 1 and Smaller: Insulation shall be one of the following:
   a. Flexible Elastomeric: 1/2 inch thick.
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch.
2. NPS 1-1/4 and Larger: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot Water:
1. NPS 1 and Smaller: Insulation shall be one of the following:
   a. Flexible Elastomeric: 1/2 inch thick.
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch.
2. NPS 1-1/4 and Larger: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

C. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities (ADA):
1. All Pipe Sizes: Insulation/protection shall be the following:
   a. Protective Shielding Pipe Covers or Protective Shielding Piping Enclosures.

D. For piping smaller than 1 1/2 inches and located in partitions within conditioned spaces, reduction of the scheduled thickness by 1 inch shall be permitted, but not to a thickness less than 1 inch.

3.13 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Domestic Cold Water:
1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 2 inches thick.

B. Domestic Hot Water:
1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

3.14 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Sanitary Waste Piping, All Sizes, Where Heat Tracing Is Installed: Cellular glass, 2 inches thick.

3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Piping, Concealed:

1. None.

C. Piping, Exposed:

1. PVC, Color-Coded by System: 30 mils thick.

D. Equipment, Concealed:

1. None.

E. Equipment, Exposed:
1. None.

3.16 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Piping, Concealed:

1. None.

C. Piping, Exposed:
1. Aluminum, Stucco Embossed with Z-Shaped Locking Seam per the requirements of ASTM C1729. Minimum jacket thickness shall be based on the outer insulation diameter:
   a. 8-inches and smaller: 0.024 inches thick.
   b. 10-inches to 36-inches: 0.032 inches thick.
   c. 38-inches and larger: 0.040 inches thick.
2. Stainless Steel, Type 304 or Type 316, Stucco Embossed with Z-Shaped Locking Seam: 0.024 inch thick.
3. Self-Adhesive Outdoor Jacket: 60-mil- thick.

END OF SECTION 220700

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Domestic water piping.

B. Contractor shall perform all work within the building and to a point five (5) feet from the building wall, unless otherwise noted.
   1. Contractor shall coordinate with site water services provided under another Division.
   2. The contractor shall make the final connection of the building water service to the site water service.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Pipes, tubes, fittings, and specialties for each type of piping.
   2. Joining materials.
   3. Encasement for piping.
   4. Transition fittings.
   5. Dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

1.5 FIELD CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
   1. Notify Owner no fewer than ten days in advance of proposed interruption of water service.
   2. Do not interrupt water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping: 125 psig unless otherwise indicated.

2.2 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."

C. Comply with NSF 372 for low lead.

D. All pipe and fittings shall be from a United States domestic manufacturer.

2.3 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L and ASTM B 88, Type M water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:
   1. MSS SP-123.
   2. Cast-copper-alloy, hexagonal-stock body.
   3. Ball-and-socket, metal-to-metal seating surfaces.
   4. Solder-joint.

G. Copper Press Joint Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Apollo Valves; Conbraco Industries, Inc.
      b. Elkhart Products Corporation
      c. Mueller Industries, Inc.
      d. NIBCO INC.
      e. Viega LLC

2. Description:
   a. Cast- or wrought-copper press-connect fitting complying with material requirements of ASME B16.18 or ASME B16.22 and performance criteria of ASME B16.51 and IAPMO PS 117.
   b. Sealing elements for press fittings shall be factory installed EPDM.
   c. Press end fittings shall have technology to allow identification of an unpressed fitting.
   d. All fittings in contact with drinking water shall be listed by a third party agency to NSF/ANSI 61 and 372.

2.4 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:
   1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:
   1. AWWA C110/A21.10, ductile or gray iron.
   2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Plain-End, Ductile-Iron Pipe: AWWA C151/A21.51.

D. Appurtenances for Grooved-End, Ductile-Iron Pipe:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Shurjoint Piping Products USA Inc
      b. Smith-Cooper International
      c. Star Pipe Products
      d. Victaulic Company
   2. Fittings for Grooved-End, Ductile-Iron Pipe: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions that match pipe.
   3. Mechanical Couplings for Grooved-End, Ductile-Iron-Piping:
      a. AWWA C606 for ductile-iron-pipe dimensions.
      b. Ferrous housing sections.
      c. EPDM-rubber gaskets suitable for hot and cold water.
      d. Bolts and nuts.
      e. Minimum Pressure Rating: 250 psig.

2.5 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:
   1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
   2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.6 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Standard: ASTM A 674 or AWWA C105/A 21.5.

B. Material: Linear low-density polyethylene film of 0.008-inch minimum thickness.

C. Form: Tube.

D. Color: Black or natural.

2.7 TRANSITION FITTINGS

A. General Requirements:
   1. Same size as pipes to be joined.
   2. Pressure rating at least equal to pipes to be joined.
   3. End connections compatible with pipes to be joined.
   4. Description:
      a. CPVC one-piece fitting with manufacturer's equivalent dimensions.
      b. One end with threaded brass insert and one solvent-cement-socket end.

2.8 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric unions shall not be used. In lieu of dielectric union, use an approved brass fitting.

C. Dielectric Flanges:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. WATTS
      b. Wilkins
      c. Zurn Industries, LLC
   2. Standard: ASSE 1079.
   3. Factory-fabricated, bolted, companion-flange assembly.
   4. Pressure Rating: 150 psig minimum at 180 deg F.

5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc
   b. Calpico, Inc
   c. Central Plastics Company
   d. Pipeline Seal and Insulator, Inc
2. Description:
   a. Nonconducting materials for field assembly of companion flanges.
   b. Pressure Rating: 150 psig.
   c. Gasket: Neoprene or phenolic.
   d. Bolt Sleeves: Phenolic or polyethylene.
   e. Washers: Phenolic with steel backing washers.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 STORAGE AND PROTECTION

A. Delivery: Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.

B. Storage and protection: Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer.

C. Store piping on a flat surface to prevent unwanted deformation.

3.3 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping to verify actual locations of piping connections before equipment and fixture installation.

C. Examine walls, floors and roofs for suitable conditions where piping will be installed.

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

3.4 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground pipe in PE encasement according to ASTM A 674 or AWWA C105/A21.5.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

H. Install seismic restraints on piping.

I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

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

K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

L. Install piping to permit valve servicing.

M. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

N. Install piping free of sags and bends.

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

P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

Q. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump.

R. Install thermostats in hot-water circulation piping.

S. Install thermometers on inlet and outlet piping from each water heater.

T. Install sleeves for piping penetrations of interior walls, ceilings, and floors.
   1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install sleeve seals for piping penetrations of exterior concrete walls and slabs.
   1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install escutcheons for exposed piping penetrations of finished walls, ceilings, and floors.
   1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.5 JOINT CONSTRUCTION

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

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Press Fit Joints for Copper Tubing: Press connections shall be made in accordance with the manufacturer’s installation instructions. Clean end of tube. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool(s) approved by the manufacturer.

F. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

G. Joint Construction for Grooved-End Steel Piping: Make joints according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install

coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

H. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

I. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.6 INSTALLATION OF TRANSITION FITTINGS

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
   1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
   2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings.

3.7 INSTALLATION OF DIELECTRIC FITTINGS

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use approved brass fitting.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.8 INSTALLATION OF VALVES

A. General valve installation requirements are specified in Section 220523, “Valves for Plumbing Piping.”

3.9 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for hangers, supports, and anchor devices in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

C. Install hangers for piping and tubing, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install vinyl-coated hangers for PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Install vinyl-coated hangers for PEX tubing, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support horizontal piping within 12 inches of each fitting.

G. Support vertical runs of piping and tubing to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

H. Support vertical runs of PVC piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.10 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
   2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
   4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.11 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.12 FIELD QUALITY CONTROL

A. Perform the following tests and inspections in the presence of the Commissioning Agent, Owner, Architect or his representative:
   1. Piping Inspections:
      a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
      b. During installation, notify authorities having jurisdiction at least two days before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
         1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
         2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
      c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
      d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

   2. Piping Tests:
      a. Fill water piping. Check components to determine that they are not air bound and that piping is full of water.
      b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
      c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
      d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
      e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
      f. Prepare reports for tests and for corrective action required.

B. Water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Provide minimum 48 hours notice prior to testing to allow the Architect, Engineer, Commissioning Agent, Owner or his representative the opportunity to attend.

E. Tests shall be conducted and written report of testing submitted before any insulation is installed. Insulation installed prior to tests shall be removed.

3.13 ADJUSTING

A. Perform the following adjustments before operation:
   1. Close drain valves, hydrants, and hose bibbs.
   2. Open shutoff valves to fully open position.
   3. Open throttling valves to proper setting.
   4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
      a. Adjust calibrated balancing valves to flows indicated.
   5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
   6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
   7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
   8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.14 CLEANING

A. Clean and disinfect potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Fill and isolate system according to either of the following:
         1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
         2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
      c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
      d. Repeat procedures if biological examination shows contamination.
      e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.15 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, trap-seal primer piping shall be one the following:
   1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

D. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and soldered joints.
   2. Hard copper tube, ASTM B 88, Type L; copper press fittings; and press joints.

E. Aboveground domestic water piping, NPS 2-1/2 and larger, shall be the following:
   1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and soldered joints.

F. Aboveground, trap-seal primer piping shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and soldered joints.
   2. Hard copper tube, ASTM B 88, Type L; copper press fittings; and press joints.

3.16 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty:
      a. Use full-port ball valves for piping NPS 2 and smaller.
      b. Use ball or butterfly valves with flanged ends for piping NPS 2-1/2 and larger.
   2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
   3. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves.
   4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Vacuum breakers.
   2. Water pressure-reducing valves.
   3. Balancing valves.
   4. Temperature-actuated, water mixing valves.
   5. Strainers.
   6. Hose bibbs.
   7. Drain valves.
   8. Shock absorbers/Water-hammer arresters.
   9. Trap-seal primer valves.
   10. Flexible connectors.
   11. Water meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.
   1. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61 Annex G.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Hose-Connection Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Apollo Valves; Conbraco Industries, Inc.
      b. MIFAB, Inc
      c. WATTS
      d. Zurn Industries, LLC
   2. Standard: ASSE 1011.
   3. Body: Bronze, nonremovable, with manual drain.
   4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
   5. Finish: Rough bronze.

B. Anti-Siphon Pressure Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Fire & Waterworks; A WATTS Brand
      b. Apollo Valves; Conbraco Industries, Inc.
      c. WATTS
      d. Zurn Industries, LLC
   2. Standard: ASSE 1020.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: 5 psig maximum, through middle third of flow range.
   5. Accessories:
      a. Valves: Ball type, on inlet and outlet.

2.4 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Apollo Valves; Conbraco Industries, Inc.
      b. WATTS
      c. Zurn Industries, LLC
   2. Standard: ASSE 1003.
   3. Pressure Rating: Initial working pressure of 150 psig.
   4. Size: Same as connected piping. Refer to drawings.
   5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
   6. Valves for Booster Heater Water Supply: Include integral bypass.
   7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.5 BALANCING VALVES

A. Copper Alloy Calibrated Balancing Valves, ½" – 2":
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Armstrong International, Inc
      b. Flo Fab Inc
      c. ITT Corporation
      d. NIBCO INC.
      e. TACO Comfort Solutions, Inc.
      f. WATTS
   2. Type: Ball or Y-pattern globe valve with position indicator, two checked readout ports with drip caps and memory-setting indicator.
   3. Body: Brass or bronze.
   4. Size: As required for scheduled flow, but not larger than NPS 2.
   5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Cast-Iron Calibrated Balancing Valves, 2-1/2" and larger:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Armstrong International, Inc
      b. Flo Fab Inc
      c. ITT Corporation
      d. NIBCO INC.
      e. WATTS
   2. Type: Adjustable with Y-pattern equal percentage globe valve, two readout ports, and memory-setting indicator.
   3. Size: As required for scheduled flow, but not smaller than NPS 2-1/2.

C. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

2.6 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
      a. Apollo Valves; Conbraco Industries, Inc.
      b. Armstrong International, Inc
      c. Leonard Valve Company
      d. POWERS; A WATTS Brand
      e. TACO Comfort Solutions, Inc.
      f. WATTS
      g. Zurn Industries, LLC
   2. Standard: ASSE 1017.
   3. Pressure Rating: 125 psig.
   4. Type: Thermostatically controlled, water mixing valve.
   5. Material: Lead free bronze body with corrosion-resistant interior components.
   6. Connections: Threaded union inlets and outlet.

7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: Indicated on drawings.
9. Valve Finish: Rough bronze.

B. Point-of-Use, Thermostatic, Water Tempering Valves:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Leonard LF-170, 270 or 370 Series or comparable product by one of the following:
   a. Apollo Valves; Conbraco Industries, Inc.
   b. Bradley Corporation
   c. Lawler Manufacturing Company, Inc
   d. Leonard Valve Company
   e. POWERS; A WATTS Brand
   f. WATTS
   g. Zurn Industries, LLC
2. Standard: ASSE 1070, thermostatically controlled, water tempering valve.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Material: Lead-free, bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable, locking (tamper resistant).
6. Inlets and Outlet: Threaded or compression fittings, integral check valves on inlets.
7. Finish: Rough or chrome-plated bronze.
8. Pressure-Temperature:
   a. Minimum Flow: 0.25 GPM
   b. Maximum Pressure: 125 PSIG.
   c. Maximum Hot Water temperature: 200°F.
   d. Approach Temperature 5°F above set point.
   e. Temperature Adjustment Range: 90°F -140°F
   f. Tempered-Water Setting: 105 deg F.
9. Accessories:
   a. Cold water by-pass port (single fixture only). Not required for single handle or sensor faucet installations.
   b. Mounting bracket.
   c. Ball valves.
   d. For concealed wall mounted valves, provide recessed cabinet, white enamel, 18-gauge body and door, with left-hand hinge, plexiglas window in door and inlet/outlet knock-out holes for mounting flexibility.

2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:

a. Strainers NPS 2 and Smaller: 0.033 inch.
b. Strainers NPS 2-1/2 to NPS 4: 0.062 inch.
c. Strainers NPS 5 and Larger: 0.125 inch.

6. Drain: Factory-installed, hose-end drain valve.

2.8 HOSE BIBBS

A. Hose Bibbs (HB-1):
1. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith 5670-H or comparable product by one of the following:
a. Jay R. Smith Mfg. Co
b. Josam Company
c. MIFAB, Inc
d. WATTS
e. Zurn Industries, LLC
2. Standard: ASME A112.18.1 for sediment faucets.
3. Type: Exposed, bent nose hose valve with flange and vacuum breaker, not subject to freezing.
4. Body Material: Bronze.
5. Seat: Bronze, replaceable.
6. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
7. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
8. Pressure Rating: 125 psig.
9. Vacuum Breaker: Integral, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
10. Finish
a. Equipment Rooms: Rough bronze, or chrome or nickel plated.
b. Service Areas: Rough bronze.
c. Finished Rooms: Chrome or nickel plated.
11. Operation
a. Equipment Rooms: Wheel handle or operating key.
b. Service Areas: Wheel handle.
c. Finished Rooms: Operating key.
12. Include operating key with each operating-key hose bibb.
13. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.9 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:
1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.10 SHOCK ABSORBERS/WATER-HAMMER ARRESTERS

A. Shock Absorbers/Water-Hammer Arresters:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AMTROL, Inc.
      b. Jay R. Smith Mfg. Co
      c. Josam Company
      d. MIFAB, Inc
      e. Oatey
      f. Precision Plumbing Products
      g. Sioux Chief Manufacturing Company, Inc.
      h. WATTS
      i. Zurn Industries, LLC
   2. Standard: ASSE 1010 or PDI-WH 201.
   3. Type: Copper tube with piston.
   4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes B through F.
      a. Shock absorbers shall be the same size as the line on which they are installed, up to 1” pipe size. Pipe lines larger than 1” shall have 1-inch shock absorbers installed.

2.11 TRAP-SEAL PRIMER DEVICE

A. Flush Valve, Trap-Seal Primer Device:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide Precision Plumbing Products Model FVP or comparable product by one of the following:
      a. Jay R. Smith Mfg. Co
      b. MIFAB, Inc
      c. Precision Plumbing Products
      d. Sioux Chief Manufacturing Company, Inc.
      e. WATTS
      f. Zurn Industries, LLC
   2. Type: Vacuum breaker trap primer
   3. Body: 1-1/2” x 12” 17 GA with compression fitting.
   4. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
   5. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
   6. Finish: Chrome plated.
   7. Accessories: Vacuum breaker, chrome plated wall flange, compression fittings.

2.12 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flex-Hose Co., Inc
   2. Flexicraft Industries
   3. Hyspan Precision Products, Inc
   4. Metraflex Company (The)
   5. Proco Products, Inc

6. Unaflex

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   1. Working-Pressure Rating: Minimum 250 psig.
   2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
   3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
   1. Working-Pressure Rating: Minimum 250 psig.
   2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
   3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install unions or flanges at all connections to each piece of equipment and on both sides of valves and other in-line devices that require removal for maintenance.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

   1. Locate backflow preventers in same room as connected equipment or system.
   2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
   3. Provide 4” high by 4” wide concrete containment curb with drain below incoming water service reduced-pressure-principle backflow preventers. Interior of containment curb shall be 6” larger than the footprint of the backflow preventer.

C. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

D. Install balancing valves in locations where they can easily be adjusted.

E. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

   1. Install cabinet-type units recessed in or surface mounted on wall as specified.

F. Install Y-pattern strainers for water on supply side of each water pressure-reducing valve and pump.

G. Install ground hydrants with 1 cu. yd. of crushed gravel around drain hole. Set ground hydrants with box flush with grade.

H. Set freeze-resistant yard hydrants with riser pipe in concrete or pavement. Do not encase canister in concrete.

I. Install water-hammer arresters in water piping at the end of all branch lines and as indicated on the drawings according to PDI-WH 201. Pipe extensions shall not be used in place of shock absorbers.

J. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

K. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

L. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow. Coordinate 120-v power source with Division 26.

M. Install meters with inlet and outlet shutoff valves. Install bypass around meter with shutoff valve.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Test each reduced-pressure-principle backflow preventer and double-check, backflow-prevention assembly according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221119

SECTION 221316 - SANITARY WASTE AND VENT PIPING AND SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Hub-and-spigot, cast-iron soil pipe and fittings.
   2. Hubless, cast-iron soil pipe and fittings.
   3. Specialty pipe fittings.
   4. Encasement for underground metal piping.
   5. Floor drains.
   6. Trap-seal insert device.
   7. Cleanouts.
   8. Air-admittance valves.
   9. Miscellaneous sanitary drainage piping specialties.
   10. Interceptors

B. Contractor shall perform all work within the building and to a point five (5) feet from the building wall, unless otherwise noted.
   1. Contractor shall coordinate with site sanitary drainage services provided under another Division.
   2. The contractor shall make the final connection of the building sanitary drainage to the site sanitary drainage.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

1.5 QUALITY ASSURANCE

A. Piping, drains and specialty materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary piping specialty components.

1.6 FIELD CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Owner no fewer than ten days in advance of proposed interruption of sanitary waste service.
   2. Do not proceed with interruption of sanitary waste service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
   1. Soil, Waste, and Vent Piping: 10-foot head of water.
   2. Waste, Force-Main Piping: 50 psig.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. All pipe and fittings shall be from a United States domestic manufacturer.

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AB & I Foundry
   2. Charlotte Pipe and Foundry Company
   3. Tyler Pipe

B. Pipe and Fittings:
   1. Marked with CISPI collective trademark and NSF certification mark.

2. Class: ASTM A 74, Service class.

C. Gaskets: ASTM C 564, rubber.

2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AB & I Foundry
2. Charlotte Pipe and Foundry Company
3. Tyler Pipe

B. Pipe and Fittings:
1. Marked with CISPI collective trademark and NSF certification mark.
2. Standard: ASTM A 888 or CISPI 301.

C. Heavy-Duty, Hubless-Piping Couplings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ANACO-Husky
b. Charlotte Pipe and Foundry Company
c. Ideal-Tridon
d. Tyler Pipe
2. Standard: ASTM C 1540.
3. Description: Corrugated stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.5 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Shielded, Nonpressure Transition Couplings:
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Fernco Inc
2) Mission Rubber Company, LLC; a division of MCP Industries
3) Plastic Oddities
b. Standard: ASTM C 1460.
c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
d. End Connections: Same size as and compatible with pipes to be joined.

B. Dielectric Fittings
   1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
   2. Dielectric unions shall not be used. In lieu of dielectric union, use an approved brass fitting.
   3. Dielectric Flanges:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) WATTS
         2) Wilkins
         3) Zurn Industries, LLC
      b. Standard: ASSE 1079.
      c. Factory-fabricated, bolted, companion-flange assembly.
      d. Pressure Rating: 150 psig minimum at 180 deg F.
      e. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

2.6 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Standard: ASTM A 674 or AWWA C105/A 21.5.

B. Material: Linear low-density polyethylene film of 0.008-inch minimum thickness.

C. Form: Tube.

D. Color: Black or natural.

2.7 FLOOR DRAINS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Jay R. Smith Mfg. Co
   b. Josam Company
   c. MIFAB, Inc
   d. Sioux Chief Manufacturing...
   e. Wade; a subsidiary of McWane Inc.
   f. WATTS
   g. Zurn Industries, LLC.

B. FD-1 (Finished Floor):
   1. Basis-of-Design Product: Provide Josam 30000-S-ARE-50 or comparable product
   2. Pattern: Floor drain.
   3. Body Material: Cast iron.
   4. Drainage Flange: Required, double.
   5. Flashing Collar: Required, non-puncturing.
   6. Weepholes: Required.
   7. Outlet: Bottom.

8. Backwater Valve: Not required.
9. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant epoxy.
10. Sediment Bucket: Not required.
11. Strainer: Adjustable
12. Strainer Material and Finish: Satin nickel-bronze, copper alloy.
13. Top Shape: Square.
14. Dimensions of Top or Strainer: 6”x6”.
15. Funnel: Not required.
16. Features: 1/2” trap-seal primer valve drain connection.

2.8 TRAP-SEAL INSERT DEVICE

A. Trap-Seal Insert Device:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide ProSet Trap Guard or comparable product by one of the following:
      a. Jay R. Smith Mfg. Co
      b. Precision Plumbing Products
      c. ProVent Systems
      d. RectorSeal
   2. Standard: ASSE 1072.
   3. Material: HDPE housing, soft EPDM sealing gasket.

2.9 CLEANOUTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Jay R. Smith Mfg. Co.
   2. Josam Company; Josam Div.
   3. MIFAB, Inc.
   4. Tyler Pipe.
   5. Wade.
   6. WATTS.
   7. Zurn Industries, LLC.

B. Exposed and Above-Ceiling Cleanouts:
   1. Basis-of-Design Product: Provide Josam Series 58900 or comparable product.
   2. Size: Same as connected branch.
   3. Body Material: No-hub, cast-iron soil pipe test tee] as required to match connected piping.
   4. Closure: Bronze, countersunk plug.
   5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

C. Finished Floor Cleanouts:
   1. Basis-of-Design Product: Provide Josam Series 55000-1-SQ or comparable product.
   2. Size: Same as connected branch.
   3. Type: Adjustable cast-iron housing.
   4. Body or Ferrule: Cast iron.

5. Outlet Connection: No hub, hub with gasket or inside caulk (based on location).
6. Closure: Internal cast-iron or plastic plug.
7. Adjustable Housing Material: Cast iron with threads.
8. Cover Material and Finish: Scoriated satin nickel-bronze, copper alloy.
9. Frame and Cover Shape: Square.
10. Top Loading Classification: Light Duty.
11. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

D. Unfinished Floor Cleanouts:
1. Basis-of-Design Product: Provide Josam Series 58460A-AE or comparable product.
2. Size: Same as connected branch.
3. Type: Adjustable cast-iron housing.
4. Body: Cast iron.
5. Outlet Connection: No hub, hub with gasket or inside caulk (based on location).
6. Closure: Internal bronze countersunk plug.
7. Cover Material and Finish: Satin nickel-bronze, copper alloy.
8. Cover Shape: Round.
9. Top Loading Classification: Light Duty.
10. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

E. Wall Cleanouts:
1. Basis-of-Design Product: Provide Josam Series 58910-Z or comparable product.
2. Size: Same as connected drainage piping.
3. Body: No-hub, cast-iron soil pipe as required to match connected piping.
4. Closure Plug:
   a. Bronze.
   b. Countersunk head.
   c. Drilled and threaded for cover attachment screw.
   d. Size: Same as, or not more than, one size smaller than cleanout size.
5. Wall Access For Concealed Riser:
   a. Round, flat, nickel-bronze, copper-alloy cover plate with screw.
6. Wall Access for Concealed Riser:
   a. Square, stainless-steel wall-installation frame and cover.

F. Test Tees:
1. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301.
2. Size: Same as connected drainage piping.
3. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
4. Closure Plug: Countersunk, brass.
5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

2.10 AIR-ADMITTANCE VALVES

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

1. Durgo, Inc.
2. Oatey.
3. ProSet Systems Inc.
4. Studor, Inc.

B. Fixture Air-Admittance Valves:
1. Standard: ASSE 1051, Type A for single fixture or Type B for branch piping.
2. Housing: Plastic.
3. Operation: Mechanical sealing diaphragm.
4. Size: Same as connected fixture or branch vent piping.

2.11 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Deep-Seal Traps:
1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
a. NPS 2: 4-inch- minimum water seal.
b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

B. Pipe and fittings shall be moved to the trench, carefully lowered and set to line and grade. Pipe shall be laid on the shaped sub-grade. No blocking will be permitted and the bleeding shall be such that it forms a continuous bearing with a minimum width of bearing equal to 0.6 the outside diameter of the pipe for the full length of the pipe, except for that portion at the bell hole.

C. No pipe or fitting shall be installed until sufficient trench has been completely excavated to satisfy the Architect that no unforeseen obstructions of any kind are likely to be encountered. Pipe shall be cut by the Contractor when required without any additional compensation. Special care shall be exercised by the Contractor to prevent damage to any pipe.

D. Before placing in the trench, each pipe or fitting shall be carefully cleaned of any foreign substance which may have collected therein and shall be kept clean at all times thereafter. For this purpose, the open ends of all pipes and fittings in the trench shall be closed to the satisfaction of the Architect before leaving the work for the night and for all holidays or other items of interruption to the work.

3.2 PIPING INSTALLATION

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

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

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

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

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

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

H. Install piping to allow application of insulation.

I. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
   1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
   2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.
      a. Straight tees, elbows, and crosses may be used on vent lines.
   3. Do not change direction of flow more than 90 degrees.
   4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
      a. Reducing size of waste piping in direction of flow is prohibited.

K. Lay buried building waste piping beginning at low point of each system.
   1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
   2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
   3. Maintain swab in piping and pull past each joint as completed.

L. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:
   1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
   2. Horizontal Sanitary Waste Piping: 2 percent downward in direction of flow.
   3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
   1. Install encasement on underground piping in corrosive soils according to ASTM A 674 or AWWA C105/A 21.5.

N. Plumbing Specialties:
   1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
      a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
   2. Install drains in sanitary waste gravity-flow piping.

O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

P. Install sleeves for piping penetrations of interior walls, ceilings, and floors.
   1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

Q. Install escutcheons for exposed piping penetrations of finished walls, ceilings, and floors.
   1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hubless, Cast-Iron Soil Piping Coupled Joints:
   1. Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

C. Joint Restraints and Sway Bracing:
   1. Provide joint restraints and sway bracing for sanitary drainage piping joints to comply with the following conditions:
      a. Provide axial restraint for pipe and fittings 8 inches and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
      b. Provide rigid sway bracing for pipe and fittings 8 inches and larger, upstream and downstream of all changes in direction 45 degrees and greater.

c. Provide rigid sway bracing for pipe and fittings 8 inches and larger, upstream and downstream of all changes in direction and branch openings.

3.4 SPECIALTY INSTALLATION

A. Transition Couplings:
   1. Install transition couplings at joints of piping with small differences in ODs.
   2. In Drainage Piping: Nonpressure transition couplings.

B. Dielectric Fittings:
   1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

C. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.
   2. Set floor drains slightly below elevation of surrounding finished floor to allow positive floor drainage.
   3. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
      a. Maintain integrity of waterproof membranes where penetrated.
   4. Install individual deep-seal traps for floor drains connected to sanitary building drain, unless otherwise indicated.

D. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.

E. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

F. Install trap seal insert devices in accordance with manufacturer's instructions and approved product data submittals.

G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

H. Install fixture air-admittance valves on fixture drain piping where indicated on Drawings.

I. Install deep-seal traps on floor drains and other indirect waste outlets, unless otherwise noted.

J. Install blocking reinforcement for wall-mounting-type specialties.

K. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for hangers, supports, and anchor devices in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

C. Install hangers for metal piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

F. Support vertical runs of metal piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

G. Support vertical runs of plastic piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:
   1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.7 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 48 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
      a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.
      a. Expose work that was covered or concealed before it was tested.
   3. Roughing-in Plumbing Test Procedure:
      a. Test waste and vent piping except outside leaders on completion of roughing-in.
      b. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
      c. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
      d. Inspect joints for leaks.
   4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.
      a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
      b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
      c. Air pressure must remain constant without introducing additional air throughout period of inspection.
      d. Inspect plumbing fixture connections for gas and water leaks.
   5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   6. Prepare reports for tests and required corrective action.

C. Reinspection: Piping will be considered defective if it does not pass tests and inspections. Make required corrections and arrange for reinspection.

D. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

E. All new and existing sanitary drainage systems to the point of service connection or termination outside the building footprint for sanitary drainage shall be completely cleared with a plumber's snake and flushed after a building is completed and prior to Substantial Completion.

3.9 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Repair damage to adjacent materials caused by waste and vent piping installation.

E. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
   1. If drains are not covered and it is suspected that dirt, debris or trash has entered the drainage system, the interior drainage system shall be professionally cleaned to the Architect's satisfaction and at no expense to the Owner.

3.10 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil, waste and vent piping shall be the following:
   1. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

C. Underground, soil, waste, and vent piping shall be the following:
   1. Hub and spigot, cast-iron soil pipe and fittings, service class; gaskets; and gasketed joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.

END OF SECTION 221316

SECTION 224200 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Plumbing fixtures.
   2. Supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide all plumbing fixtures indicated on the contract drawings and as specified herein.

B. The Contractor shall provide metal supports necessary to adequately and substantially hang and set all fixtures subject to the approval of the Architect. No wood grounds, wood plugs, or expansion bolts shall be permitted for fixture support. Provide floor mounted carriers where specified below and as required to hang fixtures.

C. NSF Standard: Comply with NSF standards for materials that will be in contact with potable water.

D. Unless specified to be provided integral to the faucet, all handwashing fixtures (lavatories, hand sinks) shall be provided with factory calibrated mixing valve which conforms to ASSE 1070 not to exceed 110°.

2.2 MANUFACTURERS

A. Water Closet Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Standard America
   2. Kohler Co
   3. Sloan Valve Company
   4. TOTO USA, INC
   5. Zurn Industries, LLC

B. Urinal Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Standard America
   2. Kohler Co
   3. Sloan Valve Company
   4. TOTO USA, INC
   5. Zurn Industries, LLC

C. Flushometer Valve Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Sloan Valve Company
   2. TOTO USA, INC
   3. Zurn Industries, LLC

D. Toilet Seat Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Standard America.
   2. Bemis Manufacturing Company.
   3. Church Seats.
   4. Kohler Co.
   5. Toto USA, Inc.

E. Lavatory and Sink Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Standard America
   2. Kohler Co
   3. TOTO USA, INC

F. Stainless Steel Sink Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eagle Group; Foodservice Equipment Division.
   2. Elkay Manufacturing Co.
   3. Griffin Products, Inc.
   4. Just Manufacturing
   5. Kohler Co

G. Faucet Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Standard America.
   2. Chicago Faucets.
   3. Eljer
   4. Kohler Co.
   5. Sloan Valve Company.
   6. T & S Brass and Bronze Works, Inc.
   7. WaterSaver

H. Drain Accessory (P-Traps, Strainers, Angle Stops, Escutcheons and Supplies) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brasscraft
   2. Chicago
   3. Dearborn
   4. EBC
   5. McGuire
   6. Zurn

2.3 WATER CLOSETS

A. P-1 Water Closets: Wall mounted, back outlet, top spud.
   1. Fixture:
      a. Toto CT708EG, vitreous china, siphon jet, elongated, 1.28 gallons per flush, NPS 1-1/2 inlet, white with anti-microbial ceramic glaze.
   2. Flushometer Valve:
      a. Sloan G2 Optima Plus 8111-1.28 exposed, sensor activated, battery powered, diaphragm type, 1.28 gallons per flush, polished chrome finish, courtesy overide.
   3. Toilet Seat:
      a. Church No. 9500SSCT commercial heavy-duty, elongated rim, open front, less cover, white, stainless steel check-hinge with gasket. Shall comply with American Nation Standard Z124.5.
   4. Support:
      a. Josam 12000-XSD Series extra special duty 1,000 lb floor mounted water closet carrier with cantilevered supports. Include additional extension coupling, faceplate, and feet as required for installation in pipe space. Secure to floor with 1/2" bolts and anchors.
   5. Remarks:
      a. Contractor shall verify and coordinate rough-in locations.
      b. Installation shall meet the American with Disabilities Act guidelines and ANSI A117.1 Accessible and Usable Buildings and Facilities.
      c. Plumb trap primer connection from flush valve to floor drain.

B. P-1a Water Closets: Floor mounted, bottom outlet, top spud.

   1. Fixture:
      a. Toto CT725CU, vitreous china, siphon jet, elongated, 1.28 gallons per flush, NPS 1-1/2 inlet, white with anti-microbial ceramic glaze.

2. Flushometer Valve:
   a. Sloan G2 Optima Plus 8111-1.28 exposed, sensor activated, battery powered, diaphragm type, 1.28 gallons per flush, polished chrome finish, courtesy overide.
3. Toilet Seat:
   a. Church No. 9500SSCT commercial heavy-duty, elongated rim, open front, less cover, white, stainless steel check-hinge with gasket. Shall comply with American Nation Standard Z124.5.
4. Remarks:
   a. Contractor shall verify and coordinate rough-in locations.
   b. Installation shall meet the American with Disabilities Act guidelines and ANSI A117.1 Accessible and Usable Buildings and Facilities.
   c. Plumb trap primer connection from flush valve to floor drain.

2.4 URINALS

A. P-2 Urinals: Wall mounted, back outlet, top spud.
1. Fixture:
   a. Toto UT105UG, vitreous china, washout flush, 0.125 gallons per flush, NPS 3/4 inlet, white with anti-microbial ceramic glaze.
2. Flushometer Valve:
   a. Sloan ECOS 8186-0.125 exposed, sensor activated, battery powered, diaphragm type, 1.28 gallons per flush, polished chrome finish, courtesy overide.
3. Strainer or Trapway:
   a. Manufacturer's standard strainer with integral trap.
4. Support:
   a. Josam 17550 Series floor mounted urinal carrier. Include additional extension coupling, faceplate, and feet as required for installation in pipe space.
5. Remarks:
   a. Contractor shall verify and coordinate rough-in locations. Modern contoured design.
   b. Installation shall meet the American with Disabilities Act guidelines and ANSI A117.1 Accessible and Usable Buildings and Facilities.

2.5 LAVATORIES

A. P-3 Lavatories: Oval, self-rimming, counter mounted.
1. Fixture:
   a. American Standard 0475.047 Aqualyn, vitreous china, oval, 20 by 17 inches, one hole faucet punching, front overflow, white.
2. Faucet:
   a. Sloan Lino EAF-250-ITM, automatic-type, battery-powered, electronic-sensor-operated, nonmixing, solid-brass valve, single hole, 0.5 gpm, rigid spout, laminar flow outlet, 6-volt lithium CR-P2 commercial battery (3-year life), polished chrome finish with an integral ASSE 1070 valve. Time out setting for faucet shall be set for 12 seconds.
3. Strainer:

a. McGuire 155-WC cast brass chrome plated offset wheelchair strainer with polished chrome cast brass elbow, 17 gauge 1-1/4 inch seamless brass offset tailpiece, heavy rubber basin washer and fiber friction washer. Offset lavatory strainer shall be in compliance with CSA or other recognized testing authority and bear both manufacturer and testing mark.

4. Trap:
   a. McGuire 8902C cast brass chrome plated 1-1/4" x 1-1/2" P-trap with cleanout with 17 gauge tubular wall bend, cast brass slip nuts. Trap shall be in compliance with CSA and bear both manufacturer and testing mark.
5. Supplies and Stops:
   a. Chicago Faucets 1017-ABCP angle stop fitting with supply tube and loose key. 2-1/4" tee handle, tapered square broach, compression cartridge, 1/2 NPT female thread inlet, 3/8 NPT female compression outlet.
6. Remarks:
   a. Installation shall meet the American with Disabilities Act guidelines and ANSI A117.1 Accessible and Usable Buildings and Facilities.
   b. Contractor shall verify and coordinate rough-in locations.

2.6 SINKS

A. P-4 Kitchen Sink: Stainless steel, self-rimming, undermount
1. Fixture:
   a. Just Manufacturing US-ADA-1821-A undermount single-bowl sink, seamless 18 gauge, type 304, 18-8 stainless steel. Polished top and interior surfaces, highlighted bowl rim. Smooth, fully coated underside. 5 1/2" deep, center drain punched for 3-½" drain opening.
2. Faucet:
   a. Chicago Faucets No. 201-G8AE2805F317AB, concealed deck-mount faucet with 8" fixed centers, rigid/swing gooseneck spout, 8" center-to-center, 0.5 GPM pressure compensating, non-aerating, laminar outlet, 4" vandal-proof wristblade handles, rebuildable compression cartridge.
3. Strainer:
   a. McGuire 1151-WC cast brass chrome plated offset basket strainer with polished chrome cast brass elbow, 17 gauge 1-1/2 inch seamless brass offset tailpiece, heavy rubber basin washer and fiber friction washer. Offset basket strainer shall be in compliance with CSA or other recognized testing authority and bear both manufacturer and testing mark.
4. Trap:
   a. McGuire 8912C cast brass chrome plated 1-1/2" x 1-1/2" P-trap with cleanout with 17 gauge tubular wall bend, cast brass slip nuts. Trap shall be in compliance with CSA and bear both manufacturer and testing mark.
5. Supplies and Stops:
   a. Chicago Faucets 1017-ABCP angle stop fitting with supply tube and loose key. 2-1/4" tee handle, tapered square broach, compression cartridge, 1/2 NPT female thread inlet, 3/8 NPT female compression outlet.
6. Remarks:
   a. Installation shall meet the American with Disabilities Act guidelines and ANSI A117.1 Accessible and Usable Buildings and Facilities.
   b. Contractor shall verify and coordinate rough-in locations.

B. P-5 Mop Sink: Floor mounted, terrazzo.
   1. Fixture:
      a. Fiat Model TSBC1610 corner mop sink, one piece, 24”x24” precast, ground and polished terrazzo with stainless steel caps.
   2. Faucet:
      a. Chicago Faucets No. 897-CP, wall mounted sink faucet for hot and cold water with 7-5/8" - 8-3/8" adjustable centers. Chrome plated, vacuum breaker spout with pail hook and wall brace. 2-3/8" metal, vandal-proof, lever handles with sixteen-point, tapered broach and secured blue and red index buttons. Rebuildable compression cartridge, opens and closes 90°, closes with water pressure, features square, tapered stem. Adjustable supply arms shall include 1/2" NPT female union nut. 3/4" male hose thread outlet. Integral stop valves for servicing the faucet.
   3. Strainer:
      a. Fiat 1453-BB flat type stainless steel.
   4. Remarks:
      a. Fiat E-77-AA vinyl bumper guard, Fiat 889-CC mop hanger and stainless steel wall guards.
      b. Install terrazzo mop basin on 1/2" layer of mortar per manufacturer's instructions.
      c. Contractor shall verify and coordinate rough-in locations.

2.7 WATER OUTLET BOXES

A. P-6 Clothes Washer Outlet Box: Recessed.
   1. Fixture:
      a. IPS Guy Gray Model T200TPPVCHA water outlet box, 20 gauge box and 20 gauge faceplate, white powder coat on cold rolled steel finish, 1/4 turn ball valve with 1/2” sweat connection and hammer arrester, 2” drain.
   2. Remark:
      a. Contractor shall verify and coordinate rough-in locations.

2.8 GROUT

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

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

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls and floors for suitable conditions where fixtures will be installed.

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

3.2 FIXTURE INSTALLATION

A. Water-Closets:
   1. Water-Closet Installation:
      a. Install level and plumb according to roughing-in drawings.
      b. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
      c. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.
   2. Support Installation:
      a. Install supports, affixed to building substrate, for wall-hung water closets.
      b. Use carrier supports with waste-fitting assembly and seal.
      c. Install floor-mounted, back-outlet water closets attached to building floor substrate, onto waste-fitting seals; and attach to support.
      d. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
   3. Flushometer Valve Installation:
      a. Install flushometer-valve, water-supply fitting on each supply to each water closet.
      b. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
      c. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
      d. Install actuators in locations that are easy for people with disabilities to reach, with handle mounted on accessible side of fixture.
      e. Provide offset flush connection as required to coordinate with wall mounted grab bars to all ADA water closets with flush valves.
   4. Install toilet seats on water closets.

B. Urinals:
   1. Urinal Installation:
      a. Install urinals level and plumb according to roughing-in drawings.
      b. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
      c. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.
      d. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.

e. Install trap-seal liquid in waterless urinals.

2. Support Installation:
   a. Install supports, affixed to building substrate, for wall-hung urinals.
   b. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
   c. Use carriers without waste fitting for urinals with tubular waste piping.
   d. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.
3. Flushometer-Valve Installation:
   a. Install flushometer-valve water-supply fitting on each supply to each urinal.
   b. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
   c. Install lever-handle flushometer valves for accessible urinals with handle mounted on accessible side of fixture.

C. Lavatories:
1. Install lavatories level and plumb according to roughing-in drawings.
2. Install supports, affixed to building substrate, for wall-mounted lavatories.
3. All faucet handles, where possible, shall have color coded "indexes" identifying the service used.
4. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.
5. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220700 "Plumbing Insulation."

D. Sinks
1. Install sinks level and plumb according to roughing-in drawings.
2. Install supports, affixed to building substrate, for wall-hung sinks.
3. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.
4. Set floor-mounted sinks in leveling bed of cement grout.
5. Install water-supply piping with stop on each supply to each sink faucet.
   a. Install stops in locations where they can be easily reached for operation.
   b. Install check valves on water-supply piping serving mop sink faucets.
6. All faucet handles, where possible, shall have color coded "indexes" identifying the service used.
7. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220700 "Plumbing Insulation."

E. Water Outlet Boxes:
1. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs.

F. Wall Flange and Escutcheon Installation:
1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

G. Joint Sealing:
   1. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
   2. Match sealant color to fixture color.
   3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

H. Confirm operation of all electronic-sensor mechanisms. If hard-wired through transformers, test operation of electronic-sensor mechanisms prior to installing back-up batteries

I. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.3 CONNECTIONS

A. Connect fixtures with water supplies and soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to fixtures, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Adjust detection range and flow duration for all electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean fixtures and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed fixtures and fittings.

C. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224200

SECTION 226813 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Pipes, tubes, and fittings.
   2. Piping specialties.
   3. Piping and tubing joining materials.
   4. Manual gas shutoff valves.
   5. Earthquake valves.
   6. Pressure regulators.
   7. Dielectric fittings.

1.3 DEFINITIONS

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

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

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

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Piping specialties.
   2. Corrugated, stainless-steel tubing with associated components.
   3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
   4. Pressure regulators. Indicate pressure ratings and capacities.
   5. Dielectric fittings.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the

same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
1. Shop Drawing Scale: 1/4 inch per foot.

C. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Detail fabrication and assembly of seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For motorized gas valves, pressure regulators and service meters to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

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

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

C. 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.

1.8 DELIVERY, STORAGE, AND HANDLING

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

B. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

C. Protect stored PE pipes from direct sunlight.

1.9 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
   1. Notify Owner no fewer than ten days in advance of proposed interruption of natural-gas service.
   2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:
   1. Piping and Valves: 100 psig minimum unless otherwise indicated.
   2. Service Regulators: 65 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: As indicated on the drawings. Not more than 5 psig.

C. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2.2 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. All pipe and fittings shall be from a United States domestic manufacturer.

2.3 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
   2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.

3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   a. Material Group: 1.1.
   b. End Connections: Threaded or butt welding to match pipe.
   c. Lapped Face: Not permitted underground.
   d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
   e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.4 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
   1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
   2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
   3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
   4. Corrugated stainless-steel tubing with polymer coating.
   5. Operating-Pressure Rating: 0.5 psig.
   6. End Fittings: Zinc-coated steel.
   7. Threaded Ends: Comply with ASME B1.20.1.
   8. Maximum Length: 60 inches

B. Y-Pattern Strainers:
   1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
   3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
   4. CWP Rating: 125 psig.

C. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.5 JOINING MATERIALS

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

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

2.6 MANUAL GAS SHUTOFF VALVES

A. See "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig.
   2. Threaded Ends: Comply with ASME B1.20.1.
   3. Tamperproof Feature: Locking feature for valves indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   4. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
   5. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
   1. CWP Rating: 125 psig.
   2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
   3. Tamperproof Feature: Locking feature for valves indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. A.Y. McDonald Mfg. Co.
      b. Apollo Flow Controls; Conbraco Industries, Inc.
      c. BrassCraft Manufacturing Co.; a Masco company
      d. Lyall, R. W. & Company, Inc
      e. Perfection Corporation
   2. Body: Bronze, complying with ASTM B 584.
   3. Ball: Chrome-plated bronze.
   4. Stem: Bronze; blowout proof.
   5. Seats: Reinforced TFE; blowout proof.
   6. Packing: Threaded-body packnut design with adjustable-stem packing.
   7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   8. CWP Rating: 600 psig.
   9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. A.Y. McDonald Mfg. Co.
      b. Lee Brass Company
   2. Body: Bronze, complying with ASTM B 584.

3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Production Valve
   b. A.Y. McDonald Mfg. Co.
   c. Durco
   d. Homestead
   e. Mueller Co.
2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Valve Boxes:
1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.7 EARTHQUAKE VALVES

A. Earthquake Valves, Maximum Operating Pressure of 5 psig: Comply with ASCE 25.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Vanguard Valves, Inc
2. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
3. Maximum Operating Pressure: 5 psig.
4. Cast-aluminum body with nickel-plated chrome steel internal parts.

5. Nitrile-rubber valve washer.
6. Sight windows for visual indication of valve position.
7. Threaded end connections complying with ASME B1.20.1.
8. Wall mounting bracket with bubble level indicator.

2.8 PRESSURE REGULATORS

A. General Requirements:
   1. Single stage and suitable for natural gas.
   2. Steel jacket and corrosion-resistant components.
   3. Elevation compensator.
   4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Actaris
      b. American Meter Company
      c. Eclipse Innovative Thermal Technologies
      d. Fisher Control Valves & Instruments; a brand of Emerson Process Management
      e. Itron Gas
      f. Maxitrol Company
      g. Richards Industries
      h. Sensus
   2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
   3. Springs: Zinc-plated steel; interchangeable.
   4. Diaphragm Plate: Zinc-plated steel.
   5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
   6. Orifice: Aluminum; interchangeable.
   7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
   8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
   9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
   10. Overpressure Protection Device: Factory mounted on pressure regulator.
   11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
      a. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
   12. Maximum Inlet Pressure: 5 psig.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton
      b. Harper Wyman Co

c. Maxitrol Company
d. SCP, Inc

2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 1 psig.

2.9 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric unions shall not be used. In lieu of dielectric union, use an approved brass fitting.

2.10 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 INSTALLATION OF OUTDOOR PIPING

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Steel Piping with Protective Coating:
   1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
   2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer, or replace pipe having damaged PE coating with new pipe.

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

D. Install pressure gage downstream from each service regulator.

3.4 INSTALLATION OF INDOOR PIPING

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

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

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

D. Do not install piping in concealed locations unless sleeved with the sleeve open at both ends.

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

F. Where installing piping above accessible ceilings, allow sufficient space for ceiling panel removal.

G. Locate valves for easy access. Do not locate valves within return air plenums.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

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

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
   1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
   2. Install sediment trap on both sides of regulators for gas reduction to 2 psig with valve and capped.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

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

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
   1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
   2. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
      a. Exception: Tubing passing through partitions or walls does not require striker barriers.
   3. Prohibited Locations:
      a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
      b. Do not install natural-gas piping in solid walls or partitions.

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

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

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gauge upstream and downstream from each line regulator. Pressure gauges are specified in Section 220519 "Meters and Gauges for Plumbing Piping."

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.5 INSTALLATION OF VALVES

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Do not install valves in return-air plenums.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

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

C. Threaded Joints:
1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:
1. Construct joints in accordance with AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

3.7 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment " for hangers, supports, and anchor devices.

C. Install hangers for steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install hangers for corrugated stainless-steel tubing, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping within 12 inches of each fitting.

F. Support vertical runs of steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

G. Support vertical runs of corrugated stainless-steel tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.8 PIPING CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous and bonded to gas-appliance equipment grounding conductor of the circuit powering the appliance in accordance with NFPA 70.

C. Where installing piping adjacent to appliances, allow space for service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

3.9 LABELING AND IDENTIFYING

A. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 PAINTING

A. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Alkyd System: MPI EXT 5.1D.
      a. Prime Coat: Alkyd anticorrosive metal primer.
      b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
      c. Topcoat: Exterior alkyd enamel (flat).
      d. Color: Gray.

B. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Alkyd System: MPI INT 5.1E.
      a. Prime Coat: Alkyd anticorrosive metal primer.
      b. Intermediate Coat: Interior alkyd matching topcoat.
      c. Topcoat: Interior alkyd (flat).
      d. Color: Gray.

C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.11 CONCRETE BASES

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

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Provide minimum 48 hours notice prior to testing to allow the Architect, Engineer, Commissioning Agent, Owner or his representative the opportunity to attend.

3.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.14 OUTDOOR PIPING SCHEDULE

A. Aboveground natural-gas piping shall be one of the following:
   1. NPS 3/4 through 2: Steel pipe with malleable-iron fittings and threaded joints.

B. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE

A. Aboveground, piping shall be one of the following:
   1. NPS 3/4 through 2: Steel pipe with malleable-iron fittings and threaded joints.

B. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

C. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.

B. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.

C. Valves in branch piping for single appliance shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.

END OF SECTION 226813

SECTION 23 05 00 - COMMON WORK RESULTS FOR MECHANICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section describes the common work requirements for the mechanical work included in Division 23 and applies to all sections of Division 23.

1.3 DEFINITIONS

A. Following are definitions of terms and expressions used in the Mechanical and Electrical Sections:

1. Provide: Furnish and install
2. Directed: Directed by the Architect or Engineer
3. Indicated: Indicated in Contract Documents
4. Concealed: Hidden from normal sight; includes items within furred spaces, pipe and duct shafts, above suspended ceilings and within return air plenums.
5. Exposed: Non concealed - Work within Equipment Rooms shall be considered exposed.
6. Exterior: Items being or situated outside. Items located within a crawl space shall be considered exterior.
7. Conditioned: Heated or cooled space, or both, within a building and, where required, provided with humidification or dehumidification means, so as to be capable of maintaining a space condition falling within the comfort envelope set forth in ASHRAE 55.
8. Piping: Includes pipes, fittings, valves, hangers, and accessories comprising a system.
9. Ductwork: Includes ducts, fittings, housings, dampers, hangers, air devices, and accessories comprising a system.

1.4 CODES, REGULATIONS, AND PERMITS:

A. References to codes, standards, specifications, and regulations apply to the latest edition adopted by the jurisdiction where the project is located.

B. All materials furnished and all work installed shall comply with the applicable rules, regulations, and recommendations of the following bodies:

1. International Building Code
2. International Existing Building Code
3. International Mechanical Code
4. International Plumbing Code
5. International Fire Code
6. International Energy Code
7. National Electric Code
8. National Fire Protection Association Standards
9. State Fire Marshal Regulations
10. Local Fire Marshal Regulations
11. ASHRAE Standards and Handbooks (Latest Editions)
12. Local Health Department
13. State Health Department
14. Local Utility Companies
15. Underwriters Laboratories
16. Owner's Insurance Underwriter Standards
17. Environmental Protection Agency

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

1.5 EQUIPMENT LIST

A. Provide a spreadsheet list of all equipment provided with the drawing tag number or designation, name, manufacturer, model number, serial number and full electrical characteristics.

B. This list shall be provided to the TAB agent, Commissioning Agent, BAS providers and to the Owner prior to beginning TAB work and as soon after all equipment is received on site.

1.6 EQUIPMENT START-UP AND INITIAL OPERATION

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

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

C. It is the Contractor's responsibility to place each item of equipment, installed by him, in operating condition. This responsibility includes all auxiliaries, piping, wiring, etc., the start-up of each unit, and a check of its performance.

1.7 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Refer to Section 017900 "Demonstration and Training" for additional information.

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

C. Contractor shall instruct the Owner's representative fully in the operation, adjustment, and maintenance of all equipment furnished.

1.8 SITE VISIT

A. Prior to preparing the bid, it is recommended that the Contractor and subcontractors shall visit the site and familiarize themselves with all existing conditions, make all necessary investigations as to locations of utilities, and all other matters which can affect the work.

B. No additional compensation will be made to the Contractor as a result of his failure to familiarize himself with the existing conditions under which the work must be performed.

1.9 DRAWINGS

A. The Contract Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. Any offsets, rises, or transitions not shown on the drawings and required to provide a complete system shall be provided at no additional contract cost. Do not scale the drawings. Consult the Architectural and Structural drawings and details for exact location of structure and equipment; where same are not definitely located, obtain this information from the Architect.

B. In the event of ambiguities within or between parts of the Contract Documents, the contractor shall 1) provide the better quality or greater quantity of work, or 2) comply with the more stringent requirement, either or both in accordance with the Architect's interpretation.

1.10 ELECTRICAL WORK

A. Under Division 23 MECHANICAL, provide the following items of electrical work which shall conform with the applicable requirements of the Electrical Division:

1. Low voltage temperature control wiring.

a. Concealed wiring shall be installed in conduit.
b. Exposed wiring shall be installed in conduit.
c. Refer to Section 260533 - Raceways and Boxes for Electrical Systems for installation requirements.

2. Interlock wiring for mechanical equipment and devices.
3. IT/network cabling between the BAS and Owner/Agency IT network.

B. Under Division 26 ELECTRICAL, provide:

1. Power wiring, complete from power source to motor or equipment junction box, including power wiring through motor starters, power factor correction devices, and line reactors. Power factor correction devices shall be provided under Division 23 and installed under Division 26.
2. Motor control centers or motor starter, panelboards.
3. All miscellaneous individual motor starters, unless noted or specified otherwise.

1.11 SINGULAR NUMBER

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

PART 2 - PRODUCTS

2.1 MATERIALS

A. Refer to Section 013300 "Submittal Procedures" for additional information.

B. All component parts of each items of equipment or device shall bear the manufacturers' name plate; giving name of manufacturer, description, size, type, serial or model number, electrical characteristics, etc., in order to facilitate the maintenance or replacement. The name plate of a subcontractor or distributor will not be acceptable. Where Underwriters' Laboratories standards apply, material and equipment shall be approved by them and shall bear the UL Label.

C. In specifying materials, three (3) general procedures are used. The three (3) classifications are as follows:

1. GROUP 1: When a material or equipment is specified by brand name or other identifying information and three (3) or more brands are named it is considered that any one (1) of the brands so named will perform as desired, and the Contractor shall base his proposal on one (1) of the named brands. The first brand named or identified basis of design shall be used as a standard. The other brands named shall be equal to the specified brand in all respects. If one (1) of the other brands named is

used it shall be the Contractor's responsibility to verify proper clearances and fit of the substituted equipment.

2. GROUP 2: When the material or equipment is specified with the phrase "...or approved equal..." after a brand name and other identifying information, it is intended that the brand name is used for the purpose of establishing a minimum acceptable standard of quality and performance and Contractor may base his bid proposal on any item which is in all respects equal to that specified and presents essentially the same appearance. It shall be the Contractor's responsibility to ensure proper fit and clearances of all substituted equipment.
3. GROUP 3: When material is specified as complying with the requirements of published "Standard Specification" of trade associations, American Society of Testing and Materials, government specifications, etc. the Contractor shall base his proposal on any item which can be shown to comply in all respects to the referred "Standard Specification".

D. It is distinctly understood: (1) that the Architect will use his own judgment in determining whether or not any materials, equipment or methods offered in substitution are equal to those specified; (2) that the decision of the Architect on all such questions of equality is final; and (3) that all substitutions will be made at no increase in cost to the Owner.

E. Upon receipt of written approval from Architect, Contractor may proceed with substitution providing Contractor assumes full responsibility for, and makes, at his own expense, any changes or adjustments in construction or connection with other work that may be required by the substitution of such materials, equipment or methods. In the event of any adverse decisions by the Architect no claim of any sort shall be made or allowed against the Owner.

F. All pipe and fittings shall be from a domestic manufacturer.

2.2 INSTALLATION AND COORDINATION DRAWINGS

A. General

1. Prior to fabricating or installing work, the contractor shall prepare, submit and use composite installation and coordination drawings to assure proper coordination and installation of work. No installation or construction work shall begin until the coordination drawings are completed, submitted, and approved.
2. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems. Composite coordination drawings shall include new and existing elements, components, and systems.
3. Show relationship and integration of different construction elements that require coordination during fabrication or installation to fit in space provided or to function as intended.

4. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are important to efficient flow of Work.
5. Consideration shall be made for scheduling, sequencing, movement, and positioning of large equipment into building during construction.
6. Indicate penetrations in floors, walls, and ceilings and their relationship to assembly construction, other penetrations and installations. Identify where additional bracing and offsets are required to comply with Contract Documents.
7. Indicate any required installation sequences to minimize cutting and patching.
8. Indicate all equipment and devices indicated on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals include manufacturer's literature showing internal wiring
9. Coordination Drawing Organization: Organize coordination drawings as follows:
    a. Floor Plans and Reflected Ceiling Plans: Show architectural and structural elements, and mechanical, plumbing, fire-protection, fire-alarm, and electrical work. Show locations of visible ceiling-mounted devices relative to acoustical ceiling grid. Supplement plan drawings with section drawings where required to adequately represent the work.
    b. Plenum Space: Indicate subframing for support of ceiling and wall systems, mechanical, electrical, plumbing and fire protection components, and related work. Locate components within ceiling plenum to accommodate architectural ceiling height and layout of light fixtures indicated on Drawings.

10. Systems: Include, but do not necessarily limit to, the following:
    a. HVAC:
        1) All equipment and equipment bases.
        2) Size and bottom elevations of horizontal ductwork, including insulation, bracing, flanges, and support systems.
        3) Size and horizontal elevations of vertical ductwork, including insulation, bracing, flanges, and support systems.
        4) Ductwork, grilles, registers, diffusers, dampers, access panels,
        5) Maintenance clearances (including tube and filter removal), insulation installation clearances
        6) Any item that may impact coordination with other disciplines.
    b. HVAC Piping:
        1) All equipment and equipment bases.
        2) Size and bottom elevations of horizontal piping, including insulation, bracing, flanges, and support systems. Notate code required slope elevations.
        3) Size and horizontal elevations of vertical piping, including insulation, bracing, flanges, and support systems.
        4) Connections to equipment, valve and trim locations, access panels.

5) Maintenance clearances, valve steam clearances, insulation installation clearances
6) Any item that may impact coordination with other disciplines.

c. Plumbing:
1) All equipment and equipment bases.
2) Size and bottom elevations of horizontal piping, including insulation, bracing, flanges, and support systems. Notate code required slope elevations.
3) Size and horizontal elevations of vertical piping, including insulation, bracing, flanges, and support systems.
4) Connections to equipment, valve and trim locations, access panels.
5) Maintenance clearances, valve steam clearances, insulation installation clearances
6) Any item that may impact coordination with other disciplines.

d. Electrical and Specialty Systems:
1) Runs of vertical and horizontal conduit 1-1/2 inches in diameter and larger and racks of smaller conduit are required.
2) Light fixture, exit light, emergency battery pack, smoke detector, and other fire-alarm locations.
3) Panel board, switch board, switchgear, transformer, busway, generator, and motor control center locations.
4) Location of pull boxes and junction boxes, dimensioned from column center lines.
5) Any item that may affect coordination with other disciplines.

e. Framing: All king studs, headers, bracing, miscellaneous framing, and any items that may affect coordination with other disciplines.

B. Production of Coordination Drawings

1. Draw plans to a scale not less than 1/4 inch equals one (1) foot in AutoCAD or REVIT format. Include plans, sections, and elevations of proposed work. Dimension all work as specified and as required for coordinated installation.
2. Reproduction of any portion of the mechanical and electrical contract drawings for re-submittal as a shop drawing is strictly prohibited. Shop drawings produced in such a manner will be rejected and returned not reviewed. Installation and coordination drawings shall be to scale reflecting actual equipment sizes purchased for the project.
3. The Construction Manager shall obtain and provide in AutoCAD or REVIT the base background documents to each contractor to establish a common platform for each contractor to use for their design drawings. Coordination will be accomplished by each Contractor superimposing his work on drawings.
4. Contractor coordination meetings shall be held continuously until the coordination drawings are complete and approved by all parties. Meetings shall be scheduled as required to complete the drawings in a timely manner as to not impact the project schedule. Additional time or compensation shall not be awarded based on the complexity or effort required to complete the coordination drawings.

5. In the event of conflicts involving location and layout of work, unless otherwise directed the Construction Manager shall use the following priority to resolve the conflict:
   a. Structure and partitions shall have highest priority.
   b. Equipment locations and access
   c. Ceiling systems and recessed light fixtures.
   d. Gravity drainage lines.
   e. Large pipe mains, valves and devices.
   f. Low pressure ductwork, diffusers, registers, grilles, dampers
   g. Small piping, tubing, electrical conduit and devices. Conduits installed in corridors shall be maintained at least 6-9” above finished ceiling and similarly grouped and tightly spaced.
   h. Access panels.

6. Any conflicts, etc., discovered in the coordination stages prior to Contractor(s) sign-off which cannot be resolved by the Contractor(s) shall be brought to the Architect's attention for resolution.

C. Submittals

1. Submit drawing files using Portable Data File (PDF) format. Include transmittal indicating that each specialty trade has signed-off on each submitted coordination drawing.
2. For each area, submit:
   a. Composite overlay drawing of each area with all trades shown.
   b. Individual trade drawing of each area, i.e. Reflected Ceiling Plan, HVAC Ductwork, HVAC Piping, Plumbing, Fire Protection, Electrical.

3. Consultant will review coordination drawings to confirm that the Work is being coordinated, but not for the details of the coordination, which are Contractor's responsibility. If Consultant determines that coordination drawings are not being prepared in sufficient scope or detail, or are otherwise deficient, Consultant will so inform Contractor, who shall make changes as directed and resubmit.
4. Review of coordination drawings shall not diminish responsibility under this Contract for final coordination of installation and maintenance clearances of all systems and equipment with architectural, structural, mechanical, electrical and other work.
5. Contractor is responsible for timely updates to the coordination drawings to indicate as-built conditions for their own work. Updates are required to include all changes regardless of the source or reason for the change, including changes initiated by the Owner, Architects or Engineers.

D. Installation

1. Any conflicts, etc., discovered after the created and submission of the coordination and installation drawings and during the installation of the Work will be the responsibility of the Contractor(s) to resolve with the

approval of Architect. Any and all costs for these resolutions shall be solely the responsibility of the Contractor(s).

2. Work fabricated/installed prior to the completion of the coordination and installation drawings is performed at the Contractors own risk, and compensation of time/costs for corrections will not be awarded.
3. Any work installed that is not in conformance with final approved coordination and installation drawings shall be required to be removed and relocated, and compensation of time/costs for corrections will not be awarded.

2.3 DRIVES FOR MACHINERY

A. Equip each motor driven machine with a V-belt drive except those which are specified as direct drive. Where factory designed and assembled belt drives which do not conform to the following are proposed to be furnished, such non-conformity must be noted on the shop drawings submittals and may be cause for rejection of the item.

B. Provide OSHA approved guards, for all belt drives, constructed in accordance with SMACNA standards. Submit shop drawings for approval.

C. Select each drive according to the ratings and recommendations of the manufacturer for the service with which used, giving proper allowance for sheave diameter, center distance, and arc of contact less than one hundred eighty degrees. Size the motor driving a pump or fan to have a nameplate rating of not less than ten (10) percent above the total of actual brake horsepower and drive loss at specified capacity.

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

E. Provide any changes to the sheaves, belts, pulleys or drive package to obtain specified airflow.

F. Select the motor of a capacity needed to operate the equipment at the specified mid-position operating condition. Where non-overloading motors are specified, select the motor capacity rating at the most closed position of the motor sheave. In no case shall motors be a smaller size than those indicated on the drawings.

G. Do not select fan sheave smaller in diameter than thirty (30) percent of the fan wheel diameter.

H. Construct sheaves of cast iron or steel, bored to fit properly on the shafts, and secured with key ways of proper size (not set screws). Key ways may be omitted for sheaves having 1/2 inch or smaller bores where set screws may be used.

PART 3 - EXECUTION

3.1 MATERIAL LIST

A. Provide a spreadsheet list of all equipment provided with the drawing tag number or designation, name, manufacturer, model number, serial number and full electrical characteristics.

B. This list shall be provided to the TAB agent, Commissioning Agent, BAS provider and to the Owner prior to beginning TAB work and as soon after all equipment is received on site.

3.2 WORKMANSHIP

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

B. Workmanship proven to be of poor quality or unsatisfactory in the commissioning phase of the project as deemed by the Architect shall be removed and replaced to the satisfaction of the Architect.

3.3 EQUIPMENT PERFORMANCE

A. All equipment, devices, controls, and hardware shall be proven to operate successfully throughout the guarantee period. Systems shall be proven during all-weather seasons and be demonstrated to affect the design conditions at times. System components or equipment items that fail to consistently deliver the design conditions shall be removed and replaced as directed by the Architect. The cost of required equipment replacements shall be borne by the Contractor.

B. All equipment shall be tested after installation and be proven to deliver the manufacturers quoted design capacity. When capacity is in question as deemed by the Architect, the Contractor shall perform a detailed and comprehensive field performance test to certify the equipment capacity. System effect or installed performance factors may not be applied to performance ratings unless they were previously included when the equipment was submitted for approval. Equipment that fails to deliver manufacturers quoted design capacity shall be removed and replaced at the Contractors expense.

C. Workmanship proven to be of poor quality or unsatisfactory in the commissioning phase of the project as deemed by the Architect shall be removed and replaced to the satisfaction of the Architect.

3.4 EQUIPMENT CONNECTIONS

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

3.5 WELDING

A. Welding shall conform to current standards and recommendations of the National Certified Pipe Welding Bureau, with all South Carolina Occupational Safety and Health Acts, State, City and County Fire Prevention Code Requirements, and NFPA Standard 241 including provision of appropriate portable fire extinguishers.

B. Before assigning any welders to work covered by this specification, the Contractor shall provide the Architect with the names of pipe welders to be employed for the work, together with each welder's assigned number, letter, or symbol which shall be used to identify the work of that welder and which shall be affixed immediately upon completion of each weld. Contractor shall also submit, with the list of names, copies of each welder's certified qualification tests prescribed by the National Certified Welding Bureau or by other reputable testing laboratory using procedures covered in the American Society of Mechanical Engineers Building Construction Code, Section IX, "Qualification Standard Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators". Welders must be certified for all positions.

C. If requested by the Architect, the Contractor shall submit identifying stenciled test coupons made by any welder in question. The Contractor shall require any welder to retake the tests when, in the opinion of the Architect, the work of the welder creates a reasonable doubt as to his proficiency. Tests, when required, shall be conducted at no additional expense to the Owner; and the welder in question shall not be permitted to work as a welder on this project until he has been recertified. Recertification of the welder shall be made to the Architect only after the welder has taken and passed the required test; welder must pass the test without benefit of retests in order to resume work as a welder on this project.

D. Welding shall conform to the ANSI Code for Pressure Piping ANSI B31.9, Building Services Piping. The Contractor shall be responsible for the quality of welding and shall repair or replace any work not in accordance with these specifications. Contractor shall, without cost to the Owner, check welds by radiograph, ultrasonic testing, sectioning or a combination of these methods wherever there is a question raised by the Architect as to the quality of a weld. Examination of the questionable weld shall be in addition to other system tests specified. Welds shall have penetration complete to the inside diameter of the pipe. The recommended spacing and levels between ends of pipes prior to welding shall be used in all cases to assure full penetration.

E. Welders on pressure piping shall be certified and carry their identification stamp with them. Welds on lines with operating pressures above 100 psig shall be stamped.

3.6 HANDLING AND STORAGE OF MATERIAL

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

B. All equipment delivered to the job site shall be stored on pedestals, above the ground and under roof or other approved covering. All enclosures for equipment shall be weatherproof. All motors, drives, switchgear, panels, etc. which are not totally enclosed, that are involved in the work, shall be stored in a heated, dry, water protected area with a minimum temperature of fifty degrees (50) Fahrenheit. All valves shall be stored under roof on wood pedestals, above ground. All insulation shall be stored under roof or in trailers, adequately protected from the weather. The Contractor shall follow all written instructions and recommendations of the manufacturer and all requirements of the Architect in oiling, protection and maintenance of equipment during storage. It shall be the Contractor's complete responsibility for the storage and care of the equipment and materials.

C. If any equipment and/or materials are found to be in poor condition at the time of installation the Architect may, at his discretion, order the Contractor to furnish and install new equipment and/or material at no cost to the Owner.

3.7 COOPERATION WITH OTHER TRADES

A. Mechanical trades shall give full cooperation to other trades and shall furnish in writing, with copies to Architect any information necessary to permit the work of all trades to be installed satisfactorily and with least possible interference or delay. Exact location of all mechanical and equipment, devices, etc. in finished spaces shall be coordinated with Architectural reflected ceiling plans, elevations and details.

3.8 CLEANING AND PAINTING

A. Thoroughly clean all exposed surfaces of equipment and material and leave in a neat, clean condition.

B. Restore and touch-up factory finishes which have been damaged during construction.

3.9 ACCESSIBILITY

A. Equipment shall be installed per manufacturer's recommended clearance guidelines with sufficient space for maintenance personnel service, operate, and maintain equipment.

B. Locate all above ceiling equipment which must be serviced, operated, or maintained, in fully accessible positions to eliminate the need for access panels and doors. Equipment shall include, but not be limited to, valves, clean-outs, motors, controllers, dampers, drain points, etc.

C. Where overhead equipment cannot be located above spaces with either no ceilings or removable acoustical ceiling tiles, contractor shall provide, as part of the contract and no expense to the Owner, fourteen (14) gauge painted steel access doors where required and/or where directed (color shall match ceiling).

1. Access doors shall be Milcor or approved equal to suit material in which installed.
2. Access doors installed in fire rated walls or shafts shall be labeled and shall match rating of the construction.
3. Doors shall be of sufficient size to allow access to all components; minimum size shall be eighteen (18) inches by eighteen (18) inches.
4. Doors in Toilet Rooms and Janitor's Closets shall be Type 304 stainless steel.
5. All doors shall have cylinder locks operable from same key.
6. Submit shop drawings for approval. Locations shall be coordinated with the Architect and indicated on the composite installation and coordination drawings

D. Equipment deemed inaccessible by the Architect shall be reworked by the Contractor at no expense to the Owner.

3.10 EQUIPMENT BASES AND SUPPORTS

A. Concrete bases, curbs, and supports will be furnished and installed under this Division and shall be in accordance with Division 3.

B. The Subcontractors shall furnish, to the General Contractor, all required foundation sizes, bolts, washers, sleeves, plates and templates for equipment.

C. The size of the foundation bolts shall be as recommended by the manufacturer.

D. All equipment shall be set on the foundations, shimmed level with steel shims, and grouted up under base for uniform bearing by the Subcontractor.

E. Under this Section, provide all equipment supports; consisting of inertia pads, platforms, gratings, structural members and related materials required for the mechanical and electrical work.

F. The type and size of the supporting channels and supplementary steel shall be determined by the Subcontractor and shall be of sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.

3.11 MOLD AND CONDENSATION PREVENTION DURING CONSTRUCTION

A. Piping Systems: Cold piping systems shall not be operated prior to insulation and vapor barrier installation in order to prevent condensation on the piping.

B. Air Systems: Air handling systems shall not be operated prior to insulation and vapor barrier installation in order to prevent condensation on the ductwork. Air systems shall not be operated in portions of the building not yet fully enclosed, where systems can be exposed to warm, humid air conditions.

C. Room thermostats shall not be set lower than 74 degrees F.

D. Contractor shall notify the Architect immediately if signs of condensation or mold are discovered.

END OF SECTION 23 05 00

SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, induction motors for use on alternating-current power systems and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

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

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

1.4 SUBMITTALS

A. Shop Drawings and Product Data: Shop drawings and product data for motors shall be provided with the submittal package for the piece of equipment that it serves. In accordance with Division 01, Section “Submittals” provide the following:

1. Product catalog data: nameplate data and ratings; materials of construction; mounting arrangement, size and location of motor terminal box and conduit entry, grounding lugs and coatings.

B. Warranties

1. In addition to the warranty requirements of the General Conditions, warranties for each motor shall be covered in the warranty for the entire mechanical assembly (fan & motor, pump and motor, etc).

C. Manufacturer Seismic Qualification Certification: Submit certification that motors, accessories, and components will withstand seismic forces defined in Division 23, Section "Mechanical Vibration, Sound and Seismic Controls.” Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Operation and Maintenance Data: For factory-installed motors to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain factory-installed motors through one source from a single manufacturer.

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

C. Comply with NFPA 70, "National Electrical Code."

D. NRTL Listing: Motors shall be NRTL-listed.

1. Term "Listed": As defined in "National Electrical Code," Article 100.
2. Listing Agency Qualifications: "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.

E. Comply with NEMA MG 1, "Motors and Generators."

F. Comply with UL 1004, "Motors, Electric."

G. Provide factory test reports in accordance with Part 2 of this Section.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Whenever possible, motor and driven equipment shall be shipped complete as an entire assembly.

B. Inspect equipment immediately upon arrival and any irregularities or damage shall be reported to the Manufacturer/Supplier immediately.

C. Store in accordance with manufacturer’s recommendations.

1.7 IDENTIFICATION

A. Nameplates: All motors shall have a stainless steel nameplate attached with stainless steel fasteners on the motor. The nameplate shall be stamped with nameplate markings listed in NEMA MG 1 20.60, plus the following:

1. Manufacturer
2. Model Number
3. Serial Number
4. Nominal efficiency
5. Minimum efficiency
6. Temperature Rise
7. Bearing manufacturer's name and catalog number

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

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

1. Different ratings, performance, or characteristics for motor are specified in another Section.
2. Motorized-equipment manufacturer requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

C. Contractor assumes responsibility for the correct direction of rotation required by the equipment drives. In the event of damage due to reverse rotation, the equipment shall be repaired or replaced at no charge to the Owner.

D. Motor Bearings: Motor bearings shall be specifically designed for the drive application, and shall be approved by the Engineer. Bearings shall have a minimum bearing life of B-10 or L-10 as defined by the AFBMA. Bearings shall be designed to carry the total hydraulic and static thrust developed by the driven load. Bearings shall be grease or oil lubricated. Oil lubricated motors shall be fitted with gravity-feed oil reservoirs. Grease lubricated bearings shall be regreasable (not sealed) and shall be supplied with grease fittings and drain plugs. Medium voltage and variable frequency controlled motor bearings shall be electrically isolated from the shaft on at least one end to prevent transmission of electric current. Current drain brushes shall be fitted where it is necessary to divert the flow of electrical current from bearings. Bearings, housing and brackets shall be constructed to permit access, removal and replacement of the bearings without disassembly of the motor.

E. Rotor: The rotor shall be dynamically and statically balanced. Assembled motor shall be tested at the factory in accordance with latest applicable NEMA MG 1and IEEE 112 methods of testing, and balanced at no more than 0.001 inches total peak-to-peak

deflection on the bearing housing and the shaft. Overall vibration readings, including all vibration frequencies, shall be taken and recorded at no load and design speed.

F. Terminal Box: Motors shall have a watertight cable terminal box. Terminal box shall be oversized, diagonally split, and rotatable in 90o increments to allow conduit and cable entry from top, bottom and sides.

G. Motor Leads: Motor leads shall be a minimum of 6 inches in length. All motor leads shall be extended from the conduit box. Motors rated over 200 HP or over 600V shall have insulated tin plated copper busbar terminals with bolt holes for compression wire lugs.

H. Drains and Breathers: Provide drain(s) in the bottom of the motor at the lowest point(s). Enclosed motors shall be fitted with breathers.

I. Screens: Provide stainless steel screens at motor ventilation openings.

J. Motor Shaft: The motor shaft shall be ASTM A322 GR140 (AISI 4140) steel and shall be sized to accommodate the required power and torque. Provide shaft end with keyway for connection to coupling with the pump shaft. Coordinate shaft design requirements with driven load.

K. Stainless Steel Hardware: Provide corrosion resistant hardware for motor components including grease fittings, plugs, nuts, bolts, washers and screws.

L. Motor Casing and Coating: Housings shall be degreased, primed and painted both inside and outside with a rust inhibitive primer and corrosion resistant polyester paint. Painting shall be performed prior to installing the motor stator windings. The primer and paint materials selected shall be suitable for the environment encountered, both inside and outside of the casing.

M. Motors connected to Variable Frequency Drives shall be “inverter duty” with additional magnet wire insulation to achieve a minimum motor impulse voltage rating equal to the VFD manufacturer’s recommendations for the motor, cable size, and cable length actually installed.

N. Shaft Grounding Ring: Each motor shaft shall be provided with a Shaft Grounding Ring (SGR) that will provide a reliable low resistance path from the motor shaft to the motor frame to prevent the buildup of destructive high frequency shaft currents that are created by the Pulse Width Modulation of the Variable Frequency Drive units. The SGR shall encircle the shaft and shall be designed to promote efficient discharge of the high frequency shaft currents to the motor frame. The motor frame shall be inherently grounded by design.

O. Power Factor Correction Capacitors: Provide motor power factor correction capacitors for all motors rated 600V or less (except variable frequency controlled motors) with less than 90% uncorrected power factor. Motor power factor correction capacitors shall be sized as recommended by the motor manufacturer to correct the motor power factor to over 90%. Motor power factor correction capacitor sizes shall not be larger than the maximum size recommended by the motor manufacturer. Enclosure type shall be NEMA 12. Capacitors shall be dry film type with fuses and discharge resistors.

P. Composite Factor: Each motor, 1 HP or larger, or motor driven equipment, 1 HP or larger shall have a composite power factor (PF) rating of ninety (90) percent to 100 percent when the driven equipment is operating at the design duty defined on the drawings. Power factor correction devices shall be provided to meet the stated criteria.

Q. Devices such as capacitors, or equipment such as solid state power factor controllers, shall be provided as part of the motor or item of motor driven equipment when required for power factor correction. Devices shall be completely mounted and wired to the motor terminal except as follows:

1. For a motor or motor driven equipment requiring other than across-the-line starting, power factor (PF) correcting capacitors, or other equipment, shall be connected to motor terminals via a contactor (controller) with a 120 volt alternating current (VAC) coil. The 120 volt alternating current (VAC) coil shall be energized via an auxiliary contact on the contactor (controller) used to establish the "run" operating mode for the motor driven equipment.
2. For two (2) speed motors, power factor (PF) shall be corrected at each speed via separate groups of capacitors or other equipment for each speed. Each group of PF correcting components shall be connected to motor terminals via a separate contactor (controller) with a 120 volt alternating current (VAC) coil. Each 120 volt alternating current (VAC) coil shall be energized via an auxiliary contact on the contactor or controller used to establish "run" operations at each speed.

R. Locked rotor kVA shall not exceed NEMA Code Letter F for motors over 10 horsepower.

S. Motors shall have the following enclosure types in accordance with NEMA MG 1:

1. For clean dry indoor areas: open drip proof (ODP) fully-guarded
2. For outdoor locations: totally-enclosed fan-cooled for small and medium machines, weather protected type II for large machines
3. Explosion-proof machines shall be provided for hazardous areas classified in accordance with NFPA 70 (National Electrical Code). Explosion proof motors shall be NRTL-listed for the hazardous area classification.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.

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

C. Motors ½ HP and Larger: Three phase, unless otherwise indicated.

D. Motors Smaller Than ½ HP: Single phase.

E. Frequency Rating: 60 Hz.

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

2.3 POLYPHASE MOTORS

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

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

C. Service Factor: 1.15.

D. Stator: Copper windings, unless otherwise indicated.

1. Multispeed Motors: Separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

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

G. Temperature Rise: One temperature rise one class below the insulation rating class; for example, Class B temperature rise with Class F insulation.

H. Insulation: Class F, unless otherwise indicated.

I. Code Letter Designation:

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

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

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

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

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

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

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

2.5 SINGLE-PHASE MOTORS

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

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

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

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

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

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

PART 3 - EXECUTION

3.1 COMMISSIONING

A. Check operating motors 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.

END OF SECTION 23 05 13

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Sleeves.
   2. Sleeve-seal systems.
   3. Sleeve-seal fittings.
   4. Grout.

B. Related Requirements:
   1. Division 07 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc
   2. CALPICO, Inc
   3. GPT; an EnPro Industries company

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

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

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

2.2 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc
   2. CALPICO, Inc
   3. GPT; an EnPro Industries company
   4. Metraflex Company (The)
   5. Proco Products, Inc
   6. Trumbull Industries

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

2.3 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc
   2. CALPICO, Inc
   3. GPT; an EnPro Industries company
   4. Metraflex Company (The)
   5. Proco Products, Inc
   6. Trumbull Industries

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

2.4 GROUT

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

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

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

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

B. Fasten sleeves securely in floors and walls so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials from being forced into space between pipe and sleeve during construction

C. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

D. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

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

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

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

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

C. Secure nailing flanges to concrete forms.

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

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

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

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

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

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

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. BrassCraft Manufacturing Co.; a Masco company
   2. Dearborn Brass
   3. Keeney Manufacturing Company (The)
   4. Mid-America Fittings, Inc.
   5. ProFlo; a Ferguson Enterprises, Inc. brand

2.2 ESCUTCHEONS

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

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

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

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

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

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

2.3 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install escutcheons on bare piping to be compatible with pipe material:
   1. Copper Piping: Brass
   2. Ferrous Piping: Steel.
   3. Plastic Piping: Steel.
   4. Stainless Steel Piping: Stainless Steel.

C. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
   1. Escutcheons for New Piping and Relocated Existing Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
      b. Chrome-Plated Piping: One-piece or split-plate, with concealed hinge with polished, chrome-plated finish.
      c. Insulated Piping: One-piece or split-plate with concealed hinge with polished, chrome-plated finish.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece or split-plate with concealed hinge with polished, chrome-plated finish.
      e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-plate with concealed hinge with polished, chrome-plated finish.
      f. Bare Piping in Unfinished Service Spaces: One-piece or split-plate with concealed hinge with polished, chrome-plated finish.
      g. Bare Piping in Equipment Rooms: One-piece or split-plate with concealed hinge with polished, chrome-plated finish.
   2. Escutcheons for Existing Piping to Remain:
      a. Chrome-Plated Piping: Split-plate with concealed hinge with polished, chrome-plated finish.

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

D. Install floor plates for exposed piping penetrations of floors in finished areas with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
1. New Piping and Relocated Existing Piping: One-piece, floor plate.
2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 230518

SECTION 230523 - VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Angle valves
   2. Globe valves
   3. Ball valves
   4. Check valves

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

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

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set angle and globe valves closed to prevent rattling.
   4. Set ball valves open to minimize exposure of functional surfaces.

5. Set butterfly valves closed or slightly open.

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles for applications of valves.

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

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

D. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

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

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

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

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

I. Valves in Insulated Piping:
   1. Include 2-inch stem extensions with protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation. For systems operating below 60 deg F, provide extended operating handles of nonthermal-conductive material.
   2. For valves used for throttling or balancing, include memory stops that are fully adjustable after insulation is applied.

2.2 ANGLE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Crane; Crane Energy Flow Solutions
   2. KITZ Corporation

B. Bronze Angle Valves, Class 150:
   1. Description:
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 300 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
      d. Ends: Threaded.
      e. Stem and Disc: Bronze.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron.

2.3 GLOBE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Apollo Flow Controls; Conbraco Industries, Inc.
   2. Crane; Crane Energy Flow Solutions
   3. Hammond Valve
   4. KITZ Corporation
   5. Milwaukee Valve Company
   6. NIBCO INC.
   7. Stockham; Crane Energy Flow Solutions
   8. WATTS
   9. Velan, Inc
   10. Victaulic Company
   11. Vogt

B. Bronze Globe Valves, Class 125:
   1. Description:
      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem and Disc: Bronze.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron.

C. Iron Globe Valves, Class 125:
   1. Description:
      a. Standard: MSS SP-85, Type I.
      b. CWP Rating: 200 psig.
      c. Body Material: ASTM A 126, gray iron with bolted bonnet.
      d. Ends: Flanged.

e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

2.4 BALL VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Apollo Flow Controls; Conbraco Industries, Inc.
2. Crane; Crane Energy Flow Solutions
3. Hammond Valve
4. Jamesbury; Metso
5. KITZ Corporation
6. Milwaukee Valve Company
7. NIBCO INC.
8. Viega
9. WATTS

B. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:
1. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded or soldered.
1) Press joint ends shall be acceptable only if also approved for the associated piping system connections.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.
k. Handle: Steel, coated lever.

C. Steel Ball Valves, Three-Piece with Full Port Stainless-Steel Trim, Class 300:
1. Description:
a. Standard: MSS SP-110.
b. CWP Rating: 1000 psig.
c. Body Design: Three piece.
d. Body Material: Carbon steel, ASTM A 216, Type WCB, Phosphate Coated.
e. Ends: Threaded or Welded.
f. Seats: Reinforced PTFE 15% glass.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Full.
j. Handle: Steel, coated lever, lockable.

2.5 CHECK VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Apollo Flow Controls; Conbraco Industries, Inc.
   2. Crane; Crane Energy Flow Solutions
   3. Hammond Valve
   4. KITZ Corporation
   5. Milwaukee Valve Company
   6. NIBCO INC.
   7. Stockham; Crane Energy Flow Solutions
   8. WATTS
   9. Velan, Inc
   10. Victaulic Company
   11. Vogt

B. Bronze Swing Check Valves with Bronze Disc, Class 125:
   1. Description:
      a. Standard: MSS SP-80, Type 3.
      b. CWP Rating: 200 psig.
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B 62, bronze.
      e. Ends: Threaded.

C. Iron Swing Check Valves with Metal Seats, Class 125:
   1. Description:
      a. Standard: MSS SP-71, Type I.
      b. CWP Rating: 200 psig.
      c. Body Design: Clear or full waterway.
      d. Body Material: ASTM A 126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

A. Valves shall be provided where indicated on the drawings and as herein specified.

B. Install shut-off valves in piping where shown and where listed below:
   1. To isolate all items of equipment.
   2. To isolate motorized flow control valves.
   3. To isolate branch lines and riser at mains.

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

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

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

F. Install valves in position to allow for handwheel operation, full stem movement and stuffing maintenance.

G. Install chainwheels on operators for globe valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

H. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.

I. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Throttling Service: Globe valves.

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

C. Select valves with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
   3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
   6. For Steel Piping, NPS 5 and Larger: Flanged ends.
   7. For Grooved-End Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Globe Valves:
   1. Pipe NPS 2 and Smaller: Bronze globe valves, Class 125, bronze disc, with threaded ends.

B. Ball Valves:
   1. Pipe NPS 2 and Smaller: Bronze ball valves, two piece, with full port and stainless-steel trim.
      a. Valves may be provided with solder-joint ends instead of threaded ends.

C. Check Valves:
   1. Pipe NPS 2 and Smaller: Bronze swing check valves with bronze disc, Class 125.
      a. May be provided with solder-joint ends instead of threaded ends.

3.6 HEATING-WATER VALVE SCHEDULE

A. Globe Valves:
   1. Pipe NPS 2 and Smaller: Bronze globe valves, Class 125, bronze disc, with threaded ends.

B. Ball Valves:
   1. Pipe NPS 2 and Smaller: Bronze ball valves, two piece, with full port and stainless-steel trim.
      a. Valves may be provided with solder-joint ends instead of threaded ends.

C. Check Valves:
   1. Pipe NPS 2 and Smaller: Bronze swing check valves with bronze disc, Class 125.
      a. May be provided with solder-joint ends instead of threaded ends.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

B. Related Requirements:
   1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
   3. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Pipe stands.
   3. Equipment supports.

1.4 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Hot-dip galvanized or electro-galvanized.
   3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

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

C. Copper Pipe and Tube Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.3 TRAPEZE PIPE HANGERS

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

2.4 THERMAL HANGER-SHIELD INSERTS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Pipe Shields Inc or comparable product by one of the following:
   1. Carpenter & Paterson, Inc
   2. Clement Support Services

3. ERICO International Corporation
4. Insulation Components, Inc.
5. National Pipe Hanger Corporation
6. Pipe Shields Inc.
7. Piping Technology & Products, Inc
8. Rilco Manufacturing Co., Inc

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

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

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

E. For Clevis or Band Hangers: Insert shall cover entire circumference of pipe. Shield shall cover lower 180 degrees of pipe.

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

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hilti, Inc.
      b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
      c. MKT Fastening, LLC
      d. Simpson Strong-Tie Co., Inc.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. B-line, an Eaton business
      b. Hilti, Inc.
      c. ITW Ramset/Red Head; Illinois Tool Works, Inc.
      d. MKT Fastening, LLC
   2. Indoor Applications: Zinc-coated or stainless steel.
   3. Outdoor Applications: Stainless steel.

C. Per IBC Section 1912 and ACI 318 Appendix D, all concrete anchors within the scope of ACI 318 require approved anchors for crack concrete. Attachment devices shall have certified load test data from an independent test laboratory and shall be capable

of carrying a minimum of five times the design load. The concrete anchors for the following supported items need to meet the crack concrete requirements:

1. Any suspended pipe, larger than 2", regardless of material.
2. All components with an Ip 1.5.
3. All components required to function after a seismic event.
4. Anywhere required by ASCE 7.
5. All suspended HVAC and air distribution equipment, including air handling units, supply air terminal units, fan coil units and fans.

2.6 MATERIALS

A. Aluminum: ASTM B 221.

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

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

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

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

F. Grout: ASTM C 1107/C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

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

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported operating components with a design safety factor of not less than five.

3.2 HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
   3. The use of cable ties, zip ties and/or tie wraps for attaching piping to metal trapeze pip-hanger is prohibited. Provide appropriate strut clamps, brackets and/or similar attachments to properly secure piping to trapeze pipe-hangers.

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

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

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

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

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

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

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

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

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

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

M. Insulated Piping:
1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 2-1/2 and Larger: Include thermal hanger shield inserts of length at least as long as protective shield. Insert thickness shall be the same thickness as piping insulation. Fill interior voids with insulation that matches adjoining insulation and seal as appropriate.

N. In no case shall wire or perforated strap be used for pipe or conduit support.

3.3 METAL FABRICATIONS

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

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

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-inch.

3.5 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

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

3.6 HANGER AND SUPPORT SCHEDULE

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

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

C. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications with field-applied finish.

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

E. Use hot dip galvanized pipe hangers and stainless-steel attachments for exterior applications. Zinc plated hangers and attachments are not acceptable for exterior use.

F. Use stainless-steel pipe hangers and stainless-steel attachments for corrosive environment applications. Zinc plated hangers and attachments are not acceptable for corrosive use.

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

H. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

L. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

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

N. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
   3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
   4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
   5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
   6. C-Clamps (MSS Type 23): For structural shapes.
   7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
   8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
   9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
   10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
   11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
   12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
      a. Light (MSS Type 31): 750 lb.
      b. Medium (MSS Type 32): 1500 lb.
      c. Heavy (MSS Type 33): 3000 lb.
   13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
   14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
   15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

O. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

P. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
   2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
   3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
   4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
   5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
   6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
   7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
   8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
      a. Horizontal (MSS Type 54): Mounted horizontally.
      b. Vertical (MSS Type 55): Mounted vertically.
      c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

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

END OF SECTION 230529

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. The International Building Code and ASCE/SEI 7 Standard apply to all work associated with the seismic installation of all new mechanical piping and equipment. Refer to Structural drawings and ASCE/SEI 7 for seismic and wind loads and additional information.

1.2 SUMMARY

A. Section Includes:
1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Elastomeric hangers.
5. Spring hangers.
6. Snubbers.
7. Restraints - rigid type.
8. Restraints - cable type.
9. Restraint accessories.
10. Post-installed concrete anchors.
11. Concrete inserts.
12. Vibration isolation equipment bases.
13. Restrained isolation roof-curb rails.

B. Related Requirements:
1. Section 220548 "Vibration and Seismic Controls for Plumbing" for devices for plumbing equipment and systems.

1.3 DEFINITIONS

A. ASCE/SEI: American Society of Civil Engineers/Structural Engineering Institute

B. IBC: International Building Code.

C. ICC-ES: ICC-Evaluation Service.

D. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   2. Include load rating for each wind-force-restraint fitting and assembly.
   3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic- and wind-force-restraint component.
   4. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction.
   5. Annotate to indicate application of each product submitted and compliance with requirements.
   6. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
   1. Detail fabrication and assembly of equipment bases.
   2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal:
   1. For each seismic-restraint and wind-load protection device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, concrete anchor and insert, and restrained isolation roof-curb rail that is required by this Section or is indicated on Drawings, submit the following:
      a. Seismic and Wind-Load Restraint, and Vibration Isolation Base Selection: Select vibration isolators, seismic and wind-load restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.
      b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.
      c. Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
      d. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
      e. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
      f. Qualified Professional Engineer: All designated-design submittals for seismic- and wind-restraint calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.

2. Seismic- and Wind-Restraint Detail Drawing:
   a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.
3. All delegated-design submittals for seismic- and wind-restraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.
4. Product Listing, Preapproval, and Evaluation Documentation: By an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and basis for approval (tests or calculations).
5. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
6. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For professional engineer and testing agency.

B. Welding certificates.

C. Field quality-control reports.

D. Seismic Qualification Data: Provide special certification for designated seismic systems as indicated in ASCE/SEI 7 Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.
   1. Provide equipment manufacturer's written certification for each designated active mechanical seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270, including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction or experience data as permitted by ASCE/SEI 7.
   2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7.
   3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.

E. Wind-Force Performance Certification: Provide special certification for HVAC components subject to high wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-force performance certification.
   1. Provide equipment manufacturer's written certification for each designated HVAC device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.
   2. Provide manufacturer's written certification for each designated louver, damper, or similar device, stating that it will remain in place and protect opening from penetration of windborne debris and comply with all requirements of authorities having jurisdiction.
   3. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-spring isolators and restrained-air-spring isolators to include in operation and maintenance manuals.

B. Manufacturer’s Inspection Report: Contractor shall submit factory-authorized service representative’s final report indicating all restraints and isolation devices as being properly installed or requiring correction.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7, and be acceptable to authorities having jurisdiction.

B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic- and Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.

1.8 COORDINATION

A. Coordinate with vibration isolation restraint manufacturer and the structural contractor/engineer of record to locate and size structural supports underneath vibration isolated restrained equipment (e.g. roof curbs, cooling towers, chillers and other similar equipment).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic and wind- load control system.
   1. Seismic and Wind-Load Performance: Equipment shall withstand the effects of earthquake motions and high wind events determined in accordance with ASCE/SEI 7.

B. Seismic Design Calculations:
   1. Perform calculations to obtain force information necessary to properly select seismic-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to is the currently adopted edition.
      a. Data indicated below to be determined by Delegated-Design Contractor must be obtained by Contractor and must be included in individual component submittal packages.
      b. Coordinate seismic design calculations with wind-load calculations for equipment mounted outdoors. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.

C. Wind-Load Design Calculations:
   1. Perform calculations to obtain force information necessary to properly select wind-load-restraint devices, fasteners, and anchorage. Perform calculations using methods acceptable to applicable code authorities and as presented in ASCE/SEI 7. Where "ASCE/SEI 7" is used throughout this Section, it is to be understood that the edition referred to is the currently adopted edition.
      a. Data indicated below that are specific to individual pieces of equipment must be obtained by Contractor and must be included in individual component submittal packages.
      b. Coordinate design wind-load calculations with seismic load calculations for equipment requiring both seismic and wind-load reinforcement. Comply with requirements in other Sections in addition to those in this Section for equipment mounted outdoors.

D. Fire/Smoke Resistance: Seismic- and wind-load-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.

E. Component Supports:
   1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
   2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7.

2.2 GENERAL

A. Select vibration isolating units for the lowest operating speed of equipment, so designed that natural frequency of equipment and base mass is not less than 1.5 times the lowest operating frequency of the moving equipment, but not a multiple or harmonic of the base frequency. Furnish vibration isolation producing a uniform loading and deflection even when equipment weight is not evenly distributed, vibration isolation shall be stable during starting and stopping of equipment without excessive traverse and eccentric movement of equipment.

B. The installed vibration isolation system for each floor or ceiling mounted item of equipment shall have a maximum lateral motion under equipment start up and shut down conditions of 1/4 inch. Motions in excess shall be restrained by approved spring type mounting.

C. The type of isolation, base, and minimum static deflection shall be as required for each specific equipment application, but not less than that specified herein when supported on a solid concrete structural slab having a thickness of not less than four (4) inches.
   1. Should vibration isolators installed for the equipment prove inadequate to prevent transmission of equipment vibrations to the building structure or limit equipment vibration originated noise in the building spaces to acceptable levels, the isolators shall be replaced with units having the largest deflection that can be practicably installed.

D. All springs installed out-of-doors shall be cadmium-plated, zinc electroplated or powder-coated after fabrication. Hardware and other metal parts shall be cadmium-plated or galvanized. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14.

E. All isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.

2.3 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. California Dynamics Corporation
      b. Isolation Technology, Inc
      c. Kinetics Noise Control, Inc.
      d. Mason Industries, Inc.
      e. The VMC Group
      f. Vibration Eliminator Co., Inc.
      g. Vibration Isolation Co., Inc.
      h. Vibration Mountings & Controls/Korfund.
      i. Vibro-Acoustics, Inc.
   2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
   3. Size: Factory or field cut to match requirements of supported equipment.
   4. Pad Material: Oil and water resistant with elastomeric properties.

5. Surface Pattern: Waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.

2.4 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. California Dynamics Corporation
      b. Isolation Technology, Inc
      c. Kinetics Noise Control, Inc.
      d. Mason Industries, Inc.
      e. The VMC Group
      f. Vibration Eliminator Co., Inc.
      g. Vibration Isolation Co., Inc.
      h. Vibration Mountings & Controls/Korfund.
      i. Vibro-Acoustics, Inc.
   2. Mounting Plates:
      a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
      b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
   3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. California Dynamics Corporation
      b. Isolation Technology, Inc
      c. Kinetics Noise Control, Inc.
      d. Mason Industries, Inc.
      e. The VMC Group
      f. Vibration Eliminator Co., Inc.
      g. Vibration Isolation Co., Inc.
      h. Vibration Mountings & Controls/Korfund.
      i. Vibro-Acoustics, Inc.
   2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
      a. Housing: Cast-ductile iron or welded steel.
      b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.6 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. California Dynamics Corporation
      b. Isolation Technology, Inc
      c. Kinetics Noise Control, Inc.
      d. Mason Industries, Inc.
      e. The VMC Group
      f. Vibration Eliminator Co., Inc.
      g. Vibration Isolation Co., Inc.
      h. Vibration Mountings & Controls/Korfund.
      i. Vibro-Acoustics, Inc.
   2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
   3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.7 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. California Dynamics Corporation
      b. Isolation Technology, Inc
      c. Kinetics Noise Control, Inc.
      d. Mason Industries, Inc.
      e. The VMC Group
      f. Vibration Eliminator Co., Inc.
      g. Vibration Isolation Co., Inc.
      h. Vibration Mountings & Controls/Korfund.
      i. Vibro-Acoustics, Inc.
   2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod (where required).

9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.8 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Kinetics Noise Control, Inc
   2. Mason Industries, Inc.
   3. Novia; A Division of C&P
   4. Vibration Mountings & Controls, Inc

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
   1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be seismically prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318.
   2. Preset Concrete Inserts: Seismically prequalified in accordance with ICC-ES AC446 testing.
   3. Anchors in Masonry: Design in accordance with TMS 402.
   4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
   5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.9 RESTRAINTS - RIGID TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business
   2. California Dynamics Corporation
   3. Hilti, Inc.
   4. Mason Industries, Inc.
   5. Unistrut; Part of Atkore International

B. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.10 RESTRAINTS - CABLE TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Gripple Inc.
   2. Kinetics Noise Control, Inc.
   3. Mason Industries, Inc.
   4. Novia; A Division of C&P
   5. Vibration & Seismic Technologies, LLC

6. Vibration Mountings & Controls, Inc.

B. Seismic-Restraint Cables: ASTM A603 galvanized-steel or ASTM A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

C. Restraint cable assembly with cable fittings must comply with ASCE/SEI 19. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.11 RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Novia; A Division of C&P
5. TOLCO
6. Vibration & Seismic Technologies, LLC

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.12 POST-INSTALLED CONCRETE ANCHORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Simpson Strong-Tie Co., Inc.
5. Unistrut; Atkore International.

B. Mechanical Anchor Bolts:

1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

C. Adhesive Anchor Bolts:
1. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

D. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7, Ch. 13.
1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

2.13 CONCRETE INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Simpson Strong-Tie Co., Inc.
5. Unistrut; Atkore International.

B. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC466 testing.

C. Comply with ANSI/MSS SP-58.

2.14 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. California Dynamics Corporation
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Novia; A Division of C&P
5. The VMC Group
6. Vibration Eliminator Co., Inc
7. Vibration Isolation
8. Vibration Mountings & Controls, Inc

B. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.
   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Concrete Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   a. Include supports for suction and discharge elbows for pumps.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.15 RESTRAINED ISOLATION ROOF-CURB RAILS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. California Dynamics Corporation
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Novia; A Division of C&P
5. The VMC Group
6. Thybar Corporation

B. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

C. Upper Frame: The upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces.

D. Lower Support Assembly: The lower support assembly shall be formed sheet metal section containing adjustable and removable steel springs that support the upper frame. The lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

G. Acoustical Barrier: The floating member of the roof curb shall have a perimeter angle cross members to support two layers of 5/8" waterproof sheetrock laid on with staggered joints. Sheetrock must surround ducts to provide a continuous sound break. This acoustical barrier shall be caulked to minimize sound transmission between the rooftop air handling unit and the building. Where the mechanical arrangement makes attachment to the floating member unfeasible, the barrier shall be attached at the highest practical elevation of the fixed curb with provision for 1" thick closed cell neoprene flexible seals around any ductwork. A 4-inch layer of 1.5 density fiberglass shall cover the entire solid roof surface under the unit. Ductwork shall be externally lined with sound absorbent material coated with a dampening compound such as Mason Industries MDC-10 or approved equal. Complete instructions shall be provided by the spring isolation curb manufacturer. Acoustical package shall be Mason Industries, Inc. Type RSC-dB or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction.

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

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

3.3 INSTALLATION OF VIBRATION-CONTROL, WIND-LOAD CONTROL, AND SEISMIC-RESTRAINT DEVICES

A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Devices Schedules, where indicated on Drawings, or where Specifications indicate they are to be installed on specific equipment and systems.

B. Provide seismic-restraint and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Seismic-Restraint Devices Schedules, where indicated on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

C. Housekeeping Pads:
   1. All floor-mounted equipment shall be set on concrete housekeeping pads designed by the seismic engineer to meet the specific seismic requirements of each piece of floor mounted equipment.
   2. Housekeeping pads shall rest on a structural floor and be constructed per the details provided by the seismic engineer.
   3. Housekeeping pad shall be constructed as one continuous monolithic pour. Forms shall be constructed to allow removal after concrete pour without prying against pad.

D. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

E. Installation of vibration isolators, wind-load restraints, must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

F. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

G. Equipment Restraints:
   1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint, and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

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

I. Install seismic- and wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.

J. Equipment Bases:
1. Fill concrete inertia bases, after installing base frame, with 3000-psi concrete; trowel to a smooth finish.
   a. Cast-in-place concrete materials and placement requirements are specified in Division 3.
2. Concrete Bases: Anchor equipment to concrete base according to supported equipment manufacturer's written instructions for seismic codes at Project site.
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
   b. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use Setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
   e. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
   f. Cast-in-place concrete materials and placement requirements are specified in Division 3.

K. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction that provides required submittals for component.

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

M. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

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

O. Mechanical Anchor Bolts:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Provide flexible connections in piping systems where they cross structural seismic joints, expansion joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in other sections for piping flexible connections.

3.5 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

A. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Coordinate dimensions of steel equipment rails and bases, concrete inertia bases, and restrained isolation roof-curb rails with requirements of isolated equipment specified in this and other Sections. Where dimensions of these bases are indicated on Drawings, dimensions may require adjustment to accommodate actual isolated equipment.

3.6 ADJUSTING

A. Adjust isolators after system is at operating weight.

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

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:
   1. Perform tests and inspections with the assistance of a factory-authorized service representative.
   2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   3. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
   4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
   5. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
   6. Test to 90 percent of rated proof load of device.
   7. Measure isolator restraint clearance.
   8. Measure isolator deflection.
   9. Verify snubber minimum clearances.

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

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare testing agency test and inspection reports.

F. Manufacturer’s Inspection:
   1. A representative of the isolation materials manufacturer shall inspect the completed system and report in writing any installation errors, improperly selected isolation or restraint devices, or other faults that could affect the performance of the system.
   2. Contractor shall submit manufacturer's representative’s final report indicating all isolation as being properly installed or requiring correction. If corrections are required, include steps to be taken to properly complete the isolation work.

3.8 VIBRATION ISOLATION AND SEISMIC-RESTRAINT SCHEDULE

A. Rooftop Air-Handling Units:
   1. Isolation Type: Restrained Isolation Roof-Curb
   2. Base Deflection: 1.5”

B. Fans in Air-Handling Units:
   1. Isolation Type: Restrained-Spring Isolator
   2. Base Deflection: 1.5”
   3. Base Type: Concrete Inertia Base.
   4. Remarks: Thrust Restraints.

C. Roof Mounted Fans:
   1. Isolation Type: Restrained Isolation Roof-Curb Rail
   2. Base Deflection: 1.5”

D. Suspended Fan Coil Units:
   1. Isolation Type: Spring Hanger
   2. Deflection: 0.5”

E. First Four (4) Pipe Hangers near Isolated Equipment:
   1. Isolation Type: Spring Hanger
   2. Deflection:
      a. Piping 3-inches and smaller: 0.75”
      b. Piping 4-inches to 6-inches: 1.5”
      c. Piping Larger than 6-inches: 2.5”

END OF SECTION 230548

SECTION 230550 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFDs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. Related Requirements:
   1. Section 230513 “Common Motor Requirements for HVAC Equipment.”
   2. Section 230900 “Building Automation and Temperature Control System.”

1.3 SCOPE

A. Air handling unit VFDs shall be furnished and installed by the air handling unit manufacturer.

B. Power wiring for VFDs shall be provided under Division 26.

1.4 DEFINITIONS

A. BAS: Building Automation System.

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. LCD: Liquid-crystal display.

F. LED: Light-emitting diode.

G. OCPD: Overcurrent protective device.

H. PID: Control action, proportional plus integral plus derivative.

I. RFI: Radio-frequency interference.

J. VFD: Variable-frequency drive.

1.5 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFD indicated.
   1. Include dimensions and finishes for VFDs.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFD indicated.
   1. Include mounting and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Variable frequency drives shall be included in the development of the Coordination and Installation Drawings, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Required working clearances and required area above and around VFDs.
   2. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements.
   3. Show support locations, type of support, and weight on each support.
   4. Indicate field measurements.

B. Seismic Qualification Data: Certificates, for each VFD, accessories, and components, from manufacturer.
   1. Certificate of compliance.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

C. Product Certificates: For each VFD from manufacturer.

D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

E. Sample Warranty: For special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
   b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
   c. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
   d. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.8 DELIVERY, STORAGE, AND HANDLING

A. VFDs should be delivered, stored and handled in a manner that protects them from damage, moisture, dirt and intrusion of foreign materials.

B. Store VFDs indoors in clean, dry space with uniform temperature to prevent condensation. Maximum ambient temperature for storage shall be -40 to 120 degrees Fahrenheit.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Inc.
   2. Danfoss Inc.
   3. Yaskawa Electric America, Inc.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFDs:
   1. VFDs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

B. Application: Variable torque.

C. VFD Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
   1. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
   2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans and blowers; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage (not applicable to fan arrays).
   1. For fan arrays, output rating shall match fan array motor selection.

F. Unit Operating Requirements:
   1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.
   2. Input AC Voltage Unbalance: Not exceeding 5 percent.
   3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
   4. Minimum Efficiency: 96 percent at 60 Hz, full load.
   5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
   6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
   7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F. Operating up to 122 degF shall be possible with 10 percent de-rating if required.
   8. Humidity Rating: Less than 95 percent (noncondensing).
   9. Altitude Rating: Not exceeding 3300 feet.
   10. Vibration Withstand: Comply with NEMA ICS 61800-2.
   11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
   12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
   13. Output Carrier Frequency: Selectable; 0.5 to 12 kHz.
   14. Stop Modes: Programmable; includes fast, free-wheel, and dc coast or ramp to stop.

G. Isolated Control Interface: Allows VFDs to follow remote-control signal over a minimum 4:1 speed range.
   1. Signal: Electrical.

H. Internal Adjustability Capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.
   3. Acceleration: 0.1 to 999.9 seconds.
   4. Deceleration: 0.1 to 999.9 seconds.

5. Current Limit: 30 to minimum of 110 percent of maximum rating.

I. Self-Protection and Reliability Features:
1. Surge Suppression: Factory installed as an integral part of the VFD, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFD and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection (drive and bypass mode).
9. Short-circuit protection.
10. Motor-overtemperature fault.

J. Automatic Reset/Restart: Attempt five restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

K. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

L. Integral Input Disconnecting Means and OCPD:
1. VFDs With a Bypass System:
a. UL 489, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.
b. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFD input current rating, whichever is larger.
2. VFDs Without a Bypass System:
a. NEMA KS 1, fusible switch with pad-lockable, door-mounted handle mechanism.
b. Disconnect Rating: Not less than 115 percent of VFD input current rating.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFDs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFDs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.
1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 CONTROLS AND INDICATION

A. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
   1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
   2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
      a. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.

B. Historical Logging Information and Displays:
   1. Real-time clock with current time and date and battery backup.
   2. Running log of total power versus time.
   3. Total run time.
   4. Fault log, maintaining last three faults with time and date stamp for each.

C. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFD door and connected to display VFD parameters including, but not limited to:
   1. Output frequency (Hz).
   2. Motor speed (rpm).
   3. Motor status (running, stop, fault).
   4. Motor current (amperes).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. PID feedback signal (percent).
   8. DC-link voltage (V dc).
   9. Set point frequency (Hz).
   10. Motor output voltage (V ac).

D. Control Signal Interfaces:
   1. Electric Input Signal Interface:
      a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
      b. A minimum of six multifunction programmable digital inputs.
   2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS system for HVAC or other control systems:
      a. 0- to 10-V dc.
      b. 4- to 20-mA dc.
      c. Fixed frequencies using digital inputs.
   3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:
      a. Output frequency (Hz).
      b. Output current (load).
      c. DC-link voltage (V dc).
      d. Motor torque (percent).

e. Motor speed (rpm).
f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

E. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans for pressure, flow, or temperature regulation.
   1. Number of Loops: Two.

F. Interface with BAS System for HVAC: Factory-installed hardware and software shall interface with BAS system for HVAC to monitor, control, display, and record data for use in processing reports. VFD settings shall be retained within VFD's nonvolatile memory.
   1. Hardwired Points:
      a. Monitoring: On-off status.
      b. Control: On-off operation.
   2. Communication Interface: The standard protocols shall be Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet. Communication shall interface with BAS system for remotely control and monitor from an operator workstation. Control features and monitoring points displayed locally at control panel shall be available through the BAS system and mapped to graphical user interfaces.

2.5 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations. Provide minimum 5 percent impedance AC line reactor or DC bus chokes of equivalent impedance.

B. Output Filtering: For separation between motor and VFD of greater than 100 feet, provide dV/dT filters.

C. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for the First Environment restricted level (Category C2).

2.6 OPTIONAL FEATURES

A. Damper control circuit with end-of-travel feedback capability.

B. Communication Port: RJ-45 port.

2.7 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.
   1. Dry and Clean Indoor Locations: Type 1.
   2. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12:
   3. Outdoor Locations: Type 4X.
   4. Wash-Down Areas: Type 4X, stainless steel.
   5. Other Wet or Damp Indoor Locations: Type 4.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as "Plenum Rated."

2.8 ACCESSORIES

A. Phase-Failure: Solid-state sensing circuit with isolated output contacts for hard-wired connections.

B. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

C. Programming Tools: To support the drive's life cycle from startup and monitoring, to backup, and performance tuning.

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to manufacturers' standard procedures and in accordance with ISO 9001, latest revision.
   1. Test each VFD while connected to a full motor load that is comparable to that for which the VFD is rated, at rated drive amperes at 105 degrees Fahrenheit in a temperature chamber.
   2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Test and inspection reports shall be available upon request.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

3.2 INSTALLATION

A. Roof-Mounting Controllers: Install VFD on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

B. Seismic Bracing: Comply with requirements specified in Section 260548 "Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Comply with NECA 1.

E. Controllers shall be located so that door can be fully opened without interference.

3.3 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Section 230553 “Identification for HVAC Piping and Equipment."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each VFD with engraved nameplate.
   3. Label each enclosure-mounted control and pilot device.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Inspect VFD, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
   3. Test continuity of each circuit.
   4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).
   5. Test each motor for proper phase rotation.
   6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   8. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFDs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges.

E. Set field-adjustable pressure switches.

F. All field adjustments shall be recorded and kept in cabinet with drawings.

3.7 STORAGE AND PROTECTION

A. Replace VFDs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFDs.

END OF SECTION 230550

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Warning tape.
   4. Pipe labels.
   5. Duct labels.
   6. Stencils.
   7. Valve tags.
   8. Underground Warning Labels.
   9. Warning tags.

1.3 ACTION SUBMITTALS

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

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Pipe Label Schedule: Include a listing of all piping to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals. Include Service Abbreviation, Number Sequence, Valve Location and Valve Function.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

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

a. Brady Corporation
b. Brimar Industries, Inc.
c. Carlton Industries, LP
d. Craftmark Pipe Markers
e. Kolbi Pipe Marker Co.
f. LEM Products Inc.
g. Seton Identification Products

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
3. Letter and Background Color: As indicated for specific application under Part 3.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 4 by 2-1/2 inch.
6. Minimum Letter Size: 3/4 inch.
7. Fasteners: Stainless-steel rivets or self-tapping screws, or double face adhesive.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number as indicated on the mechanical drawings and schedules.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation
2. Brimar Industries, Inc.
3. Carlton Industries, LP
4. Craftmark Pipe Markers
5. Kolbi Pipe Marker Co.
6. LEM Products Inc.
7. Seton Identification Products

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.

C. Letter and Background Color: As indicated for specific application under Part 3.

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

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

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

G. Fasteners: Stainless steel rivets or self-taping screws.

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

I. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA70E and other applicable codes and standards.

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

2.3 WARNING TAPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation
   2. Brimar Industries, Inc.
   3. Carlton Industries, LP
   4. Craftmark Pipe Markers
   5. Kolbi Pipe Marker Co.
   6. LEM Products Inc.
   7. Seton Identification Products

B. Material: Vinyl.

C. Minimum Thickness: 0.005 inch.

D. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.

E. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.

F. Maximum Temperature: 160 deg F.

G. Minimum Width: 4 inches.

2.4 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation
   2. Brimar Industries, Inc.
   3. Carlton Industries, LP
   4. Craftmark Pipe Markers
   5. Kolbi Pipe Marker Co.
   6. LEM Products Inc.
   7. Seton Identification Products

B. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

C. Letter and Background Color: As indicated for specific application under Part 3.

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

E. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

F. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
   1. Pipe size.
   2. Flow-Direction Arrows: Include flow-direction arrows on distribution piping. Arrows may be either integral with label or applied separately.
   3. Lettering Size: [Size letters in accordance with ASME A13.1 for piping.

2.5 DUCT LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation
   2. Brimar Industries, Inc.
   3. Carlton Industries, LP
   4. Craftmark Pipe Markers
   5. Kolbi Pipe Marker Co.
   6. LEM Products Inc.
   7. Seton Identification Products

B. Self-Adhesive Labels: Printed vinyl plastic with contact-type, permanent-adhesive backing.
   1. Ducts up to 24”: Minimum of 2-1/2” x 16” and has a letter size of 1-1/2”.
   2. Ducts Larger than 24”: Minimum of 4” x 24” and has a letter height of 2-1/2”.

C. Letter and Background Color: As indicated for specific application under Part 3.

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

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

F. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:
   1. Duct size.
   2. Flow-Direction Arrows: Include flow-direction arrows on distribution ducts. Arrows may be either integral with label or may be applied separately.
   3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

2.6 STENCILS

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

a. Brimar Industries, Inc.
b. Carlton Industries, LP
c. Champion America
d. Craftmark Pipe Markers
e. Kolbi Pipe Marker Co.
f. Marking Sevices Inc.

2. Lettering Size:
   a. Ducts up to 24": 1-1/2".
   b. Ducts Larger than 24": 2-1/2".
3. Stencil Material: Fiberboard or metal.
4. Stencil Paint: Exterior, gloss, Enamel. Paint may be in pressurized spray-can form.
5. Identification Paint: Exterior, Enamel. Paint may be in pressurized spray-can form.
6. Letter and Background Color: Color as indicated for specific application under Part 3.

2.7 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation
   2. Brimar Industries, Inc.
   3. Carlton Industries, LP
   4. Craftmark Pipe Markers
   5. Kolbi Pipe Marker Co.
   6. LEM Products Inc.
   7. Seton Identification Products

B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.04-inch or anodized aluminum, 0.031-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass link chain or beaded chain.

C. Letter and Background Color: As indicated for specific application under Part 3.

D. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Include valve-tag schedule in operation and maintenance data..

2.8 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Brady Corporation
   2. Brimar Industries, Inc.

3. Carlton Industries, LP
4. Craftmark Pipe Markers
5. Kolbi Pipe Marker Co.
6. LEM Products Inc.
7. Seton Identification Products

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

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 INSTALLATION, GENERAL REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

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

D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

A. Permanently fasten labels on each item of mechanical equipment.

B. Sign and Label Colors:
1. White letters on an ANSI Z535.1 safety-blue background.

C. Locate equipment labels where accessible and visible.

D. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

E. For equipment located above the ceiling, in addition to a label on the equipment, labels are to be permanently affixed to the ceiling grid framing as near to the item as possible using epoxy glue. Where hard ceilings are used, the label is to be affixed to the frame of the access panel for the unit.
   1. The thermostat that controls each piece of equipment shall be identified with an identical but appropriately sized label.

3.4 PIPE COLOR CODING

A. Paint exposed and insulated piping in finished areas and mechanical rooms.
   1. Finished Areas: Color shall be the same as the adjacent surface. Color by Architect.
   2. Mechanical Rooms: Color shall be the same as the pipe label background color.
   3. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
   4. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Exterior non-insulated piping shall be painted with two coats of rust inhibitive paint. Colors shall be approved by the Owner after a sample is provided for each service. Do not paint aluminum jackets.

C. Do not paint exposed copper piping or galvanized piping.

D. Do not paint aluminum or stainless-steel jackets.

E. Painting of piping is specified in Division 09.

3.5 INSTALLATION OF PIPE LABELS

A. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

B. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Within 3 ft. of each valve and control device.
   2. At access doors, manholes, and similar access points that permit view of concealed piping.
   3. Within 3 ft. of equipment items and other points of origination and termination.
   4. Within 3 ft. above and below every floor penetration and on either side of every wall penetration.
   5. At least one pipe marker per pipe in every room.
   6. Spaced at maximum intervals of 20 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping, ductwork, and equipment.

C. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

D. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

E. Pipe Label Color Schedule:

1. Chilled-Water Piping:
   a. Background: Safety green.
   b. Letter Colors: White.
   c. Designation: CHILLED WATER SUPPLY, CHILLED WATER RETURN
2. Heating Water Piping:
   a. Background: Safety green.
   b. Letter Colors: White.
   c. Designation: HEATING WATER SUPPLY, HEATING WATER RETURN
3. Air Conditioning Condensate Piping:
   a. Background: Safety green.
   b. Letter Colors: White.
   c. Designation: AC CONDENSATE

3.6 INSTALLATION OF DUCT LABELS

A. Install self-adhesive duct labels showing service and flow direction with permanent adhesive on air ducts.

1. Provide labels in the following color codes:
   a. For outside-air and supply-air ducts: White letters on blue background.
   b. For relief-air and return-air ducts: White letters on green background.
   c. For exhaust-air ducts: White letters on yellow background.

B. Stenciled Duct-Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

C. Locate label near each point where ducts enter into and exit from concealed spaces and at maximum intervals of 20 ft. where exposed or are concealed by removable ceiling system.

3.7 INSTALLATION OF VALVE TAGS

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.

B. Ceiling valve markers shall be provided for valves above ceilings. Attach valve marker to ceiling grid directly below the valve.

3.8 INSTALLATION OF WARNING TAGS

A. Warning Tag Color: Black letters on an ANSI Z535.1 safety-yellow background.

B. Attach warning tags, with proper message, to equipment and other items where indicated on Drawings, scheduled or required.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Testing, Adjusting, and Balancing of Air Systems:
      a. Constant-volume air systems.
      b. Dual-duct systems.
      c. Variable-air-volume systems.
      d. Multizone systems.
      e. Induction-unit systems.
   2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:
      a. Constant-flow hydronic systems.
      b. Variable-flow hydronic systems.
      c. Primary-secondary hydronic systems.
   3. Testing, adjusting, and balancing of fuel oil systems for HVAC.
   4. Testing, adjusting, and balancing of steam and condensate piping systems.
   5. Testing, adjusting, and balancing of equipment.
   6. Testing, adjusting, and balancing of existing HVAC systems and equipment.
   7. Procedures for exhaust hoods.
   8. Sound tests.
   9. Vibration tests.
   10. Duct leakage tests verification.
   11. Pipe leakage tests verification.
   12. UFAD plenum leakage tests verification.
   13. HVAC-control system verification.
   14. Smoke-control system tests.
   15. Stair-pressurization system tests.
   16. Elevator-pressurization system tests
   17. Indoor-air quality measuring.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

E. TDH: Total dynamic head.

F. UFAD: Underfloor air distribution.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.

D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.
   4. Dates of use.
   5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications, Certified by AABC or NEBB:
   1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB.
   2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

D. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.6 COORDINATION

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

B. Coordinate efforts with the project Commissioning Agent. Refer to commissioning specifications for additional information.

C. Provide seven days' advance notice for each test. Include scheduled test dates and times.

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

1.7 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.8 WARRANTY

A. Performance Warranty:
   1. If AABC standards are used, provide a warranty on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.
   2. If NEBB standards are used, provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.

B. Warranty includes the following provisions:
   1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
   2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, available TAB specialists that may be engaged include, but are not limited to, the following:
   1. Carolina Air & Water Balancing Company, Inc.
   2. Hall Technology, Inc.
   3. KLG Jones, LLC.
   4. Palmetto Air & Water Balance, Inc.

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.

F. Examine equipment performance data, including fan and pump curves.
   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

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

K. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

L. Examine AHU, boiler and terminal unit by-pass piping used for water treatment flushing. Verify that valves in flushing bypass piping are fully closed.

M. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.

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

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

P. Examine operating safety interlocks and controls on HVAC equipment.

Q. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

R. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

A. Prepare a TAB plan that includes the following:
   1. Equipment and systems to be tested.
   2. Strategies and step-by-step procedures for balancing the systems.
   3. Instrumentation to be used.
   4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
   1. Airside:
      a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
      b. Duct systems are complete with terminals installed.
      c. Volume, smoke, and fire dampers are open and functional.
      d. Clean filters are installed.
      e. Fans are operating, free of vibration, and rotating in correct direction.
      f. Variable-frequency controllers' startup is complete and safeties are verified.
      g. Automatic temperature-control systems are operational.
      h. Ceilings are installed.

i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:
   a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
   b. Piping is complete with terminals installed.
   c. Water treatment is complete.
   d. Systems are flushed, filled, and air purged.
   e. Strainers are pulled and cleaned.
   f. Control valves are functioning in accordance with the sequence of operation.
   g. Shutoff and balance valves have been verified to be 100 percent open.
   h. Pumps are started and proper rotation is verified.
   i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
   j. Variable-frequency controllers' startup is complete and safeties are verified.
   k. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in ASHRAE 111 or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230700 "HVAC Insulation."

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

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

3.5 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:

Retain any of 40 subparagraphs below as applicable to Project.

1. Motors.
2. Fans and ventilators.

3. Rooftop air-conditioning units.
4. Dedicated outdoor-air units.
5. Fan coil units.

3.6 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

B. Prepare schematic diagrams of systems' Record drawings duct layouts.

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

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.7 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
   1. Measure total airflow.
      a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
      b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
      c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
      d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
   2. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report artificial loading of filters at the time static pressures are measured.

3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' Record drawings piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
   1. Check expansion tank for proper setting.
   2. Check highest vent for adequate pressure.
   3. Check flow-control valves for proper position.
   4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
   5. Verify that motor controllers are equipped with properly sized thermal protection.
   6. Check that air has been purged from the system.

D. Measure and record upstream and downstream pressure of each piece of equipment.

E. Measure and record upstream and downstream pressure of pressure-reducing valves.

F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
   1. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:
   1. Verify that the pressure-differential sensor(s) is located as indicated.
   2. Determine whether there is diversity in the system.

C. For systems with no flow diversity:
   1. Adjust pumps to deliver total design flow.
      a. Measure total water flow.
         1) Position valves for full flow through coils.
         2) Measure flow by main flow meter, if installed.
         3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
      b. Measure pump TDH as follows:
         1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
         2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
         3) Convert pressure to head and correct for differences in gauge heights.
         4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
         5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is

required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.
   a. Measure flow in main and branch pipes.
   b. Adjust main and branch balance valves for design flow.
   c. Re-measure each main and branch after all have been adjusted.
3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
   a. Measure flow at terminals.
   b. Adjust each terminal to design flow.
   c. Re-measure each terminal after it is adjusted.
   d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
   e. Perform temperature tests after flows have been balanced.
4. For systems with pressure-independent valves at terminals:
   a. Measure differential pressure and verify that it is within manufacturer's specified range.
   b. Perform temperature tests after flows have been verified.
5. For systems without pressure-independent valves or flow-measuring devices at terminals:
   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
6. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:
   a. Re-measure and confirm that total flow is within design.
   b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
   c. Mark final settings.

D. For systems with flow diversity:
   1. Determine diversity factor.
   2. Simulate system diversity by closing required number of control valves, as approved by Architect.
   3. Adjust pumps to deliver total design flow.
      a. Measure total water flow.
         1) Position valves for full flow through coils.
         2) Measure flow by main flow meter, if installed.
         3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
      b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gauge heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.
   a. Measure flow in main and branch pipes.
   b. Adjust main and branch balance valves for design flow.
   c. Re-measure each main and branch after all have been adjusted.
5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
   a. Measure flow at terminals.
   b. Adjust each terminal to design flow.
   c. Re-measure each terminal after it is adjusted.
   d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
   e. Perform temperature tests after flows have been balanced.
6. For systems with pressure-independent valves at terminals:
   a. Measure differential pressure, and verify that it is within manufacturer's specified range.
   b. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:
   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system pressure-differential set point(s).
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:
    a. Re-measure and confirm that total water flow is within design.

b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
c. Mark final settings.

3.10 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.11 SOUND TESTS

A. After systems are balanced and Substantial Completion, measure and record sound levels at 10 locations as designated by the Architect.

B. Instrumentation:
1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (L_{eq}).
3. The sound-testing meter must be capable of using one-third octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:
1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.

7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:
1. Report shall record the following:
   a. Location.
   b. System tested.
   c. dBA reading.
   d. Sound pressure level in each octave band with equipment on and off.

2. Plot sound pressure levels on Noise Criteria (NC) worksheet with equipment on and off.

3.12 VIBRATION TESTS

A. After systems are balanced and Substantially Completion, measure and record vibration levels on equipment having motor horsepower equal to or greater than 10.

B. Instrumentation:
1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
4. Verify calibration date is current for vibration meter before taking readings.

C. Test Procedures:
1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:
1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.

3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from AABC's "National Standards for Total System Balance." Acceptable levels of vibration are normally "smooth" to "good."
4. Include in General Machinery Vibration Severity Chart, with conditions plotted.

3.13 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.14 PIPE LEAKAGE TESTS

A. Witness the pipe pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.15 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
1. Measure and record the operating speed, airflow, and static pressure of each fan and equipment with fan(s).
2. Measure and record flows, temperatures, and pressures of each piece of equipment in each hydronic system. Compare the values to design or nameplate information, where information is available.
3. Measure motor voltage and amperage. Compare the values to motor nameplate information.
4. Check the refrigerant charge.
5. Check the condition of filters.
6. Check the condition of coils.
7. Check the operation of the drain pan and condensate-drain trap.
8. Check bearings and other lubricated parts for proper lubrication.
9. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. TAB After Construction: Before performing testing and balancing of renovated existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished in accordance with renovation scope indicated by Contract Documents. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.16 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Chilled-Water Flow Rate: Plus 10 percent or minus 0 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.17 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.18 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
   1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   2. Include a list of instruments used for procedures, along with proof of calibration.
   3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Pump curves.
   2. Fan curves.
   3. Manufacturers' test data.
   4. Field test reports prepared by system and equipment installers.
   5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:
   1. Title page.
   2. Name and address of the TAB specialist.
   3. Project name.
   4. Project location.
   5. Architect's name and address.
   6. Engineer's name and address.
   7. Contractor's name and address.
   8. Report date.
   9. Signature of TAB supervisor who certifies the report.
   10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   11. Summary of contents, including the following:
      a. Indicated versus final performance.
      b. Notable characteristics of systems.
      c. Description of system operation sequence if it varies from the Contract Documents.
   12. Nomenclature sheets for each item of equipment.
   13. Data for terminal units, including manufacturer's name, type, size, and fittings.
   14. Notes to explain why certain final data in the body of reports vary from indicated values.
   15. Test conditions for fans performance forms, including the following:
      a. Settings for outdoor-, return-, and exhaust-air dampers.
      b. Conditions of filters.
      c. Cooling coil, wet- and dry-bulb conditions.
      d. Heating coil, dry-bulb conditions.
      e. Face and bypass damper settings at coils.
      f. Fan drive settings, including settings and percentage of maximum pitch diameter.
      g. Variable-frequency controller and inlet vane settings for variable-air-volume systems.
      h. Settings for pressure controller(s).
      i. Other system operating conditions that affect performance.
   16. Test conditions for pump performance forms, including the following:

a. Variable-frequency controller settings for variable-flow hydronic systems.
b. Settings for pressure controller(s).
c. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:
1. Unit Data:
a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.
2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Inlet and discharge static pressure in inches wg.
e. For each filter bank, filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. List for each internal component with pressure-drop, static-pressure differential in inches wg.
j. Outdoor airflow in cfm.
k. Return airflow in cfm.
l. Outdoor-air damper position.

m. Return-air damper position.

F. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
1. Unit Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and speed.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches.
2. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.
2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and speed.

c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan speed.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
a. System fan and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

I. Air-Terminal-Device Reports:
1. Unit Data:
a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft..
2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

K. Vibration Measurement Reports:
1. Date and time of test.
2. Vibration meter manufacturer, model number, and serial number.
3. Equipment designation, location, equipment, speed, motor speed, and motor horsepower.
4. Diagram of equipment showing the vibration measurement locations.
5. Measurement readings for each measurement location.
6. Calculate isolator efficiency using measurements taken.
7. Description of predominant vibration source.

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

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

3.19 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of the Architect, Owner’s representative or Commissioning authority.

B. Architect, Owner’s representative or Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be

limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:
   1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.
   2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.20 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulation for the following HVAC services:
   1. HVAC piping.
   2. HVAC equipment.
   3. HVAC duct services.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail insulation application at pipe expansion joints for each type of insulation.
   4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   5. Detail removable insulation at piping specialties.
   6. Detail removable insulation at equipment connections.
   7. Detail application of field-applied jackets.
   8. Detail application at linkages of control devices.
   9. Detail field application for each equipment type.

C. Samples:
   1. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

1.5 QUALITY ASSURANCE

A. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Piping Mockups:
    a. One 10-foot section of NPS 2 straight pipe.
    b. One each of a 90-degree threaded, welded, and flanged elbow.
    c. One each of a threaded, welded, and flanged tee fitting.
    d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.
    e. Four support hangers including hanger shield and insert.
    f. One threaded strainer and one flanged strainer with removable portion of insulation.
    g. One threaded reducer and one welded reducer.
    h. One pressure temperature tap.
    i. One mechanical coupling.

2. Ductwork Mockups:
    a. One 10-foot section each of rectangular and round straight duct.
    b. One each of a 90-degree mitered round and rectangular elbow, and one each of a 90-degree radius round and rectangular elbow.
    c. One rectangular branch takeoff and one round branch takeoff from a rectangular duct. One round tee fitting.
    d. One rectangular and round transition fitting.
    e. Four support hangers for round and rectangular ductwork.
    f. Each type of damper and specialty.
3. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
4. Notify Architect seven days in advance of dates and times when mockups will be constructed.
5. Obtain Architect's approval of mockups before starting insulation application.
6. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
7. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
8. Demolish and remove mockups when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

2.2 INSULATION MATERIALS

A. Comply with requirements in PART 3 - EXECUTION articles for where insulating materials shall be applied.

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

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

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

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

F. Calcium Silicate:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Industrial Insulation Group, LLC (IIG-LLC).

b. Johns Manville; A Berkshire Hathaway Company.

2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
4. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. FOAMGLAS; an Owens Corning company
2. Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Block Insulation: ASTM C 552, Type I.
4. Special-Shaped Insulation: ASTM C 552, Type III.
5. Board Insulation: ASTM C 552, Type IV.
6. Preformed Pipe Insulation with Factory-Applied ASJ or ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
8. Thermal conductivity (k-value) at 75 deg F shall be 0.29 Btu x in./h x sq. ft. x deg F or less.

H. Flexible Elastomeric Insulation:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Aeroflex USA, Inc.
b. Airex Manufacturing
c. Armacell LLC
d. K-Flex USA
2. Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
3. Thermal conductivity (k-value) at 75 deg F shall be 0.25 Btu x in./h x sq. ft. x deg F or less (1-inch wall).

I. Mineral-Fiber Blanket Insulation:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. CertainTeed Corporation
b. Johns Manville; a Berkshire Hathaway company
c. Knauf Insulation
d. Manson Insulation Inc.
e. Owens Corning
2. Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I without factory-applied jacket, Type II with factory-applied vinyl jacket or Type III with factory-applied FSK

jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

3. Compressed thermal conductivity (k-value) at 75 deg F shall be 0.25 Btu x in./h x sq. ft. x deg F or less. Minimum installed R-Value of 3.0 (hr•ft^2•°F)/Btu per inch thickness.

J. High-Temperature, Mineral-Fiber Blanket Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Industrial Insulation Group, LLC (IIG-LLC)
      b. Johns Manville; a Berkshire Hathaway company
      c. Knauf Insulation
      d. Rock Wool
      e. ROXUL
      f. Thermafiber, Inc.; an Owens Corning company
   2. Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

K. Mineral-Fiber, Preformed Pipe Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation
      b. Johns Manville; a Berkshire Hathaway company
      c. Knauf Insulation
      d. Manson Insulation Inc.
      e. Owens Corning
   2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ or ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   3. Thermal conductivity (k-value) at 75 deg F shall be 0.23 Btu x in./h x sq. ft. x deg F or less.

L. Mineral-Fiber, Pipe Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Johns Manville; a Berkshire Hathaway company
      b. Knauf Insulation
      c. Manson Insulation Inc.
      d. Owens Corning
   2. Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   3. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 75 deg F is 0.24 Btu x in./h x sq. ft. x deg F or less.

M. Mineral-Fiber Board Insulation:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation

b. Johns Manville; a Berkshire Hathaway company
c. Knauf Insulation
d. Manson Insulation Inc.
e. Thermafiber, Inc.; an Owens Corning company

2. Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For equipment applications, provide insulation with factory-applied ASJ or ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Thermal conductivity (k-value) at 75 deg F shall be 0.23 Btu x in./h x sq. ft. x deg F or less.

N. High-Temperature, Mineral-Fiber Board Insulation:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Industrial Insulation Group, LLC (IIG-LLC)
b. Johns Manville; a Berkshire Hathaway company
c. Knauf Insulation
d. Rock Wool
e. ROXUL
f. Thermafiber, Inc.; an Owens Corning company
2. Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

O. Polyisocyanurate:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Dow
b. ITW Insulation Systems; Illinois Tool Works, Inc.
c. Johns Manville; a Berkshire Hathaway company
2. Faced, rigid cellular polyisocyanurate sheathing material intended for use as thermal duct insulation.
3. Comply with ASTM C1289 Type 1, Class 1. The compressive resistance shall not be less than 16.0 psi and a minimum installed R-Value of 6.0 (hr•ft2•°F)/Btu per inch thickness.
4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
a. Duct Applications: FSK.

2.3 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Johns Manville; a Berkshire Hathaway company

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. 3M
      b. CertainTeed Corporation
      c. Johns Manville; a Berkshire Hathaway company
      d. Nelson Firestop; a brand of Emerson Industrial Automation
      e. Thermal Ceramics
      f. Unifrax Corporation

2.4 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

2.5 ADHESIVES

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

B. For indoor applications, use adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aeroflex USA, Inc.
   2. Armacell LLC
   3. Childers Brand; H. B. Fuller Construction Products
   4. Dow Corning Corporatio
   5. Eagle Bridges - Marathon Industries
   6. Foster Brand; H. B. Fuller Construction Products.
   7. Johns Manville; a Berkshire Hathaway company
   8. K-Flex USA
   9. P.I.C. Plastics, Inc.
   10. Mon-Eco Industries, Inc.
   11. Speedline Corporation
   12. Vimasco Corporation.

D. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

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

F. Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

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

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

I. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

J. PVC Jacket Adhesive: Compatible with PVC jacket.

2.6 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. For indoor applications, use mastics that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Childers Brand; H. B. Fuller Construction Products
2. Eagle Bridges - Marathon Industries
3. Foster Brand; H. B. Fuller Construction Products.
4. Knauf Insulation
5. Mon-Eco Industries, Inc.
6. Vimasco Corporation

D. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.

2.7 LAGGING ADHESIVES

A. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Childers Brand; H. B. Fuller Construction Products
   2. Foster Brand; H. B. Fuller Construction Products.
   3. Vimasco Corporation

C. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
   1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
   2. Service Temperature Range: 0 to plus 180 deg F.
   3. Color: White.

2.8 SEALANTS

A. Use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24)

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Childers Brand; H. B. Fuller Construction Products
   2. Eagle Bridges - Marathon Industries
   3. Foster Brand; H. B. Fuller Construction Products.
   4. Knauf Insulation
   5. Mon-Eco Industries, Inc.
   6. Pittsburgh Corning Corporation
   7. Vimasco Corporation

C. Cellular-Glass and Polyisocyanurate Joint Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Permanently flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 100 to plus 300 deg F.
   4. Color: White or gray.

D. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.
   4. Color: Aluminum.

E. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.
   4. Color: White.

2.9 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.10 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Alpha Associates, Inc

2.11 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; 30 mils thick; roll stock ready for shop or field cutting and forming.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Johns Manville; a Berkshire Hathaway company
      b. P.I.C. Plastics, Inc.
      c. Proto Corporation
      d. Speedline Corporation
   2. Adhesive: As recommended by jacket material manufacturer.
   3. Color: White
   4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, and mechanical joints.

D. Metal Jacket:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ITW Insulation Systems; Illinois Tool Works, Inc.
      b. RPR Products, Inc.
   2. Aluminum Jacket: Comply with ASTM B 209, ASTM C 1729, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
      a. Factory cut and rolled to size.

b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
e. Factory-Fabricated Fitting Covers:
    1) Same material, finish, and thickness as jacket.
    2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    3) Tee covers.
    4) Flange and union covers.
    5) End caps.
    6) Beveled collars.
    7) Valve covers.
    8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
    a. Factory cut and rolled to size.
    b. Material, finish, and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
    d. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
    e. Factory-Fabricated Fitting Covers:
        1) Same material, finish, and thickness as jacket.
        2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
        3) Tee covers.
        4) Flange and union covers.
        5) End caps.
        6) Beveled collars.
        7) Valve covers.
        8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Underground Direct-Buried Jacket: 125-mil- thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. Pittsburgh Corning Corporation
        b. Polyguard Products, Inc

F. Self-Adhesive Outdoor Jacket: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Polyguard Products, Inc.

2. Warranty: Minimum 10-year warranty that water will not leak directly through membrane as a result of deterioration of the membrane caused by ordinary wear and tear.

2.12 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Width: 3 inches.
2. Thickness: 6.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 58 ounces force/inch in width.
4. Elongation: 8.5 percent.
5. Tensile Strength: 23 lbf/inch in width.

2.13 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
    a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    b. Spindle: Aluminum, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
    c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
    a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
    b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
    c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
    a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    b. Spindle: Aluminum, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
    c. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
    a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

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

2.14 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems and equipment to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.
   3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
   1. For exterior, above-grade piping: Before insulating, apply a corrosion coating to insulated surfaces as follows:
      a. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
      b. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials clean and dry during application and finishing.

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

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
      a. For below-ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

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

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

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

P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

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

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

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
   1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
   2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
   3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
   4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
   5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
   6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
   7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

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

D. Insulate reheat coils, including exposed tubing U-bends, on concealed air terminal units.

E. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
   4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
   3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   2. Install insulation to flanges as specified for flange insulation application.
   3. Finish valve and specialty insulation same as pipe insulation.

E. Insulation Installation on Boiler Breechings:
   1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
   2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
   3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

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

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

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed sections of cellular-glass insulation to valve body.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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

B. Insulation Installation on Pipe Flanges:
   1. Install pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
   4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install mitered sections of pipe insulation.
   2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed valve covers manufactured of same material as pipe insulation when available.

2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

E. Insulation Installation on HVAC Ducts
1. Install insulation over entire surface of ducts.
2. Apply 50 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
3. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

F. Provide latex-based, UV resistant protective coating for outdoor applications.

3.9 INSTALLATION OF MINERAL-FIBER INSULATION

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

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

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

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.10 INSTALLATION OF POLYISOCYANURATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

E. Insulation Installation on Ducts and Plenums:
1. Install insulation over entire surface of ducts.
2. Apply minimum 50 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
3. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.11 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

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

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

3.12 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.13 FIELD QUALITY CONTROL

A. If workmanship is of questionable quality, the contractor shall perform tests and inspections as directed by the Architect.

B. Tests and Inspections:

1. Inspect field insulated equipment, ductwork, pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation.

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

3.14 INSULATION SCHEDULE, GENERAL

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

B. HVAC Piping Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawl spaces.

2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

C. HVAC Equipment Items Not Insulated: Unless otherwise indicated, do not install insulation on equipment that is factory insulated.

D. HVAC Ducts Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.15 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:
1. All Pipe Sizes: Insulation shall be one of the following:
a. Flexible Elastomeric: 3/4 inch thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Chilled Water, above 40 Deg F:
1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
a. Flexible Elastomeric: 1 inch thick.
b. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.

C. Heating-Hot-Water Supply and Return:
1. NPS 1-1/4 and Smaller: Insulation shall be the following:
a. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches thick.

D. For piping smaller than 1 1/2 inches and located in partitions within conditioned spaces, reduction of the scheduled thickness by 1 inch shall be permitted, but not to a thickness less than 1 inch.

3.16 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, supply-air and outdoor-air duct insulation shall be the following:
1. Above Ceiling: Mineral-Fiber Blanket: 2 inches thick and 1-lb/cu. ft. nominal density.

B. Concealed, exhaust-air heat recovery duct insulation shall be the following:
1. Above Ceiling: Mineral-Fiber Blanket: 1 inch thick and 1-lb/cu. ft. nominal density.

C. Concealed, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:

1. Mineral-Fiber Blanket: 2 inches thick and 1-lb/cu. ft. nominal density.

D. Concealed, supply-air devices shall be the following:
1. Mineral-Fiber Blanket: 1 inch thick and 1-lb/cu. ft. nominal density.

E. Exposed, supply-air and outdoor duct insulation shall be the following (unfinished areas):
1. Mineral-Fiber Board: 2 inches thick and 6-lb/cu. ft. nominal density.

F. Exposed, return-air duct insulation shall be the following (unfinished areas):
1. Mineral-Fiber Board: 1 inch thick and 6-lb/cu. ft. nominal density.

G. Exposed, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:
1. Mineral-Fiber Board: 1 inch thick and 6-lb/cu. ft. nominal density.

3.17 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Piping, Concealed:

1. None.

C. Piping, Exposed:
1. PVC, Color-Coded by System: 30 mils thick.

D. Equipment, Concealed:
1. None.

E. Equipment, Exposed:
1. None.

F. Ducts and Plenums, Concealed:
1. None.

G. Ducts and Plenums, Exposed:
1. None.

END OF SECTION 230700

SECTION 230900 - BUILDING AUTOMATION AND TEMPERATURE CONTROL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified:

1.3 SCOPE

A. The Building Automation System (BAS) manufacturer shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.

B. The BAS shall be a Web based system communicating over the building owners Local Area Network (LAN). Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BAS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN. TCP/IP connections and addresses shall be provided by the owner for connection of supervisory panels to the HGTC network.

C. The primary desktop and laptop interface will be via a standard Web Browser such as Internet Explorer or Chrome. BAS contractor shall provide software license(s) for BAS WEB access for a minimum of twenty concurrent users.

D. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer. The installing manufacturer shall certify in writing, that the shop drawings have been prepared by the equipment manufacturer and that the equipment manufacturer has supervised their installation. In addition, the equipment manufacturer shall certify, in writing, that the shop drawings were prepared by their company and that all temperature control equipment was installed under their direct supervision.

E. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this

project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.

F. BAS manufacturer shall be responsible for all BAS and Temperature Control wiring for a complete and operable system. All wiring shall be done in accordance with all local and national codes.

G. Air handling unit control/end devices shall be furnished by the BAS manufacturer and factory installed by the air handling unit manufacturer. Controls contractor shall provide data sheets on all components to be mounted, indicating component dimensions, mounting hardware, and methods, as well as wiring and piping diagrams for each application identified by unit tag per the schedule in the drawings.

H. Variable Frequency Drives (VFDs):
   1. Air handling unit VFDs shall be furnished and installed by the air handling unit manufacturer.
   2. Power wiring for VFDs shall be provided under Division 26.
   3. Refer to Section 230550 "Variable Frequency Drives".

I. Lighting Panel BAS Scope of Work
   1. BAS Controls Contractor shall provide all necessary materials and labor, including integration devices, to integrate with the lighting panels (LP) as shown on the electrical drawings.

J. BAS provider shall provide IT cabling and network between devices, controllers and building controllers so that a complete BAS is installed, functional and accessible via tie into the BAS network from a single location during TAB and commissioning. BAS network and cabling shall be compliant with and compatible with the Owner's IT department requirements so that BAS may be connected to an Owner's switch(s) once that system is complete.

1.4 INTERFACE REQUIREMENTS

A. The new system shall be an extension of and connected to the existing Siemens management system which is used for energy management.

B. The BAS contractor shall provide all necessary hardware and software to integrate the new control system with the existing Siemens BAS without additional hardware or gateways. Integration means the ability to monitor, override, change set points, and provide real-time bi-directional dynamic data exchange between the new control system and the existing BAS hardware and software.

C. The existing BAS is a Siemens system. The BAS is comprised of multiple supervisory controllers, monitoring and communicating with various building control systems over the Ethernet LAN system. The new building control system will be connected to, and communicate with, the existing campus BAS server via the Ethernet LAN

D. All new control points, monitoring points and software points shall be added to the existing Siemens BAS database and shall be available for monitoring and adjustment

at any computer, with current copy of Microsoft Internet Explorer software (Release 6.0 or later), that is connected to the HGTC LAN.

E. All new building software and databases shall be archived on the hard drive at the BAS server. In the event that any building controller should lose its program that controller's archived software program shall be downloaded across the BAS network from the BAS server to the respective building controller.

F. The BAS contractor will provide all necessary hardware, software, and labor to allow communication with all any computer, with current copy of Microsoft Internet Explorer (Release 6.0 or later), that is connected to the LAN.

G. Integrity of the existing BAS shall be maintained during installation.

H. The new building control system shall be compatible in every respect with existing Siemens BAS hardware and software. All new controllers shall be compatible with Siemens database and software development tools.

1.5 WORK BY OTHERS

A. Electrical Contractor provides:
   1. 120V power to all BAS and/or Temperature control panels. Where not shown on plans, locations shall be determined by the BAS contractor and coordinated with the Architect and electrical contractor.
   2. Wiring of all power feeds through all disconnect starters to electrical motor.
   3. Wiring of any remote start/stop switches and manual or automatic motor speed control devices not furnished by BAS manufacturer.
   4. Wiring of electrical sub-metering devices furnished by BAS manufacturer.

B. Control Devices for Installation by Installers
   1. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
   2. Deliver the following to duct fabricator and installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
      a. Airflow sensors, switches and stations
      b. Pressure sensors.
   3. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
      a. DDC control valves
      b. Pipe-mounted sensors, switches and transmitters.
   4. Deliver the following to electrical installers for installation. Include installation instructions to Installer and supervise installation for compliance with requirements.
      a. Meters/Sub-Metering Devices

C. Communication Interface to Equipment with Integral Controls

1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
2. Equipment to Be Connected:
   a. Fan coil units
   b. Packaged air handling unit controllers
   c. Variable-frequency controllers

D. Communication Interface to Other Building Systems:
1. DDC system shall have a communication interface with systems having a communication interface.
2. Systems to Be Connected:
   a. Access controls.
   b. Fire-alarm system
   c. Lighting controls. BAS shall connect to all Lighting Control panels and contactors for lighting control. Refer to the electrical drawings for location and quantity.
   d. Power monitoring.

E. The control manufacturer shall cooperate with the air and water balancing agency in the performance of their work as required or directed.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of product include the following:
1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
   a. Gateways.
   b. Routers.
   c. DDC controllers.
   d. Enclosures.
   e. Electrical power devices.
   f. UPS units.
   g. Accessories.
   h. Instruments.
   i. Control damper actuators.
   j. Control valves and actuators.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.

7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. Shop Drawings:
   1. General Requirements:
      a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
      b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
      c. Drawings Size: 11x17.
   2. Include plans, elevations, sections, and mounting details where applicable.
   3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   4. Detail means of vibration isolation and show attachments to rotating equipment.
   5. Plan Drawings indicating the following:
      a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
      b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
      c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
      d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
      e. Network communication cable and raceway routing.
      f. Information, drawn to scale, of ¼”=1’-0”.
      g. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.
   6. Schematic drawings for each controlled HVAC system indicating the following:
      a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
      b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
      c. A graphic showing location of control I/O in proper relationship to HVAC system.
      d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
      e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
      f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
      g. Narrative sequence of operation.
      h. Graphic sequence of operation, showing all inputs and output logical blocks.
   7. Control panel drawings indicating the following:
      a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.

b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
c. Front, rear, and side elevations and nameplate legend.
d. Unique drawing for each panel.

8. DDC system network riser diagram indicating the following:
   a. Each device connected to network with unique identification for each.
   b. Interconnection of each different network in DDC system.
   c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
   d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
9. DDC system electrical power riser diagram indicating the following:
   a. Each product requiring power with associated requirements (volts/phase//hertz/amperes/connection type) listed for each.
10. Monitoring and control signal diagrams indicating the following:
    a. Control signal cable and wiring between controllers and I/O.
    b. Point-to-point schematic wiring diagrams for each product.
    c. Control signal tubing to sensors, switches and transmitters.
    d. Process signal tubing to sensors, switches and transmitters.
11. Color graphics indicating the following:
    a. Itemized list of color graphic displays to be provided.
    b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
    c. Intended operator access between related hierarchical display screens.

C. System Description:
1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:
   a. Loss of power.
   b. Loss of network communication signal.
   c. Loss of controller signals to inputs and outpoints.
   d. Operator workstation failure.
   e. Server failure.
   f. Gateway failure.
   g. Network failure
   h. Controller failure.
   i. Instrument failure.
   j. Control damper and valve actuator failure.
4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
      b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
      c. As-built versions of submittal Product Data.
      d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
      e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
      f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
      g. Engineering, installation, and maintenance manuals that explain how to:
         1) Design and install new points, panels, and other hardware.
         2) Perform preventive maintenance and calibration.
         3) Debug hardware problems.
         4) Repair or replace hardware.
      h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
      i. Backup copy of graphic files, programs, and database on electronic media such as digital media.
      j. List of recommended spare parts with part numbers and suppliers.
      k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
      l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
      m. Licenses, guarantees, and warranty documents.
      n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
      o. Owner training materials.

1.8 QUALITY ASSURANCE

A. The BAS system shall be designed and installed, commissioned and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 20 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment.

B. The manufacturer shall provide onsite, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BAS.

C. The Bidder shall be regularly engaged in the manufacturing, installation and maintenance of BAS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project.

D. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

E. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology and extend new field panels on a previously installed network.

1.9 PERFORMANCE REQUIREMENTS

A. Comply with the following performance requirements:
   1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
   2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
   3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
   4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
   5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
   6. Program Execution Frequency: Run capability of applications as often as five seconds but selected consistent with mechanical process under control.
   7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
   8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
      a. Water Temperature: Plus or minus 1 deg F.
      b. Water Flow: Plus or minus 2 percent of full scale.
      c. Water Pressure: Plus or minus 2 percent of full scale.
      d. Space Temperature: Plus or minus 1 deg F.
      e. Ducted Air Temperature: Plus or minus 1 deg F.
      f. Outside Air Temperature: Plus or minus 2 deg F.
      g. Dew Point Temperature: Plus or minus 3 deg F.
      h. Temperature Differential: Plus or minus 0.25 deg F.
      i. Relative Humidity: Plus or minus 5 percent.
      j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
      k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
      l. Air Pressure (Space): Plus or minus 0.01-inch wg.

m. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
n. Carbon Dioxide: Plus or minus 50 ppm.
o. Electrical: Plus or minus 5 percent of reading.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
a. Install updates only after receiving Owner's written authorization.
3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: From date of Substantial Completion.
a. One-year parts and labor.
b. Three-year parts.
c. For Gateway: One-year parts and labor warranty for each.

B. The on-line support services shall allow the local BAS subcontractor to dial out over telephone lines to monitor and control the facility's building automation system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall be extended to include normal business hours, after business hours, weekends and holidays.

1.11 IDENTIFICATION

A. Identify control wires with a distinctive number on a nonconducting tag attached to each end or at junction points or by color coding of that wire or tube. Designate on control diagram the identifying color and/or number or other identifying designation used.

B. Identify all control equipment and devices, including panels, controllers, valves, and automatic dampers, firestats, etc., by a method approved by the Architect. Designations shall match those used on control diagrams and shop drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Automated Logic Corporation
   2. Hoffman Building Technologies
   3. Johnson Controls Inc. (Metasys).
   4. Siemens Building Technologies, Inc.
   5. Trane

B. System must extend and connect to the existing Siemens network control systems installed in HGTC Campus.

2.2 GENERAL DESCRIPTION

A. The Building Automation System (BAS) shall use an open architecture. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.

B. The Building Automation shall consist of the following:
   1. Standalone Network Control Engine (NCE)
   2. Field Equipment Controller(s)
   3. Input/Output Module(s)
   4. Local Display Device(s)
   5. Distributed User Interface(s)
   6. Network processing, data storage and communications equipment
   7. Other components required for a complete and working BAS

C. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

2.3 BAS ARCHITECTURE

A. Automation Network
   1. The BAS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Utilize existing application and data server as required for systems operation.
   2. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
   3. Network Control Engine (NCE) shall reside on the automation network.

4. The automation network will be compatible with other campus-wide networks. Where indicated, the automation network shall be connected to the campus network and share resources with it by way of standard networking devices and practices.

B. Control Network
   1. Network Control Engine (NCE) shall provide supervisory control over the control network.
   2. Control networks shall provide either “Peer-to-Peer,” Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 38,400 baud.
   3. DDC Controllers shall reside on the control network
   4. Wireless communication between DDC controllers is acceptable. All sensors shall be wired.

C. Dedicated Web Based User Interface
   1. The BAS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. Real-time control functions, including scheduling, history collection and alarming, shall be resident in the BAS Network Engines and Data Server to facilitate greater fault tolerance and reliability.
   2. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BAS Contractor and by other third-party applications suppliers, including but not limited to Microsoft Office Applications. Specifically, it must be implemented to conform to the following interface standards.
      a. Edge or Google Chrome or Safari for user interface functions.
      b. Microsoft Office Professional for creation, modification and maintenance of reports, sequences and other necessary building management functions.
      c. Microsoft Outlook or other e-mail programs for supplemental alarm functionality and communication of system events, and reports.
      d. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries.
   3. PC Hardware/Software – The personal computer(s) shall be configured as specified in the Computing Hardware and Software section.
   4. Provide one operational device as herein specified and located on plans.
   5. Mobile, Web Based, User Interface (MUI) General
      a. All functionality as outlined within this section shall be provided as a standard catalog product software suite from the BAS manufacturer. Custom functionality development to meet these requirements is not acceptable.
      b. The mobile, web-based, user interface shall be HTML5-compliant and provide access to the system from smartphones, tablets, portable and desktop computers. User Interfaces that require software installation on the client device (e.g. Java, MicrosoftSilverlight®, Adobe® Flash®), or software downloads from an online app store shall not be acceptable for these purposes.
      c. The mobile user interface shall provide system operators with a simple space/zone/location-based navigation approach to finding information,

including the ability to search for any location by name and to bookmark a location in a standard browser.

d. The mobile user interface shall organize and display information using customer specific locations and spaces. At a minimum, the user interface shall provide:
   1) Organization of all space, equipment and point information in a familiar way (using standard equipment names and location descriptions), reducing the need for extensive training prior to use.
   2) A navigation mechanism or tree for users to select the specific location or space for accessing information – only spaces and locations in the navigation tree or equipment serving that space, nothing more.
   3) The ability to search for and/or bookmark any location, space, or equipment by name for quick access to critical or troublesome areas.
   4) Application of the same navigation mechanisms across any client device (e.g. Smart phone, tablet, personal computer) for consistency and ease of use.

e. The same user interface elements shall be accessible from any type of personal computer or mobile device running any type of operating system supported (e.g. iOS, Android, Windows®). It shall automatically adapt and optimize the display for the screen size and touch screen navigation.

f. Navigation Trees
   1) A dedicated location-based navigation tree shall be provided as part of the user interface in order to navigate to specific places within the facility on a hierarchical basis (typ. Campus, Facility, Building, Wing, Floor, Room.)
   2) The location-based tree shall use place names familiar to the operator without training or familiarization regarding special codes and conventions utilized in the generation of the BAS.
   3) Clicking or tapping on a location name in the tree shall display the home page associated with the space and simultaneously expand the tree to display the next level of spaces below the one selected.
   4) Provide a means for qualified users to view an all hardware items navigation tree of devices connected to the BAS network in order to enable troubleshooting of equipment and communications.
   5) A click or tap on a device in the network tree shall display a dashboard for that device including information regarding related equipment and access to a separate focus view of commandable points associated with the piece of hardware. A click or tap on such a point shall display a control dialogue box allowing the user to modify or command that point as indicated. The dialog box shall contain an annotation box for describing why the action was taken or special circumstances that apply.
   6) Specific hardware and software types in the Network tree shall also include access to one or more the following views in their dashboard depending on hardware type or network element (e.g. MS/TP trunk):
      a) Summary View
      b) Diagnostic View
      c) Network View
      d) Trend View

7) Provide a means to hide the Network Tree and return to the Spaces Tree at any time by clicking on the Spaces Icon above the tree.
8) Provide a means to restrict user access to any space in the Spaces Tree and thereby prevent manipulation of equipment associated with the space.

g. Dashboard Displays
1) The user interface shall provide the ability to view equipment visualizations, floor plans, and/or other graphics on mobile or desktop client devices in a browser environment, without the need for additional plugins or software. Graphics shall be accessible via a space (for floorplans, campus maps, etc.) or equipment dashboard.
2) Standard dashboards shall be configured for each defined space including one of the following predefined or custom elements:
a) Equipment Serving Space
b) Potential Problem Areas
c) Equipment Summary
d) Graphic Display (if specified)
e) Schedule
3) Standard dashboards shall be configured for each system or device (typ. mechanical or electrical equipment) including the following predefined or custom elements:
a) Trend
b) Equipment Activity Summary
c) Equipment Relationships Summary
d) Equipment Data
e) Graphic Display
f) Schedule
4) Users with appropriate permissions shall have access to a Dashboards Manager that can change the display order of Summaries and Data elements, add or remove elements and apply custom dashboards layouts to equipment and space by type.
5) Dashboard Manager shall apply dashboards to spaces or equipment based on the viewing platform (Desktop/Tablet or Phone) in order to tailor the user experience to the needs of the specific user base.
6) Default dashboard displays by space and equipment type shall be created per the guidelines in this specification or by mutual agreement with the Owner’s representative.

h. Alarm Management
1) The user interface shall provide a single display of all potential issues in a facility including items currently in alarm, warning, override, out-of-service and offline.
2) The user interface shall provide notification of new alarms, visually and audibly.
3) The user interface shall provide the ability to view a summary of alarms, including a chart of the number of alarms in each of the defined alarm priority ranges. The priority ranges should be filterable.
4) The user interface shall provide the capability to view multiple occurrences of the same alarm, ultimately providing the ability to acknowledge or discard all occurrences of the alarm in a single action.

5) The user interface shall provide the capability to view, and filter on, all alarms present in a well-defined mechanical system using the equipment serving equipment relationships.
6) The user interface shall provide the capability to acknowledge and discard all occurrences of at least 1000 alarms in one operation.
7) The user interface shall provide the user with the understanding of what physical space is being affected when an alarm occurs. The user interface shall provide the ability to filter alarms by physical space affected when the alarm occurred.
8) The user interface shall provide the capability to monitor alarms 24/7 without requiring an active login to the system, accessible via segregated web page. The user interface shall provide the capability to enabled or disable the 24/7 alarm monitor mode if desired.
9) The user interface shall provide the capability to annotate alarms using a pre-defined selection list or by providing custom text.
10) The user interface shall provide the capability to filter down alarm list and bookmark the filtered list, allowing automatic filtering to be applied when the bookmark is accessed.
11) Provide a means to export a .csv or .pdf copy of the currently displayed alarm list.
12) Provide a means to set up an alarm escalation feature. If an alarm is not acknowledged or discarded by recipients within a user-selected time, the alarm shall be escalated to an additional set of recipients.

i. Send Announcement
1) Administrative users should have the ability to alert staff of planned outages in advance. The communication avenues should include:
a) Email
b) A message shown on the login screen
c) A banner shown to logged in users

j. Equipment Activity Summary
1) The user interface shall provide a filterable, single display, of all activity related to a specific piece of equipment including user changes, discarded user changes, pending alarms, discarded alarms, and acknowledged alarms for at least one year of historical data.
2) Items shall be listed in timed order with the latest activity at the top of the list.
3) Filters shall allow only specific activities for specific data points occurring within a specific time and date window to be displayed.
4) Provide a means to export a .csv copy of the currently displayed summary by clicking or tapping on the export icon.
5) Provide a means to create a custom trend graph containing the data shown in the currently displayed summary by tapping or clicking on the trend icon in the header bar and selecting the specific points to trend in the resulting selection panel.
6) Clicking on the information icon in front of any displayed activity listed in the summary shall expand the display to include the name of the user, server time, value prior to the activity, the ability to annotate the activity and a user selectable icon for displaying a trend graph of the point.

k. Equipment Relationships Summary

1) The user interface shall provide a summary of all equipment and spaces related to the operation of the system or device currently selected for viewing.
2) The user interface shall include the capability to navigate to the home page of any related piece of equipment or space with a single click or tap on the desired element.

l. Equipment Data Summary
1) The user interface shall provide a summary of all data pertaining to a particular piece of mechanical or electrical equipment in a tabular format. Clicking or tapping on any value in the summary shall display a related command panel allowing the user to command, override, or change service condition of the point selected and to annotate such actions for future reference.
2) Provide a means to export a .pdf copy of the report with a single click on the associated export icon.

m. Equipment Serving Space Summary
1) The user interface shall provide a summary of all mechanical and electrical equipment as defined in the points list that serves a selected space from the navigation tree.
2) The summary shall be capable of including a subset of the viewable points for each system representing the key elements of interest to operators without subjecting them to long lists of points irrelevant to basic operation.
3) Clicking or tapping on any item in the summary shall navigate to the item's assigned home page in the user interface.
4) Provide a means to view a custom trend of information contained in the summary with a single click of the trend icon residing in the title header.
5) Provide a means to display specific systems and points by filtering equipment types desired.
6) Because the data is intended to be a snapshot of the current conditions in the space it shall not dynamically update but a click or tap on the update icon at any time performs that function.

n. Potential Problem Areas Summary
1) The user interface shall provide a summary of all points in the system related to the space that are not operating correctly (e.g. alarm, off normal or not communicating correctly) in order to provide the operator with a quick update on current conditions.
2) The information shall include:
a) Point status (via color)
b) Point name
c) Value of the point when the summary was taken
d) Equipment that contains the offending point
e) Space that is served by that equipment
3) Data points in the summary may be filtered by one or more types of off-normal condition (e.g. above setpoint, offline and overridden).
4) The summary may be exported in .csv format for inclusion in spreadsheets or other documents.

o. Equipment Summary
1) The user interface shall provide a summary that allows the user to compare all similar equipment that serves the space as well as

downstream (child) spaces in order to evaluate conditions quickly and determine patterns for troubleshooting purposes.

2) Each unique equipment type shall be selectable and display a representative set of values along with the space(s) being served by the device. Equipment types can be selected from a dropdown menu in the summary.
3) Clicking or tapping on a selected device in the summary shall navigate to the home page for that piece of equipment while clicking or tapping a data point shall display the command panel for that point.
4) Provide a means to export a .pdf copy of the currently displayed summary by clicking or tapping on the export icon.
5) Provide a means to create a custom trend graph containing the data shown in the currently displayed summary by clicking on the trend icon in the header bar and selecting the specific points to trend in the resulting selection panel.
6) Provide a means to sort data within the summary by clicking on the desired column heading, allowing to sort from lowest to highest value or vice versa.
7) Provide a means to edit the column types and column order within the summary to provide relevant information in accordance with Operators' preferences.
8) Provide a means to link to an advanced search and reporting function directly from the Equipment Summary that will pre-populate the advanced report with the data from the Equipment Summary.

p. User Defined Summaries
1) Provide the capability to view, command, and modify large quantities of similar data in summaries without the use of a secondary application (e.g. a spreadsheet). These summaries shall be generated automatically or user defined.

q. Trend
1) The user interface shall provide the capability to view historical trend data from multiple pieces of equipment in both bar and line formats.
2) The user shall have the ability to navigate to a selection list of frequently viewed trends.
3) Trend graphs shall have to ability to be smartly auto-generated based on equipment and space relationships.
4) The user shall have the ability to view up to 3 graphs of differing units of measurement in a single screen and select which data points to plot on each to help with readability.
5) Each graph shall include a dedicated selection icon to export a copy of the graphic and data in .pdf format or the data only as a .csv file.
6) Trend graphs shall allow the plotting of non-trended point's default values.
7) The user shall have the ability to add any trended to point a custom trend graph.
8) The user shall have the ability to save trend graphs for reference later.
9) The user shall be able to specify the duration of time and aggregation period for each trend line.

10) The user shall have the ability to decide whether to show raw or aggregate trend data.

r. Operator Access
1) The user interface shall provide the ability to segment access to building data based on the space(s) or location(s) the user is physically located in and/or manages. The user interface shall provide the capability to assign “inherited” space permissions and the ability to assign user’s space based access in bulk.
2) The user interface shall provide the ability to segment access to building data based on the space(s) or location(s) the user is physically located in and/or manages. The user interface shall provide the capability to assign “inherited” space permissions and the ability to assign user’s space based access in bulk.

s. Graphics
1) The user interface shall display an equipment visualization or graphic within the context of its associated space (building, floor, room, etc.) or equipment dashboard.
2) Graphics shall include the ability to define individual information layers for operator selection in order to clarify systems status and simplify operation on mobile devices. Where desired a master layer may be defined to include important information about the facility on all graphic screens.
3) Graphics shall support the use of photo-realistic symbols as well as color change and animation to match the status of the related system control point.
4) Provide a means to export a time stamped .pdf file of the graphic being viewed in order to communicate the current conditions in the space or the equipment being viewed and to provide a historic record.
5) An integral graphic manager shall be provided including the following features and capabilities:
a) Creation and modification of graphics from any HTML5 capable browser without the need for additional plug-ins or software packages.
b) Access to a full suite of pre-defined templates for air and water sourced HVAC applications as well as the ability to add custom templates as created for other use. Pre-aliased graphic templates may be defined and saved for repetitive representations of common mechanical and electrical equipment.
c) A full suite of pre-defined three dimensional symbols for mechanical and electrical systems as well as all line, text and shape tools required for integration into a graphic with zoom and pan capabilities on multiple platforms and in multiple browsers.
d) The ability to search and replace items in multiple graphics with a single command.
e) The ability to import and insert photos and images into the graphic.
f) The ability of the graphics manager to create and edit graphics including the ability to bind graphic elements to the values and

conditions of system points in both an on-line and off-line mode.

g) The ability to create and import custom SVG symbols that can be selectable from the graphical palette and rendered at runtime.

6) As required, the BAS Contractor shall provide software licenses in the name of the owner for programming, configuration and graphics building tools to allow designated representatives to make changes, modifications or additions to the system. While future updates or revisions may require an update fee, the owner shall incur no additional cost if they choose not to update. Systems that require any annual or time-limited licensing fees shall not be permitted.

t. Scheduling

1) The user interface shall provide the capability to display, in a singular view, all of the effective schedules in the context of the space (building/floor/room, etc.) or equipment that the schedule effects. The software should have the ability to display an effective schedule, for the present, or a future date.

2) The user interface shall provide a report of all schedules affecting a space or equipment. The report shall provide the user details of events that comprise the weekly schedule and exception schedule(s). The report shall provide a means of viewing individual breakout scheduling elements for Weekly Schedule, Exceptions and Default Commands.

3) The user interface shall provide the capability to efficiently change or modify schedules in mass quantities. This includes the capability to add, in bulk, exceptions to schedules, in addition to assigning, in bulk, weekly schedules.

u. Command and Control

1) Provide a means to command system analog and binary points via a dropdown menu accessed by clicking or tapping on the value shown in any equipment summary or graphic display and completing the task in the resultant menu including an optional annotation.

2) Commanding multiple points shall be possible on displays where multiple like system elements can be chosen.

3) The user interface shall support users adding notes on their commands.

4) The user interface shall support a choice of either permanent or temporary commands.

v. Involvement

1) The user interface shall provide in a single screen, a way to visualize all interactions (I.e. - commands, writes, references) with a single object.

2) The interface shall provide the ability to filter out any interactions (i.e. commands, writes, references) that are not pertinent.

3) The user interface shall allow seamless navigation between one object’s Involvement view to another object’s.

w. System-Level Activity

1) The user interface shall provide a timeline view of all audits that occur in the system, including:

a) Logins attempts with user specified

b) Add, delete, modification of objects
c) Commands

x. Search
1) Typing a text string in the Search box shall display a list of all occurrences of that string in the mobile user interface. When a string is represented in the description of a space or network element, selecting it shall display its default dashboard.
2) Clicking or tapping on the Advanced Search Icon shall display the Advanced Search dialog box permitting the following:
a) Search by Space and Equipment, Equipment Definition or Network Reference
b) Filter the search by wildcard name or object type
c) Multi-selection of objects for commanding or the creation of reports including Trend, Alarm, Audit and Activity for a specific period of time
d) Creation of reports in PDF or CSV formats which can be instantaneously downloaded or emailed, or scheduled to be sent at Operator-selected intervals (daily/weekly/monthly)

y. Software Updates
1) Users shall be notified when new software becomes available for download.
2) Users shall be given brief information on what's to be expected in the update.

z. Offline Operation
1) The mobile user interface shall have the ability to operate in an offline mode in order to create or edit graphics and dashboard elements.
2) Content created offline shall be available to all authorized users for inclusion of an operating user interface later.

aa. Fault Detection
1) Fault detection functionality shall be provided that identifies and displays building system-related faults and lists them color coded in order of severity. This software shall leverage defined rules and a semantic data model to ease configuration.
a) The building system fault engine shall run periodically against a minimum of seven days of historical data.

bb. Fault Triage
1) Provide a means to display additional information on a particular fault along with corrective actions in the order of their likeliness to resolve the issue, a description of the fault, charting of supporting data, and an activity log to track progress of triage attempts. Functionality shall enhance the sorting order and information in the Faults display to introduce fault occurrences and durations to better drive the most problematic issues to the top of the list.

D. Associated Application Components
1. Security/Passwords
a. Multiple-level passwords access protection shall be provided via roles and permissions. The feature will allow the system to base access on a user's job title or role and allow the user/manager access interface control, display, and database manipulation capabilities based on an assigned password.

b. Roles may be copied and altered to meet specific roles and permissions based on the particular policies.
c. The system shall allow each user to change his or her password at will.
d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
e. A maximum of 150 categories may be used to determine or assign areas of responsibilities to each user account.
f. A minimum of 100 unique passwords shall be supported.
g. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
h. Operators shall be further limited to only access, command, and modify those buildings, systems, and subsystems for which they have responsibility. Provide a minimum of 100 categories of systems to which individual operators may be assigned.
i. The system shall automatically generate a report of log-on/log-off and system activity for each user.
j. The system shall have the ability to provide a Department of Defense (DoD) specific warning banner for applicable sites that warns the user they are accessing a restricted site.
k. After successful login the last time and date that user name was previously logged in is shown on the screen.
l. Each login attempt is recorded in the system Audit Log with the option to record the IP address of the PC that made the login.

2. Screen Manager
   a. The system will allow a customized image on the login screen (e.g. organization name, logo).
   b. User View navigations can be displayed as either a set of tabs or a drop down list.
   c. Allows user preference for assigning of a background color for when an object is Out of Service which will enable the operator to quickly distinguish points that have been commanded to this state.
   d. The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.
3. Historical trending and data collection
   a. Each Network Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:
      1) Any point, physical or calculated, may be designated for trending. Two methods of collection shall be allowed:
         a) Defined time interval
         b) Upon a change of value
   b. Each Network Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.

2.4 NETWORK CONTROL ENGINE (NCE)

A. Network Control Engine (NCE)

1. The Network Control Engine shall be a fully user-programmable, supervisory controller. The NCE shall monitor the network of equipment controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Engines.
2. The NCE shall also be a fully user-programmable, equipment controller that includes a minimum of 28 I/O points.
3. Automation Network – The NCE(s) shall reside on the automation network and shall support a subnet system controllers via an integral Control network connection.
4. Automation network temporary cellular connection – The BAS shall be provided with a temporary connection via a “master” control engine whereby the Automation network and connected “slave” engines can be accessed remotely before Owner’s IT network is operational. This project shall include at least one connected control engine.
    a. The connected control engine shall be a standard catalog product of the BAS manufacturer. Non-standard or custom applications are not acceptable.
    b. This connected control engine shall be panel mounted with a cellular modem, remote antenna and antenna cables, 5 port Ethernet switch, and a power supply with convenience outlet,
    c. The “master” control engine shall communicate with a temporary Automation Data Server which can be used to remotely load graphics, generate and load database, program, commission and demonstrate the BAS.
    d. A one-year cellular contract shall be included within this contract at no additional cost to the Owner. Multiple cellular services shall be made available to choose from to allow for best connection strength at the jobsite. The costs of the remote server shall be included within this contract at no additional cost to the Owner.
5. User Interface – Each Network Control Engine shall have the ability to deliver a web-based User Interface previously described. All computers connected physically or virtually to the automation network shall have access to the web-based user interface.
6. Processor – The NCE(s) shall be microprocessor-based with a minimum word size of 32 bits. The Network Control Engine shall be a multi-tasking, multi-user, and real-time digital control process. Standard operating systems shall be employed. NCE(s) size and capability shall be sufficient to fully meet the requirements of this Specification.
7. Memory – Each NCE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
8. Secure Boot – The NCE shall prevent malicious or unauthorized software applications from loading during the system startup process.
9. Background File Transfer – The NCE shall provide the capability to download a new image and database to a network engine while the engine is still running and controlling the building.
10. User Authentication – The NCE shall support local user authentication.

11. Password Security – Access to the Network Control Engines' embedded user interface shall require a password of 8 to 50 characters including a minimum of one lower case letter, one upper case letter, one number, and one special character. An alarm shall be generated after three unsuccessful attempts within 15 minutes and the user shall be denied access until permission is renewed by a system administrator.
12. Network Security – Communication between the NCE and other system networked devices including additional Network Engines, Application and Data Servers, Open Data Servers (BACnet listed OWS), and user interface clients shall be encrypted and support HTTPS with Transport Level Security (TLS) Version 1.2. Self-signed certificates are to be provided with the option of configuring trusted certificates. Engines shall also be equipped to optionally support FIPS 140-2 Federal Government encryption standard.
13. Hardware Real Time Clock – The Network Control Engine shall include an integrated, hardware-based, real-time clock, with a supercapacitor to maintain time for a minimum of 72 hours during a power loss. Controllers using a battery to maintain time during a power loss shall not be acceptable.
14. Diagnostics – The NCE(s) shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The NCE(s) shall provide both local and remote annunciation of any detected component failures or repeated failures to establish communication.
15. Power Failure – In the event of the loss of normal power, the NCE(s) shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.
    a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
    b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.
16. Certification – The NCE(s) shall meet and be listed to the UL 916 Standard for Energy Management Equipment and be FCC Compliant to CFR47, Part 15, Subpart B, Class A.
17. Device Integration – The NCE(s) shall support integrating and supervising networked devices using the following communication protocols on the device/controller network:
    a. The NCE (s) shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135 on the controller network.
        1) The NCE (s) shall support Remote Field Bus integration via a BACnet IP to MS/TP router.
        2) The NCE (s) shall be tested and BTL listed/certified as a BACnet Building Controller (B-BC).
        3) A BACnet Protocol Implementation Conformance Statement shall be provided for the NCE(s).
    b. The NCE(s) shall optionally support integration of networked devices using the following networking protocols:
        1) BACnet
        2) Johnson Controls N2 or third party N2 Open devices.
        3) LonTalk
        4) MODBUS RTU

5) MODBUS TCP
6) KNX
7) M-Bus
8) OPC UA

18. The NCE shall employ a finite state programming to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
19. The NCE shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only, shall not be acceptable.
20. The NCE shall support the following types of inputs and outputs:
    a. Universal Inputs – shall be configured to monitor any of the following for Analog inputs: Voltage Mode, Current Mode, Resistive Mode. For Binary Inputs: Dry Contact Maintained Mode, Pulse Counter Mode
    b. Analog Outputs – shall be configured to output either of the following: Voltage Mode, Current Mode
    c. Binary Outputs – shall output the following: 24VAC Triac
    d. Configurable Outputs – shall be configured to output either of the following:
        1) Analog Output Voltage Mode
        2) Binary Output 24 VAC Triac Mode
    e. The NCE shall have the ability to monitor and control a network of sensors and actuators over a Sensor Actuator (SA) Bus dedicated to the controller. This bus shall be a MS/TP Bus supporting BACnet Standard protocol SSPC-135 supporting no less than 9 devices with a maximum distance of 1,200 Ft. between the NCE and the furthest connected device.
21. The NCE shall provide removable, labeled, screw terminal blocks for 24 VAC power, communication bus and I/O point field wiring.
22. The NCE shall include the following multi-color, flashing LEDs to indicate important operating conditions and status
23. Communications Ports – The NCE(s) shall provide the following ports for connecting networkable devices:
    a. Two (2) USB ports
    b. One (1) RS-485 port
    c. Two (2) Ethernet ports
24. The NCE shall support an integrated user interface featuring a display and keypad in lieu of on-board HOA switches for output overrides.
    a. The integrated user interface shall allow viewing and monitoring points, alarms, and trends.
    b. The integrated user interface shall allow viewing and changing setpoints, modes of operation, and parameters.
    c. The integrated user interface shall provide password protection with user-adjustable password timeout.
    d. The information presented by the integrated user interface shall be organized into folders for easy navigation.
    e. The integrated user interface shall support textual descriptions in English for each point.
    f. The display shall be, at minimum, a 2.4-inch, color display with 320x240 resolution.

g. The display shall support adjustable contrast and brightness.
h. The keypad shall include no more than seven (7) keys.

25. The NCE shall support up to 50 supervised devices across all supported integrations.

2.5 DDC EQUIPMENT CONTROLLERS

A. General Purpose Application Controller (GPAC)

1. The General Purpose Application Controller (GPAC) shall be a fully programmable, digital controller that communicates via the BACnet MS/TP protocol over the FC Bus.
   a. The GPAC shall support BACnet Standard ANSI/ASHRAE 135.
      1) The GPAC shall be BTL listed/certified.
      2) The GPAC shall be tested and certified as a BACnet Advanced Application Controller (B-AAC).
      3) A BACnet Protocol Implementation Conformance Statement shall be provided for the GPAC.
2. The GPAC shall employ finite state programming to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
3. GPAC shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.
4. The GPAC shall be assembled in a plastic housing with protection class IP20 (IEC529) and flammability rated to UL94-5VB.
5. The GPAC shall include an integral real-time clock and support time-based tasks which enables these field controllers to monitor and control schedules, calendars, alarms, and trends.
6. The GPAC can continue time-based monitoring when offline for extended periods of time from a network.
7. The GPAC can operate as a stand-alone controller in applications that do not require a networked supervisory device or for network applications where it is preferred to have the scheduling, alarming, and/or trending performed locally in the equipment controllers.
8. The GPAC shall include troubleshooting LEDs to indicate the following conditions normal or abnormal operation of power, controller fault, SA bus communications, FC Bus communications, and end of line on/off.
9. The GPAC shall have the ability to transfer and apply firmware files to all SA Bus devices (EOIM, IOM, and networked zone sensors) connected to it.
10. The GPAC shall include removable and labeled screw terminal blocks for all I/O, FC and SA Bus communication, and power wiring connections.
11. The GPAC shall accommodate the direct wiring of analog and binary I/O field points with the following resolution.
    a. Inputs – 24-bit analog-to-digital converter
    b. Outputs – +/- 200 mV accuracy in 0-10 VDC applications
12. The GPAC shall support the following types of inputs and outputs supplied in the amounts required for the specified applications:

a. Universal Inputs – 0-10 VDC analog input, 4-20 mA analog input, 0-600k ohms analog input, Dry contact binary input
b. Binary Inputs – Dry Contact Maintained Mode, Pulse Counter Mode
c. Analog Outputs – 0-10 VDC analog output, 4-20 mA analog output
d. Binary Outputs – 24 VAC Triac
e. Configurable Outputs – 0-10 VDC analog output, 24 VAC Triac binary output

13. The GPAC shall have the ability to monitor and control a network of sensors and actuators over a SA Bus.
14. The GPAC shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.
15. The GPAC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over a MS/TP Bus.
16. The GPAC shall support a Local Controller Display as a remote device communicating over the SA Bus.
    a. The Display shall use a BACnet Standard SSPC-135 MS/TP protocol.
    b. The Display shall allow the user to view monitored points without logging into the system.
    c. The Display shall allow the user to view and change setpoints, modes of operation, and parameters.
    d. The Display shall provide password protection with user adjustable password timeout.
    e. The Display shall be menu driven with separate paths for:
        1) Input/Output
        2) Parameter/Setpoint
        3) Overrides
    f. The Display shall use easy-to-read English text messages.
    g. The Display shall allow the user to select the points to be shown and in what order.
    h. The Display shall support a back lit LCD with adjustable contrast and brightens and automatic backlight brightening during user interaction.
    i. The Display shall have a keypad.
    j. The Display shall be panel mountable.

2.6 FIELD DEVICES

A. Expansion Input/Output Module (EIOM)
1. The EIOM provides additional input and output interfaces for use in digital controllers.
2. The EIOM shall communicate with controllers over the FC Bus or the SA Bus.
3. The EIOM shall support BACnet Standard ANSI/ASHRAE 135.
    a. The EIOM shall be BTL listed/certified and carry the BTL Label.
    b. The EIOM shall be tested and certified as a BACnet Smart Actuator (B-SA).
    c. A BACnet Protocol Implementation Conformance Statement shall be provided for the IOM.
4. The EIOM shall include removable screw terminal blocks for all I/O, SA/FC bus communication, and power wiring connections.

5. The EIOM shall include three (3) decimal rotary dial switches for setting the BACnet MS/TP device address.
6. The IOM shall accommodate the direct wiring of analog and binary I/O field points with the following resolution:
    a. Inputs – 24-bit analog-to-digital converter
    b. Outputs – +/- 200 mV accuracy in 0-10 VDC applications
7. The EIOM shall support the following types of inputs and outputs:
    a. Universal Inputs – 0-10 VDC analog input, 4-20 mA analog input, 0-600k ohms analog input, Dry contact binary input
    b. Binary Inputs – Dry Contact Maintained Mode, Pulse Counter Mode
    c. Analog Outputs – 0-10 VDC analog output, 4-20 mA analog output
    d. Binary Outputs – 24 VAC Triac
    e. Configurable Outputs – 0-10 VDC analog output, 24 VAC Triac binary output
8. The EIOM shall include troubleshooting LEDs to indicate the following conditions normal or abnormal operation of power, controller fault, SA bus communications, FC Bus communications, and end of line on/off.

B. Networked Thermostat (TEC)
1. The Networked Thermostat shall include an intuitive User Interface providing plain text messages.
    a. Two-line, 8 character backlit display
    b. LED indicators for Fan, Heat, and Cool status
    c. Five (5) User Interface Keys
        1) Mode
        2) Fan
        3) Override
        4) Degrees C/F
        5) Up/Down
2. The Networked Thermostats shall provide the flexibility to support the following inputs:
    a. Integral Indoor Air Temperature Sensor
    b. Duct Mount Air Temperature Sensor
    c. Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator.
    d. Two configurable binary inputs
3. The Networked Thermostats shall provide the flexibility to support the following outputs:
    a. Three Speed Fan Control
    b. On/Off Control
    c. Floating Control
    d. Proportional (0 to 10V) Control

C. Network Sensors (NS)
1. The Network Sensors (NS) shall have the ability to monitor the following variables all within a single wall-mounted enclosure (no exceptions) as required by the systems sequence of operations:
    a. Zone temperature
    b. Zone humidity
    c. Zone carbon dioxide
    d. Zone set point

2. The NS shall transmit the zone information back to the controller on the Sensor-Actuator Bus (SA Bus) using BACnet Standard protocol SSPC-135.
3. The NS shall be BTL listed/certified and carry the BTL Label.
   a. The NS shall be tested and certified as a BACnet Smart Sensors (B-SS).
4. The Network Zone Temperature Sensors shall include the following items:
   a. A backlit LCD to indicate the temperature, humidity and setpoint
   b. An LED to indicate the status of the Override feature
   c. A button to toggle the temperature display between Fahrenheit and Celsius
   d. A button to program the display for temperature or humidity
   e. A button to initiate a timed override command
   f. Available in either surface mount, wall mount, or flush mount
   g. Available with either screw terminals or phone jack

D. System Tools
1. One software copy of each system tool shall be provided with the BAS.
2. System Configuration Tool
   a. The Configuration Tool shall be a software package enabling a computer platform to be used as a stand-alone engineering configuration tool for a Network Engine.
   b. The configuration tool shall provide an archive database for the configuration and application data.
   c. The configuration tool shall provide a site discovery feature to automatically discover field devices on connected buses and networks. Automatic discovery shall be available for the following field devices:
      1) BACnet Devices
      2) LonWorks devices
      3) Johnson Controls N2 Bus devices
   d. A wireless access point shall allow a wireless enabled portable PC to make a temporary Ethernet connection to the automation network.
   e. Provide Johnson Controls SCT or approved equal.
3. Controller Configuration Tool (CCT)
   a. As part of the single software tool environment including system and controller elements, the Controller Configuration Tool (CCT) shall be used to configure, simulate and commission equipment controllers and NCE controllers.
   b. The CCT shall operate in distinct modes to facilitate efficiency at various steps in the steps leading to project completion as well as future upgrades and maintenance
   c. The configuration tool shall be capable of programming the Equipment Controllers.
      1) The configuration tool shall provide the capability to configure, simulate, and commission the Equipment Controllers.
      2) The configuration tool shall allow the equipment controllers to be run in Simulation Mode to verify the applications.
      3) The configuration tool shall contain a library of standard applications to be used for configuration.
   d. The CCT shall provide multiple options for downloading files to the controllers including direct wired, wireless and Ethernet pass thru as dictated by controller type and location.

2.7 INPUT DEVICES

A. General Requirements
   1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. Temperature Sensors
   1. General Requirements:
      a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
      b. The temperature sensor shall be of the resistance type and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
      c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:
   2. Room Temperature Sensors
      a. Room sensors shall be constructed for either surface or wall box mounting.
      b. Room sensors shall have the following options when specified:
         1) Set point reset providing a +3 degree (adjustable) range.
         2) Individual heating/cooling set point slide switches.
         3) A momentary override request push button for activation of after-hours operation.
      c. Provide digital display of sensed temperature.
   3. Thermo wells
      a. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
      b. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
      c. Thermo wells and sensors shall be mounted in a threadolet or 1/2” NFT saddle and allow easy access to the sensor for repair or replacement.
      d. Thermo wells shall be constructed of 316 stainless steel.
   4. Outside Air Sensors
      a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
      b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
      c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
   5. Duct Mount Sensors
      a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
      b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
      c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
   6. Averaging Sensors
      a. For ductwork greater in any dimension that 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.

b. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.
c. Capillary supports at the sides of the duct shall be provided to support the sensing string.

C. Humidity Sensors
1. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.
2. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.
3. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.
4. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.
5. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
6. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

D. Carbon Dioxide Sensors
1. Duct Mounted
a. Sensor shall be remote-mounted diffusion-aspirated, single-beam dual-wavelength sensor type with Infrared (IR) source, sample cell, tunable-interference filter, and IR detector. .
b. Sensing cell shall be provided with thirty (30) inch cable for duct mounting.
c. Sensor shall produce linear analog 0-1 Volt DC, 4-20 MA, and binary adjustable switch point form C outputs.
d. Range shall be 0-2000 parts per million with accuracy of two (2) percent.
e. Sensor shall be mounted in weather tight enclosure with forty-one (41) degree Fahrenheit to 104 degree Fahrenheit operating temperature.
f. Sensor shall be capable of maintaining calibration within 2% for a one year period of operation.
2. Wall Mounted
a. Sensor shall be wall-mounted diffusion-aspirated, single-beam dual-wavelength sensor type with Infrared (IR) source, sample cell, tunable-interference filter, and IR detector. .
b. Sensing cell shall be provided with thirty (30) inch cable for duct mounting.
c. Sensor shall produce linear analog 0-1 Volt DC, 4-20 MA, and binary adjustable switch point form C outputs.
d. Range shall be 0-2000 parts per million with accuracy of two (2) percent.
e. Sensor shall be mounted in weather tight enclosure with forty-one (41) degree Fahrenheit to 104 degree Fahrenheit operating temperature.
f. Sensor shall be capable of maintaining calibration within 2% for a one year period of operation.

E. Differential Pressure Transmitters

1. General Air and Water Pressure Transmitter Requirements:
   a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
   b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
   c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
   d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.
2. Low Differential Water Pressure Applications (0” - 20” w.c.)
   a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.
   b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
   c. .01-20” w.c. input differential pressure range.
   d. 4-20 mA output.
   e. Maintain accuracy up to 20 to 1 ratio turndown.
   f. Reference Accuracy: +0.2% of full span.
3. Medium to High Differential Water Pressure Applications (Over 21” w.c.)
   a. The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:
      1) Differential pressure range 10” w.c. to 300 PSI.
      2) Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability).
   b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
4. Building Differential Air Pressure Applications (-1” to +1” w.c.)
   a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
   b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
      1) -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)
      2) 4-20 mA output.
      3) Maintain accuracy up to 20 to 1 ratio turndown.
      4) Reference Accuracy: +0.2% of full span.
5. Low Differential Air Pressure Applications (0” to 5” w.c.)
   a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
   1) (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)
   2) 4-20 mA output.
   3) Maintain accuracy up to 20 to 1 ratio turndown.
   4) Reference Accuracy: +0.2% of full span.

6. Medium Differential Air Pressure Applications (5" to 21" w.c.)
   a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:
      1) Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
      2) Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.
      3) Thermal Effects: <+.033 F.S./Deg. F. over 40 F. to 100 F. (calibrated at 70 F.).
   b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

F. Air Flow Monitoring - Fan Inlet Airflow Measuring Station (AFMS)
1. Subject to compliance with all requirements of this section, provide EBTRON, Inc. Model GTx108-F (basis of design) or approved equal.
2. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.
   a. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.
   b. Vortex shedding airflow measurement devices, pitot tubes, pitot arrays, piezo-rings and other differential pressure measurement devices are not acceptable.
3. General
   a. Provide one AMD for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature of each fan at each measurement location.
   b. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.
      1) Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
   c. Airflow measurement shall be field configurable to determine the average actual or standard mass airflow rate.
      1) Actual airflow rate calculations shall have the capability of being field adjusted by the transmitter for altitudes other than sea level.
   d. Temperature output shall be field configurable to provide either the velocity-weighted duct average temperature or simple arithmetic average temperature.

4. Sensor Probes
    a. Each sensor probe shall consist of one sensor node mounted on a 304 stainless steel block with two adjustable zinc plated steel rods connected to 304 stainless steel pivoting mounting feet.
    b. Sensor node internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
    c. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67°F to 392°F and continuous and direct UV exposure.
        1) Plenum rated PVC jacket cables are not acceptable.
    d. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
    e. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.
    f. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy.
        1) Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
    g. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
    h. Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.
    i. The number of independent sensor nodes provided shall be as follows:
        1) SWSI and DWDI fans: 2 probes x 1 sensor node/per probe in each fan inlet
        2) Fan Arrays (2 to 4 fans):
            a) 2 probes x 1 sensor node per probe in each fan inlet
        3) Fan Arrays (5 to 8 fans): 1 probe x 1 sensor node per probe in each fan inlet.
5. Transmitter
    a. A remotely located microprocessor-based transmitter shall be provided for each measurement location.
    b. The transmitter shall be comprised of a main circuit board and interchangeable interface card.
    c. All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
    d. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
    e. All receptacle plug pins shall be gold plated.
    f. The transmitter shall be capable of determining the average airflow rate and temperature of each fan.
        1) Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).
    g. The transmitter shall have startup firmware to facilitate setup of multiple fans and fan areas.
    h. The transmitter shall be capable of providing a high and/or low airflow alarm.
    i. The transmitter shall be capable of providing individual fan alarming on fan array configurations.

j. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
k. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.
    1) The total airflow rate, temperature, airflow alarm, individual fan alarm and system status alarm shall be visible on the display.
l. The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and either:
    1) one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection; or
    2) one isolated Ethernet (simultaneously supported BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection. Note: LonWorks capable models shall be provided without analog outputs.
m. Analog signal capability shall include two output terminals: the first, shall provide the total airflow rate; while the second output shall be field configurable to provide one of the following:
    1) temperature
    2) airflow alarm
    3) individual fan alarm; or
    4) system status alarm
n. Network communications shall provide: the total airflow rate, average temperature, individual fan airflow rates, individual fan temperatures, airflow alarm, individual fan alarm, system status alarm, individual sensor node airflow rates, individual sensor node temperatures and fan inlet area.
o. The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.
p. The transmitter shall use a “watchdog” timer circuit to ensure continuous operation in the event of brown-out and/or power failure.

6. Performance
    a. Each sensing node shall have an airflow accuracy of ±2% of reading over an operating range of 0 to 10,000 FPM.
        1) Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
            a) Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
    b. Each sensing node shall have a temperature accuracy of ±0.15° F over an operating range of -20° F to 160° F°.
7. Install in accordance with manufacturer’s placement and installation guidelines.

G. Air Flow Monitoring – Outdoor Air Hood
1. Provide airflow temperature measurement device for installation in the outdoor air hood (with adjustable standoff) of rooftop packaged air handling unit. Provide where indicated on the drawings, upstream of the outdoor damper.
2. Each measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter. Each transmitter shall operate on 24VAC.

3. Each sensing point shall independently determine the airflow rate and temperature, which shall be equally weighted and averaged by the transmitter prior to output.
4. General
   a. Probe and Sensor Node Configurations
      1) 1 probe x 1 sensor node
      2) 2 probes x 1 sensor node/probe
   b. Installed Airflow Accuracy
      1) In Openings Less or Equal to 8 sq.ft.: ±(3% to 15%), typical.
      2) In Openings Greater Than 8 sq.ft.: Not recommended.
   c. Sensor Node Averaging Method
      1) Airflow: Independent (arithmetic average on 2 sensor configurations installed at a single measurement location).
      2) Temperature: Independent, velocity weighted average on 2 sensor configurations installed at a single measurement location.
   d. Listings and Compliance
      1) UL: 60730-1, 60730-2-9; CAN E60730-1, E60730-2-9 (EF-A2000-U Only).
      2) FCC: This device complies with Part 15 of the FCC rules.
      3) RoHS: This device is RoHS2 compliant.
   e. Environmental Limits
      1) Temperature:
         a) Probes 0 to 2,000 fpm: -20 to 160 ºF.
         b) Probes 0 to 3,000 fpm: 0 to 160 ºF .
         c) Transmitter: -20 to 120 ºF.
      2) Humidity: (non-condensing).
         a) Probes: 0 to 100%.
         b) Transmitter: 5 to 95%.
5. Individual Sensing Nodes
   a. Sensing Node Sensors
      1) Self-heated sensor: Precision, hermetically sealed, bead-in-glass thermistor probe.
      2) Temperature sensor: Precision, hermetically sealed, bead-in-glass thermistor probe.
   b. Sensing Node Housing
      1) Material: Glass-filled Polypropylene.
      2) Sensor Potting Materials: Waterproof marine epoxy.
   c. Sensing Node Internal Wiring
      1) Type: Kynar® coated copper.
   d. Airflow Measurement
      1) Accuracy: ±3% of reading (typical), 4% max. to NIST-traceable airflow standards (includes transmitter uncertainty).
      2) Calibrated Range: 0 to 3,000 fpm.
      3) Calibration Points: 7.
   e. Temperature Measurement
      1) Accuracy: ±0.15 ºF to NIST-traceable temperature standards (includes transmitter uncertainty).
6. Sensor Probe Assembly
   a. Tube
      1) Material: Mill finish 6063 aluminum.
   b. Mounting Brackets

1) Material: 304 stainless steel.
c. Mounting Type & Overall Probe Length
1) Insertion: 6, 8 or 16 in. (adjustable).
2) Stand-off: 6, 8 or 16 in. (adjustable).
d. Probe to Transmitter Cables
1) Type: FEP jacket, plenum rated CMP/CL2P, UL/cUL listed, -67 to 302 ºF, UV tolerant.
2) Standard Lengths: 10, 25 and 50 ft.
3) Connecting Plug: 0.60” nominal diameter.

7. Transmitter
a. Power Requirement: 24 VAC (22.8 to 26.4 under load) @8V-A.
b. User Interface: 16-character LCD display and 4 button interface.
c. BAS Connectivity:
1) EF-N2000 Transmitter: One field selectable (BACnet MS/TP or Modbus RTU) and non-isolated RS-485 network connection. Individual sensor node airflow rates and temperatures shall be available via the network (provide individual 24 VAC transformers for each EF-N2000 transmitter for applications requiring isolated RS-485).
d. Relay
1) Type: Dry Contact w/ onboard jumper to drive a remote LED (R1=alarm).
2) Status: N.O. or N.C. via user setup configuration.
3) Rating: 30 VDC or 24 VAC @ 3 amp. max.
e. Airflow Alarm
1) Type: Low and/or high user defined setpoint alarm.
2) Tolerance: User defined % of setpoint.
3) Delay: User defined.
4) Zero Disable: Alarm can be disabled when the airflow rate falls below the low limit cutoff value (unoccupied periods).
5) Reset Method: Manual or automatic.
6) Visual Indication: Yes, LCD display.
7) Network Indication: Yes (EF-N2000 only).
8) Analog Signal Indication: Yes, on AO2 assignment (EF-A2000 only).
9) Contact Closure Relay: Yes, on R1 assignment.
f. System Status Alarm
1) Type: Sensor diagnostic system trouble indication.
2) Visual Indication: Yes, LCD display.
3) Network Indication: Yes (EF-N2000 only).
4) Analog Signal Indication: Yes, on AO2 assignment (EF-A2000 only).
5) Contact Closure Relay: Yes, on R1 assignment.

8. Install in accordance with manufacturer’s placement and installation guidelines.
9. Basis of Design: Ebtron EB-Flow II EF-x2000-U

H. Natural Gas Meters
1. Basis-of-Design Product: Subject to compliance with requirements, provide ONICON F-5000 or comparable product by one of the following:
a. Comate Intelligent Sensor Co., Ltd
b. ONICON Incorporated
c. Sage Metering

2. Description: Thermal mass flow meter, complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown.
3. Calibration:
   a. Individually wet-calibrated against a standard that is directly traceable to NIST.
   b. Meter shall allow for field validation testing of the current calibration and provide for a printed validation test report.
   c. A certificate of calibration shall be provided with each flow meter.
4. Flow meter shall be hand-insertable up to 60 psi.
5. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
6. Sensing: Pair of encapsulated platinum sensors. Meter shall not require additional temperature or pressure compensation.
7. Accuracy:
   a. ± 1% of rate from 500-7000 SFPM.
   b. ± 2% of rate from 100-500 SFPM.
8. Flow Range: 1000:1 turndown
9. Material:
   a. Wetted metal components: 316 stainless steel.
10. Electronics Enclosure: Weathertight NEMA 4 aluminum enclosure
11. Integral microprocessor-based electronics. Provide output signal to BAS.
12. Output:
   a. (1) analog 4-20mA output
   b. (1) additional output factory configured as either a totalizing pulse or an RS485 interface for connection to a BACnet MS/TP or Modbus RTU serial network.
13. Display: Provide a D-100 Series Display Module for local or remote indication of flow rate and total.
14. Output signals: Shall be either serial network (protocol conforming to BACnet® MS/TP, BACnet/IP, LONWORKS®, MODBUS RTU RS485, MODBUS RTU TCP/IP, JCI-N2, or Siemens-P1) or via individual analog and pulse outputs.
15. Operating Instructions: Include complete instructions with each flowmeter.
16. Provide a flow conditioner if required to meet the manufacturer's minimum upstream straight pipe run requirement.
17. Each flow meter shall be covered by the manufacturer's two-year warranty.

I. Power Monitoring Devices
   1. Current Measurement (Amps)
      a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.
      b. Current Transformer – A split core current transformer shall be provided to monitor motor amps.
         1) Operating frequency – 50 - 400 Hz.
         2) Insulation – 0.6 Kv class 10Kv BIL.
         3) UL recognized.
         4) Five amp secondary.
         5) Select current ration as appropriate for application.

2. Current Transducer – A current to voltage or current to mA transducer shall be provided. The current transducer shall include:
   a. 6X input over amp rating for AC inrushes of up to 120 amps.
   b. Manufactured to UL 1244.
   c. Accuracy: +.5%, Ripple +1%.
   d. Minimum load resistance 30kOhm.
   e. Input 0-20 Amps.
   f. Output 4-20 mA.
   g. Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).

J. Power and Energy Meters:
1. Power meters shall be furnished by BAS contractor, installed and wired by the electrical contractor. Communication trunk from the BAS and integration with the BAS shall be provided by the BAS contractor. Power meter(s) shall be compatible with the Building Automation System (BAS) provided under Division 23. Refer to Electrical
2. The power meter shall be fully electronic with multi-line backlit LCD display showing measured parameters as well as alarm functions and pulse output.
3. The power meter shall perform the following measurements:
   a. Accumulated Real Energy (kWh) for each phase and total of all phases
   b. Accumulated Reactive Energy (kVARh) and Apparent Energy (kVAh) totals for all phases
   c. Net Present Demand for Real (kW), Reactive (kVAR) and Apparent (kVA) Power over a user-specified interval (block or sliding window)
   d. Maximum (Peak) Real (kW), Reactive (kVAR) and Apparent (kVA) Demand Intervals
   e. Instantaneous Real (kW), Reactive (kVAR) and Apparent Power (kVA), by phase and in total
   f. Current (amps) for each phase and average of all phases
   g. Phase-to-phase voltage for each phase and average of all phase pairs
   h. Phase-to-neutral voltage for each phase pair and average of all phases
   i. Power factor for each phase and average of all phases
   j. AC frequency
4. The power meter shall communicate using the BACnet MS/TP protocol at speeds from 9600 to 115,200 baud (no parity). The meter shall provide a BACnet Device object, a set of writable Analog Value objects for remote configuration, a set of Analog Input objects to provide access to scaled 32-bit measurement values and their unit types, and a set of Binary Input objects for indicating individual alarm conditions.
5. The meter shall be UL/CUL listed to the latest applicable safety standards.
6. Power meter models shall accept voltage input over the range of 90 to 600 VAC (50 or 60 Hz).
7. The power meter shall accept 0 to 0.333VAC input from up to three current transducers (U018 Rope Style CTs only) from 20 to 5000 amps.
8. The measured energy consumption shall be retained in non-volatile memory for the life of the product warranty.
9. The power meter shall have demand measurement programmable for up to 6 sub-intervals of 10 seconds to 546 minutes duration.
10. Meter shall be optionally available in an outdoor NEMA 4X enclosure.
11. The power meter shall operate from -30°C to +70°C.

12. The power meter shall have dimensions not exceeding 4.2” x 3.6” x 2.3”.
13. The power meter shall meet both ANSI C12.20 .5% and IEC 62053-22 Class .5S real power and energy accuracy specifications.
14. The power meter shall meet IEC 62053-22 Class 2 reactive power and energy accuracy specifications.
15. The power meter shall be configurable for operation on Single Phase (AN or AB), Split Phase (ABN), Delta (ABC), and Wye (ABCN) systems.
16. The power meter shall have automatic phase reversal compensation such that it is insensitive to the CT’s load orientation.
17. The power meter shall have separate control power inputs such that is may be powered from a different service than it measures.
18. The power meter shall have Phase Loss Alarm contacts with a user configurable phase loss threshold.
19. The power meter shall be configurable for use with Potential Transformers to 5000 volts.
20. The power meter shall support warnings for low power factor (phase current or voltage miss-wired), current over range, voltage over range, and frequency out of range.
21. The product shall have a 5-year warranty.
22. The power meter shall be Veris E50H2 or equivalent.

K. Status and Safety Switches
   1. General Requirements
      a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BAS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.
   2. Current Sensing Switches
      a. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
      b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
      c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
   3. Air Filter Status Switches
      a. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.
      b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
      c. Provide appropriate scale range and differential adjustment for intended service.
   4. Air Flow Switches
      a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.

5. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.
   a. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.
6. Low Temperature Limit Switches
   a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
   b. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.
   c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

2.8 OUTPUT DEVICES

A. Actuators
   1. General Requirements
      a. Damper and valve actuators shall be electronic. Controls submittals shall indicate actuator fail position as normally open or closed.
   2. Electronic Damper Actuators
      a. Electronic damper actuators shall be direct shaft mount.
      b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.
      c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
      d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.
   3. Electronic Valve Actuators

a. Electronic valve actuators shall be manufactured by the valve manufacturer.
b. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
c. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized Based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.
d. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

B. Control Relays
1. Control Pilot Relays
a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
b. Mounting Bases shall be snap-mount.
c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
d. Contacts shall be rated for 10 amps at 120VAC.
e. Relays shall have an integral indicator light and check button.

C. Control Valves (Chilled Water)
1. All modulating control valves shall be of the "pressure independent" type configured with one integrated valve body that incorporates one chamber with an adjustable Cv and a separate pressure regulating chamber used to maintain a constant differential pressure across the control surface.
2. Each control valve shall be individually flow tested at the factory and verified to deviate no more than ±5% through the selected operating pressure range. A calibrated performance tag shall be provided with each valve that verifies the flow rate in 10° rotation increments up to full rated flow (option with 1/2"). All testing shall be performed with instruments calibrated to the requirements of ANSI/ISA-S75.11-1985, with traceability to NIST and/or ISO standards.
3. Control valve rangeability shall be 50:1 minimum.
4. Each control valve shall be subjected to 70 psid and tested to exceed ANSI/FCI 70-2-1998 leakage ratings. Class IV leakage or better is required for control valves 2" nominal size and less. Class III leakage or better is required for control valves larger than 2".
5. In all control valves 8" and smaller, it shall be possible to modify the valve flow characteristics without removing the valve from the piping system.

6. Balancing valves and associated balancing shall not be required where pressure independent modulating control valves are installed.
7. The control valve actuator shall modulate all valves up to 8" in nominal size from 0 to 100% design flow while rotating the valve stem a maximum of 90°.
8. There shall be three ports installed at the factory integral to each valve and capable of being used to measure pressure or temperature. The first port shall be installed at the inlet to the valve. The second shall be installed between the Cv chamber and the pressure regulating chamber. The third shall be installed at the outlet of the valve. Should the ports not be provided as part of the valve body than they shall be installed in a spool piece and attached to the body.
9. The differential pressure between the first and the third port shall be used in commissioning to verify that the minimum differential pressure (typically 5 psid) required for pressure independent operation is available.
10. The differential pressure between the first and second ports shall be used to verify proper valve operation and flow regulation. It shall be possible to verify the flow rate through the control valve using the valve stem position and the differential pressure measurement between the first and second port in the valve. If these valve features are not available, a flow meter shall be installed to verify actual flow rate in operation through the valve.
11. CB valves to be standard modulating.
12. All valves shall be warranted by the manufacturer for no less than 3 years from the date of purchase.
13. Acceptable manufacturers: Belimo, Brae, Danfoss, Delta Flow.

D. Control Valves (Hot Water Systems)
1. All automatic control valves shall be “pressure independent” type, fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Specification.
2. Hot water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer’s recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.
3. Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.
4. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all special applications as indicated on the valve

schedule. Valve discs shall be composition type. Valve stems shall be stainless steel.

5. Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system, and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.
6. All valves shall be warranted by the manufacturer for no less than 3 years from the date of purchase.
7. Acceptable manufacturers: Belimo, Brae, Danfoss, Delta Flow.

2.9 MISCELLANEOUS DEVICES

A. Local Control Panels
   1. All control panels shall be factory constructed, incorporating the BAS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch.
   2. In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.
   3. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
   4. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
   5. All wiring shall be neatly installed in plastic trays or tie-wrapped.
   6. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.

B. Thermostats
   1. Electric room thermostats of the heavy-duty type shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, where required. All these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.
   1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
   2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.2 BAS SPECIFIC REQUIREMENTS

A. Graphic Displays
   1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.
   2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

B. Actuation / Control Type
   1. Primary Equipment
      a. Controls shall be provided by equipment manufacturer as specified herein.
      b. All damper and valve actuation shall be electric.
   2. Air Handling Equipment
      a. All air handers shall be controlled with a HVAC-DDC Controller
      b. All damper and valve actuation shall be electric.
   3. Terminal Equipment:
      a. Terminal Units (VAV, FCU etc.) shall have electric damper and valve actuation.
      b. All terminal units shall be controlled with HVAC-DDC Controller.

3.3 INSTALLATION

A. BAS Wiring
   1. All conduit, wiring, accessories and wiring connections required for the installation of the Building Automation, as herein specified, shall be provided by the BAS Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes, unless specified otherwise in this section.
   2. All BAS wiring materials and installation methods shall comply with BAS manufacturer recommendations.

3. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BAS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BAS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.
4. Class 2 Wiring
   a. All Class 2 (24VAC or less) wiring shall be installed in conduit.
   b. Conduit shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
5. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
6. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

B. BAS Raceway
1. All wiring shall be installed in blue conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2”.
2. Where it is not possible to conceal raceways in finished locations, surface raceway (wiremold) may be used as approved by the Architect.
3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
4. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

C. Penetrations
1. Provide fire stopping for all penetrations used by dedicated BAS conduits and raceways.
2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

D. BAS Panel Installation
1. The BAS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer’s recommendations.
2. The BAS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.

E. Input Devices
1. All Input devices shall be installed per the manufacturer recommendation.
2. Locate components of the BAS in accessible local control panels wherever possible.

F. HVAC Input Devices – General

1. All Input devices shall be installed per the manufacturer recommendation.
2. Locate components of the BAS in accessible local control panels wherever possible.
3. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.
4. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.
5. Outside Air Sensors
    a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
    b. Sensors shall be installed with a rain proof, perforated cover.
6. Water Differential Pressure Sensors
    a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
    b. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
    c. The transmitters shall be installed in an accessible location wherever possible.
7. Medium to High Differential Water Pressure Applications (Over 21” w.c.):
    a. Air bleed units, bypass valves and compression fittings shall be provided.
8. Building Differential Air Pressure Applications (-1” to +1” w.c.):
    a. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
    b. The interior tip shall be inconspicuous and located as shown on the drawings.
9. Duct Temperature Sensors:
    a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
    b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
    c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
    d. The sensor shall be mounted to suitable supports using factory approved element holders.
10. Space Sensors:
    a. Shall be coordinated with Architectural plans and mounted per ADA requirements.
    b. In public areas and/or where indicated on plans, provide sensors without controls interface, and/or a lockable interface.
    c. Space air temperature sensors shall be provided in all Electrical, AV, IT, Data, Telecom (TR) and Server rooms. Sensors shall be provided with digital display of sensed temperature.
11. Air Differential Pressure Status Switches:
    a. Static pressure tips, tubing, fittings, and air filter.
12. Water Differential Pressure Status Switches:
    a. with shut off valves for isolation.
13. Do not cover or conceal sensors with insulation.

G. HVAC Output Devices
1. All output devices shall be installed per the manufacturer's recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.
2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.
3. Control Valves:
   a. Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI.
   b. Install valves in piping with stems as vertical as possible but in no case less than forty-five (45) degrees from vertical. For soldered or welded connections, remove valve internals before installation.
   c. Wire electric valves in accordance with NFPA 70 with not less than two (2) feet of flexible liquidtight connector with watertight bushings at the valve actuator and conduit termination. Brace conduit to the building structure to prevent movement and damage.
4. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Automation is to be connected to an external control system as an input, or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems.

H. Label Installation
1. Install or permanently fasten labels on each major item of temperature control equipment.
2. Locate labels where accessible and visible.
3. For equipment, devices, sensors, etc. located above the ceiling, in addition to a label on the equipment, labels are to be permanently affixed to the ceiling grid framing as near to the item as possible using epoxy glue. Where hard ceilings are used, the label is to be affixed to the frame of the access panel for the unit.

3.4 TRAINING

A. The manufacturer shall provide a factory trained instructor to give not less than 8 hours of full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach.

B. Provide training for Owner's designated operating personnel. Training shall include:
1. Explanation of drawings, operations and maintenance manuals
2. Walk-through of the job to locate control components
3. Operator workstation and peripherals
4. DDC controller and ASC operation/function
5. Operator control functions including graphic generation and field panel programming
6. Explanation of adjustment, calibration and replacement procedures

7. Electronic Catalog and Materials

C. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Manufacturer. If such training is required by the Owner, it will be contracted at a later date.

3.5 COMMISSIONING, TESTING AND ACCEPTANCE

A. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets which shall be submitted prior to acceptance testing. Commissioning work which requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.
   1. Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications, and approved shop drawings. Test, calibrate and bring online each control sensor and device. Commissioning to include, but not be limited to:
      a. Sensor accuracy at 10, 50 and 90% of range.
      b. Sensor range.
      c. Verify analog limit and binary alarm reporting.
      d. Point value reporting.
      e. Binary alarm and switch settings.
      f. Actuator ranges.
      g. Fail safe operation on loss of control signal, electric power, network communications.

B. After control devices have been commissioned (i.e. calibrated, tested and signed off), each BAS program shall be put on line and commissioned. The contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracies. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and retested.

C. After all BAS programs have been commissioned, the contractor shall verify the overall system performance as specified. Tests shall include, but not be limited to:
   1. Data communication, both normal and failure modes.
   2. Fully loaded system response time.
   3. Impact of component failures on system performance and system operation.
   4. Time/Date changes.
   5. End of month/ end of year operation.
   6. Season changeover.
   7. Global application programs and point sharing.

8. System backup and reloading.
9. System status displays.
10. Diagnostic functions.
11. Power failure routines.
12. Battery backup.
13. Testing of all electrical and HVAC systems with other division of work.

D. Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracies and the system performance does not degrade over time.

E. Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate all system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.

F. The contractor shall supply all instruments for testing.
1. Test Instrument Accuracy:
   a. Temperature: ¼ °F or ½% full scale, whichever is less.
   b. High Pressure: ½ psi or ½% full scale, whichever is less.
   c. Low Pressure: ½% full scale
   d. Humidity: 2% RH
   e. Electrical: ¼% full scale

G. After the above tests are complete and the system is demonstrated to be functioning as specified, a thirty-day performance test period shall begin. If the system performs as specified throughout the test period, requiring only routine maintenance, the system shall be accepted. If the system fails during the test, and cannot be fully corrected within eight hours, the owner may request that performance tests be repeated.

3.6 TEMPERATURE CONTROL

A. The control sequence of operations describe the general operational intent of the control systems. Provide all hardware, software, devices, equipment and wiring as required to perform the operational intent described by the various control sequences and to fully interface with the building automation system (BAS).

B. The control diagrams indicate the general arrangement of system components to the extent that they affect process flow or control. Not all required components are shown on the control diagrams. The contractor shall thoroughly review all contract documents to ascertain the full scope of their work.

C. A full communication interface and complete interoperability with the BAS shall be provided to perform the functions herein described or indicated in the contract documents.

D. For equipment with factory controllers:

1. The BAS provider and the equipment manufacturer shall provide a complete list of all BACNET points available to be accessed from within the manufacturer's factory controllers and, specifically, identify what points can be read from the BAS, which points can be written too and which points cannot be accessed at all.
2. The BAS submittal, sequences and points list shall indicate routines that are controlled completely from the manufacturer's controllers, which routines are controlled partially by the manufacturer's controllers and BAS and which routines are controlled completely by the BAS.
3. The BAS provider and equipment manufacturer, in collaboration, shall provide coordinated submittals that indicate anything that has to be set, reset or accessed in a manufacturer's controller at the piece of equipment as opposed to being accessed at or from the BAS user interface/controller console. This coordination and collaboration shall occur at the submittal phase and well before equipment and controls are delivered to the site.

E. Unless otherwise noted, size all automatic control valves for maximum ten (10) feet water pressure drop at maximum design flow rate.

F. Refer to drawings for locations of all terminal units, room sensors, panels, dampers, valves, and equipment; where such devices are not indicated, however are required by the control sequences to achieve the intended operation, they shall be provided and located in the field where directed by the engineer.

G. Division 26 shall provide all detection devices (heat/smoke) as required by the contract documents. Division 23 shall install all detection devices including required control and power wiring required for mechanical systems. Detection devices shall provide automatic shutdown of the HVAC systems in accordance with the International Mechanical Code.

H. All temperature, humidity, pressure, time, etc. set points shall be fully adjustable through the BAS. Final system setpoints will be confirmed through system commissioning and fixed prior to building occupancy. Thereafter setpoints shall be adjustable through the BAS by trained maintenance staff.

I. All two position dampers and valves shall be proven open by the use of end switches.

J. All control devices located within chemical storage areas shall be explosion proof suitably rated for each specific application.

K. Refer to individual input/output summary schedules for additional control devices not specifically described in the control narratives. Input/output summary schedules are minimum requirements; provide all required points for complete operation of the systems.

L. All variable frequency drives (VFD) for fans shall be soft started at minimum speed and increased to required operating speed by the BAS.

M. Refer to drawings for fans that shall be equipped with an inlet air monitoring device (AMD). Where provided, the BAS shall continuously monitor the airflow rate for the fan. AMD's for exhaust fans shall be of a material suitable for the intended airstream.

N. Upon failure of any direct digital control (DDC) unit, an alarm shall be indicated on the BAS and the system shall automatically revert to the default cycle. All motors and fans shall remain in their last commanded state. When emergency power is available, the BAS shall monitor each essential power transfer switch and ramp the VFD's of selected fans and pumps to their lower limits until the emergency generator is stable and online; at which time the normal sequence of operations shall resume for selected fans and pumps.

O. In general and unless otherwise noted, heating control valves shall fail open, specialist area heating control valves shall fail closed, chilled water control valves shall fail closed. Isolation dampers at fans and air units shall fail open.

P. HVAC system controls shall not fail and lock out upon loss of power (such as under emergency conditions) and loss of power shall not be alarmed to the BAS.

Q. Where used to control both comfort heating and cooling, zone thermostatic controls shall be capable of providing a temperature range or dead band of at least 5ºF within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

END OF SECTION 230900

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:
   1. Copper tube and fittings.
   2. Steel pipe and fittings.
   3. Joining materials.
   4. Dielectric fittings.

B. Related Sections:
   1. Section 232513 "Water Treatment for Closed-Loop Hydronic Systems" for cleaning and flushing requirements.
   2. Section 232516 "Water Treatment for Open-Loop Hydronic Systems" for cleaning and flushing requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Pipe.
   2. Fittings.
   3. Joining materials.

B. Flushing and Cleaning Plan: Contractor is to submit a written plan and drawings for the flushing and cleaning plan. The plan is to include all procedures and shutdowns necessary. Plans are to identify temporary and permanent fill points, vents, bypasses, valves, gauges, and other appurtenances needed.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

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

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

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
1. Hot-Water Heating Piping: 125 psig at 250 deg F.
2. Chilled-Water Piping: 125 psig at 250 deg F.
3. Condensate-Drain Piping: 180 deg F.
4. Air-Vent Piping: 180 deg F.
5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. All pipe and fittings shall be from a United States domestic manufacturer.

2.3 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L and ASTM B 88, Type M water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

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

F. Copper Press Joint Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Apollo Valves; Conbraco Industries, Inc.
b. Elkhart Products Corporation

c. Mueller Industries, Inc.
d. NIBCO INC.
e. Viega LLC

2. Description:
   a. Cast- or wrought-copper press-connect fitting complying with material requirements of ASME B16.18 or ASME B16.22 and performance criteria of ASME B16.51 and IAPMO PS 117.
   b. Sealing elements for press fittings shall be factory installed EPDM.
   c. Press end fittings shall have technology to allow identification of an unpressed fitting.

2.4 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150.

C. Malleable-Iron Unions: ASME B16.39; Classes 150.

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

E. 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.

F. Grooved Mechanical-Joint Fittings and Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Victaulic Company
   2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
   3. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

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

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

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

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric unions shall not be used. In lieu of dielectric union, use an approved brass fitting.

C. Dielectric Flanges:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. WATTS
      b. Wilkins
      c. Zurn Industries, LLC
   2. Standard: ASSE 1079.
   3. Factory-fabricated, bolted, companion-flange assembly.
   4. Pressure Rating: 150 psig minimum at 180 deg F.
   5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Advance Products & Systems, Inc
      b. Calpico, Inc
      c. Central Plastics Company
      d. Pipeline Seal and Insulator, Inc
   2. Description:
      a. Nonconducting materials for field assembly of companion flanges.
      b. Pressure Rating: 150 psig.
      c. Gasket: Neoprene or phenolic.
      d. Bolt Sleeves: Phenolic or polyethylene.
      e. Washers: Phenolic with steel backing washers.

PART 3 - EXECUTION

3.1 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

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

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

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

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

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

R. Install shutoff valve immediately upstream of each dielectric fitting.

S. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

U. Install sleeves for piping penetrations of walls, ceilings, and floors.

V. Install sleeve seals for piping penetrations of exterior concrete walls and slabs on grade.

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

3.2 JOINT CONSTRUCTION

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

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

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

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

E. Press Fit Joints for Copper Tubing: Press connections shall be made in accordance with the manufacturer’s installation instructions. Clean end of tube. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool(s) approved by the manufacturer.

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

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

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

I. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

3.3 INSTALLATION OF DIELECTRIC FITTINGS

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use approved brass fitting.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install hangers for copper tubing and steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each fitting and coupling.

E. Support vertical runs of copper tubing and steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections.

3.6 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

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 hydronic piping systems with clean water; then remove and clean or replace strainer screens.
   4. Provide equipment bypasses to isolate components from piping where metal slag and filings are prone to collect (such as chillers, boilers, air handling units, fan coil units, air terminal units, etc). If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
   5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
   1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
   3. Isolate expansion tanks and determine that hydronic system is full of water.
   4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure or a minimum of 100 pounds per square inch gauge (psig), whichever is greater. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test.
   5. After hydrostatic test pressure has been applied for at least 15 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.
   7. Contractor shall provide minimum 48 hours' notice prior to testing to allow the Architect, Engineer, Commissioning Agent, Owner or his representative the opportunity to attend.
   8. Tests shall be conducted and written report of testing submitted before any insulation is installed. Insulation installed prior to tests shall be removed.

C. Perform the following additional tests on welded piping:
   1. Ultrasonically test ten (10) of the full penetration field welds in the chilled water supply and return systems. Testing shall be performed by a qualified

independent testing contractor. All fillet and socket welds shall be visual and dye penetrant examined on the completed weld by a qualified individual.

2. Provide documentation of each inspection of accepted or rejected welds. Provide report results within three working days for satisfactory results and one working day for unsatisfactory tests
3. If any two (2) welds fail, all welds will be ultrasonically tested and repaired as required at the Contractor's expense.
4. Remove weld defects by grinding or chipping and repair or replace weld joints in accordance with approved procedures. Restart all repaired joints.

D. Perform the following before operating the system:
1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Verify lubrication of motors and bearings.

3.8 PIPING SCHEDULE

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:
1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; copper press fittings; and press joints.
3. Schedule 40, Grade B steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; copper press fittings; and press joints.
3. Schedule 40, Grade B steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

C. Condensate-Drain Piping: Type M or Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

D. Air-Vent Piping:
1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

E. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

END OF SECTION 232113

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Hydronic specialty valves.
   2. Air-control devices.
   3. Strainers.
   4. Connectors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product:
   1. Include construction details and material descriptions for hydronic piping specialties.
   2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
   3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Ball, Butterfly, Check, Globe and Gate Valves: Comply with requirements specified in Section 230523 "Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230900 "Building Automation and Temperature Control System."

C. Bronze, Calibrated-Orifice, Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Wheatley
      b. Armstrong Pumps, Inc
      c. Bell & Gossett; a Xylem brand
      d. Flow Design, Inc
      e. Griswold Controls
      f. Hays Fluid Controls
      g. Nexus Valve, Inc.
      h. NIBCO INC.
      i. TACO Comfort Solutions, Inc.
      j. Tour & Andersson; available through Victaulic Company
   2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
   3. Ball: Brass or stainless steel.
   4. Plug: Resin.
   5. Seat: PTFE.
   6. End Connections: Threaded or socket.
   7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
   8. Handle Style: Lever, with memory stop to retain set position.
   9. CWP Rating: Minimum 125 psig.
   10. Maximum Operating Temperature: 250 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Wheatley
      b. Armstrong Pumps, Inc
      c. Bell & Gossett; a Xylem brand
      d. Flow Design, Inc
      e. Griswold Controls
      f. Nexus Valve, Inc.
      g. NIBCO INC.
      h. TACO Comfort Solutions, Inc.
      i. Tour & Andersson; available through Victaulic Company
   2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
   3. Ball: Brass or stainless steel.

4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F.

E. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Wheatley
   b. AMTROL, Inc.
   c. Apollo Flow Controls; Conbraco Industries, Inc.
   d. Armstrong Pumps, Inc
   e. Bell & Gossett; a Xylem brand
   f. Spence Engineering Company, Inc
   g. WATTS
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: Removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Wheatley
   b. AMTROL, Inc.
   c. Apollo Flow Controls; Conbraco Industries, Inc.
   d. Armstrong Pumps, Inc
   e. Bell & Gossett; a Xylem brand
   f. Spence Engineering Company, Inc
   g. WATTS
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: Removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.

10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flow Design, Inc
   b. Griswold Controls
   c. Hays Fluid Controls
   d. Nexus Valve, Inc.
   e. NIBCO INC.
2. Body: Brass or ferrous metal.
3. Flow Control Assembly, provide either of the following:
   a. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
   b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psigdifferential pressure.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow within plus or minus 5 percent, regardless of system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 200 deg F.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Wheatley
   b. AMTROL, Inc.
   c. Apollo Flow Controls; Conbraco Industries, Inc.
   d. Armstrong Pumps, Inc
   e. Bell & Gossett; a Xylem brand
   f. Nexus Valve, Inc.
   g. TACO Comfort Solutions, Inc.
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Wheatley

b. AMTROL, Inc.
c. Armstrong Pumps, Inc
d. Bell & Gossett; a Xylem brand
e. Nexus Valve, Inc.
f. Spirotherm, Inc.
g. TACO Comfort Solutions, Inc.

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

2.3 STRAINERS

A. Y-Pattern Strainers:
1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel with perforations as follows:
a. Water Service startup: 20 mesh strainer, bronze
b. Water Service up to 2 inches: 20-mesh strainer
c. Water Service 2-1/2 inches to 4 inches: 1/16 inch perforations
d. Water Service 6 inches and larger: 1/8 inch perforations
4. CWP Rating: 125 psig.

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, bronze (NPS 2 and below) or stainless steel (NPS 2-1/2 and above), wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch permanent offset or misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

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

D. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

E. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

END OF SECTION 232116

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round and flat-oval ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.
9. Seismic-restraint devices.

B. Related Sections:
1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
3. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
   1. Liners and adhesives.
   2. Sealants and gaskets.
   3. Seismic-restraint devices.

B. Shop Drawings:
   1. Factory- and shop-fabricated ducts and fittings.
   2. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
   3. Elevation of top and bottom of ducts.
   4. Dimensions of main duct runs from building grid lines.
   5. Fittings.
   6. Reinforcement and spacing.
   7. Seam and joint construction.
   8. Penetrations through fire-rated and other partitions.
   9. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
   10. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
   2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 DUCT MATERIALS

A. Comply with requirements in "Duct Schedule" Article for applications of duct material, pressure class, duct seal-class level, and duct-leakage class.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eastern Sheet Metal, Inc.
   2. McGill AirFlow LLC
   3. MKT Metal Manufacturing
   4. Set Duct Manufacturing
   5. Sheet Metal Connectors, Inc.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular

Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
   2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
   3. Coat insulation with antimicrobial coating.

G. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
   1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

H. Inner Duct: Minimum 0.028-inch solid sheet steel.

I. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Traverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

J. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements,

materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.5 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

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

1. Eastern Sheet Metal, Inc.
2. Linx Industries (formerly Lindab)
3. McGill AirFlow LLC
4. MKT Metal Manufacturing
5. SEMCO LLC
6. Set Duct Manufacturing
7. Sheet Metal Connectors, Inc.
8. Turnkey Duct Systems

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees

and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Inner Duct: Minimum 0.028-inch solid sheet steel.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
   2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
   3. Coat insulation with antimicrobial coating.

F. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
   1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at75 deg F mean temperature.

2.6 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G90.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

D. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
   1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.7 DUCT LINER

A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Aeroflex USA, Inc.
      b. Armacell LLC
      c. Ductmate Industries, Inc
      d. Evonik Foams
      e. K-Flex USA
   2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
   3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

B. Insulation Pins and Washers:
   1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel or stainless steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
   1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
   2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
   3. Butt transverse joints without gaps, and coat joint with adhesive.
   4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
   5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
   6. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
   7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
      a. Fan discharges.
      b. Intervals of lined duct preceding unlined duct.
      c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
   8. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat

sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.8 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   3. Shore A Hardness: Minimum 20.
   4. Water resistant.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   8. Service: Indoor or outdoor.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C 920.
   1. General: Single-component, acid-curing, silicone, elastomeric.
   2. Type: S.
   3. Grade: NS.
   4. Class: 25.
   5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:
   1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
   2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
   3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.9 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive and Exterior Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
   3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.10 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business
   2. Ductmate Industries, Inc
   3. Hilti, Inc.
   4. Kinetics Noise Control, Inc
   5. Mason Industries, Inc.
   6. Unistrut; Part of Atkore International
   7. Vibration & Seismic Technologies, LLC

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California or an agency acceptable to authorities having jurisdiction.
   1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 603, galvanized or ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Sizes shown on plans are air side sizes. Where ducts are shown as lined, dimensions shall be increased to reflect that thickness of the lining.

D. Install ducts in maximum practical lengths.

E. Install ducts with fewest possible joints.

F. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

G. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

J. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

K. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

M. Protect duct from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines" for an Advanced level of cleanliness.

1. For work that does not comply with these requirements, at the Architect's or Owner representative's discretion the contractor shall:
   a. Clean and restore all impacted air-moving and -distribution equipment to an advanced level of cleanliness in accordance with NADCA ACR 2013, Assessment, Cleaning & Restoration of HVAC Systems, including all items identified in the Standard as "recommended," "advised," and "suggested."
   b. Verify cleanliness according to NADCA ACR 2013, "Verification of HVAC System Cleanliness" Section.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR CLOTHES DRYER EXHAUST DUCT

A. Dryer exhaust ducts for clothes dryers shall terminate on the outside of the building and shall be equipped with a backdraft damper.

B. Screens shall not be installed at the duct termination. Ducts shall not be connected or installed with sheet metal screws or other fasteners that will obstruct the exhaust flow.

C. Exhaust ducts shall be supported at 4-foot intervals and secured in place.

D. The insert end of the duct shall extend into the adjoining duct or fitting in the direction of airflow. Ducts shall not be joined with screws or similar fasteners that protrude into the inside of the duct.

E. Each vertical riser shall be provided with a means for cleanout.

F. The maximum length of the exhaust duct shall be determined by the dryer manufacturer's installation instructions.

3.4 DUCT SEALING

A. Ductwork and all plenums with pressure class ratings shall be constructed to Seal Class A, as required to meet the requirements of ASHRAE/IES 90.1.

B. Openings for rotating shafts shall be sealed with bushings or other devices that seal off air leakage.

C. All connections shall be sealed, including but not limited to spin-ins, taps, other branch connections, access doors, access panels, and duct connections to equipment.

D. Spiral lock seams need not be sealed.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
   5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Concealed From View: Threaded rod and angle or channel supports.

E. Hangers Exposed to View:
   1. Rectangular: Threaded rod and angle or channel supports.
   2. Round or Oval: Steel cables.

F. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

G. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

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

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service, the Office of Statewide Health Planning and Development for the State of California or an agency acceptable to authorities having jurisdiction.

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

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

3.7 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner.

1. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

B. Paint exterior of exposed metal ducts in occupied, conditioned spaces. Refer to Architectural reflected ceiling plan for areas where duct will be exposed.
1. Exposed metal ducts shall be provided with grip finish.
2. Apply one coat of latex paint (color by architect) over a compatible metal primer.

C. Paint materials and application requirements are specified in Division 09.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
1. Leakage test procedures shall follow the outlines and classifications indicated in SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
   a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 percent of total installed duct area for each designated pressure class.
   b. Laboratory Exhaust Ducts with a Pressure Class of 3-Inch wg or Higher: Test duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.
   c. Kitchen Exhaust Hood Ductwork: Test duct sections totaling no less than 100 percent of total installed duct area.
   d. Dishwasher Hoods, Cagewash and Autoclave Ductwork: Test duct sections totaling no less than 100 percent of total installed duct area.
   e. All vertical ductwork located within risers, chases and shafts shall be leak tested. The tests shall include each branch connection tap up to a point just beyond the shaft wall.
3. Each tested section shall incorporate at least: 5 transverse joints, typical seams, 2 elbows, one fire damper, one access door, 2 typical branch connections and 2 terminal unit connections.
4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing. 3-5 days prior to each test, the contractor shall submit marked-up sheetmetal shop drawings of the duct section(s) to be tested, along with the allowable leakage calculations as required by SMACNA.
8. Additional tests of each pressure classification shall be required, at the owner’s, Architect’s or TAB contractors discretion, if subsequent ductwork installation

becomes suspect and does not appear to maintain the same level of quality as the section tested.

C. Duct System Cleanliness Tests:
   1. Visually inspect duct system to ensure that no visible contaminants are present.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Air Ducts:
   1. Ducts Connected to Single-Zone Air-Handling Units, downstream, from air handling units to air device:
      a. Concealed: Single wall, round, oval or rectangular as shown on drawings.
      b. Exposed to View: Double wall, round, oval or rectangular as shown on drawings.
      c. Pressure Class: Positive 2-inch wg.
      d. SMACNA Seal Class: A.
      e. SMACNA Leakage Class for Rectangular: 4.
      f. SMACNA Leakage Class for Round and Flat Oval: 2.
   2. Ducts Connected to Fan Coil Units downstream, from unit to air device:
      a. Concealed: Single wall, round, oval or rectangular as shown on drawings.
      b. Exposed to View: Double wall, round, oval or rectangular as shown on drawings.
      c. Pressure Class: Positive 2-inch wg.
      d. SMACNA Seal Class: A.
      e. SMACNA Leakage Class for Rectangular: 4.
      f. SMACNA Leakage Class for Round and Flat Oval: 2.

C. Return Air and Transfer Ducts:
   1. Ducts Connected to Fan Coil Units:
      a. Single wall, round, oval or rectangular as shown on drawings.
      b. Pressure Class: Positive or negative 2-inch wg.
      c. SMACNA Seal Class: A.
      d. SMACNA Leakage Class for Rectangular: 4.
      e. SMACNA Leakage Class for Round and Flat Oval: 2.
   2. Transfer Ducts:
      a. Single wall, round, oval or rectangular as shown on drawings.
      b. Pressure Class: Positive or negative 2-inch wg.

c. SMACNA Seal Class: A.
d. SMACNA Leakage Class for Rectangular: 4.
e. SMACNA Leakage Class for Round and Flat Oval: 2.

D. Exhaust Air Ducts:
1. Ducts Connected to Fans Exhausting General and Toilet Air (ASHRAE 62.1, Class 1 and 2):
a. Single wall, round, oval or rectangular as shown on drawings.
b. Pressure Class: Negative 2-inch wg.
c. SMACNA Seal Class: A.
d. SMACNA Leakage Class for Rectangular: 4.
e. SMACNA Leakage Class for Round and Flat Oval: 2.
2. Ducts Connected to Clothes Dryers:
a. Single wall, round, oval or rectangular as shown on drawings.
b. Material: Aluminum
c. Pressure Class: Positive 2-inch wg.
d. SMACNA Seal Class: A.
e. SMACNA Leakage Class for Rectangular: 4.
f. SMACNA Leakage Class for Round and Flat Oval: 2.

E. Intermediate Reinforcement:
1. Galvanized-Steel Ducts: Galvanized steel.
2. Stainless-Steel Ducts: Stainless steel.
3. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

F. Liner:
1. Transfer Ducts: Flexible elastomeric, 1 inch thick.

G. Double-Wall Duct Interstitial Insulation:
1. Supply Air Ducts: Flexible elastomeric, 2 inches thick.

H. Elbow Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
1) Radius-to Diameter Ratio: 1.5.
b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

I. Branch Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
      a. Rectangular Main to Rectangular Branch: 45-degree entry.
      b. Rectangular Main to Round Branch: Spin in.
         1) In no case should the round branch plus associated flange be larger than the height of rectangular main. Where the condition exists, provide a rectangular main to rectangular branch with 45-degree entry, and transition to round duct.
   2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
      a. Velocity 1000 fpm or Lower: 90-degree tap.
      b. Velocity 1000 to 1500 fpm: Conical tap.
      c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Automatic balancing dampers.
4. Control dampers.
5. Fire dampers.
6. Smoke dampers.
7. Combination fire and smoke dampers.
8. Flange connectors.
9. Duct silencers.
10. Air transfer silencers
11. Duct lagging
12. Remote damper operators.
13. Duct-mounted access doors.
14. Flexible connectors.
15. Flexible ducts.
16. Duct accessory hardware.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G90.
   2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Air Balance Inc.; a division of Mestek, Inc.
   2. American Warming and Ventilating; a division of Mestek, Inc.
   3. Flexmaster U.S.A., Inc.
   4. McGill AirFlow LLC.
   5. Nailor Industries Inc.
   6. NCA Manufacturing, Inc; a division of Metal Industries Inc.
   7. Pottorff.
   8. Ruskin Company.
   9. Tamco; T. A. Morrison & Co., Inc.
   10. Trox USA Inc.
   11. United Enertech
   12. Vent Products Company, Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 2500 fpm.

D. Maximum System Pressure: 2-inch wg.

E. Frame: Hat-shaped, 0.090-inch- thick extruded aluminum, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch width, 0.050-inch-thick extruded aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Extruded vinyl, mechanically locked.

I. Blade Axles:
   1. Material: Aluminum.
   2. Diameter: 0.20 inch.

J. Tie Bars and Brackets: Aluminum.

K. Return Spring: Adjustable tension.

L. Bearings: Synthetic pivot bushings.

M. Accessories:
   1. Adjustment device to permit setting for varying differential static pressure.
   2. Screen Mounting: Rear mounted.
   3. Screen Material: Aluminum.
   4. Screen Type: Insect.
   5. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Warming and Ventilating; a Mestek Architectural Group company
      b. McGill AirFlow LLC
      c. Nailor Industries Inc
      d. NCA Manufacturing, Inc; a division of Metal Industries Inc.
      e. Pottorff
      f. Ruskin Company
      g. Trox USA Inc.
      h. United Enertech
      i. Vent Products Co., Inc
   2. Performance:
      a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure
   3. Construction:
      a. Linkage outside of airstream.

b. Suitable for horizontal or vertical applications.

4. Frames:
   a. Hat-shaped, 16-gauge- thick, galvanized sheet steel.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized-steel, 16 gauge thick.
6. Blade Axles: Galvanized steel, hex.
7. Bearings:
   a. Molded synthetic.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Galvanized steel.
9. Locking device to hold damper blades in a fixed position without vibration.

B. Jackshaft:
1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:
1. Zinc-plated, die-cast core with dial and handle, made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.5 CONTROL DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Arrow United Industries
2. Cesco Products; a division of MESTEK, Inc.
3. Greenheck Fan Corporation
4. McGill AirFlow LLC
5. Nailor Industries Inc
6. NCA Manufacturing, Inc; a division of Metal Industries Inc.
7. Pottorff
8. Ruskin Company
9. Tamco; T. A. Morrison & Co., Inc.
10. United Enertech

B. Low-leakage rating with linkage outside airstream and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:
   1. Hat shaped.
   2. 16 gauge, galvanized sheet steel. Provide Type 304, stainless steel for installation in stainless steel ductwork and corrosive atmospheres.
   3. Mitered and welded corners.

D. Blades:
   1. Multiple airfoil-shaped with maximum blade width of 6 inches.
   2. Parallel- and opposed-blade design.
      a. Opposed blade design for modulating applications.
      b. Parallel blade design for two-position applications.
   3. Galvanized-steel. Provide Type 304, stainless steel for installation in stainless steel ductwork and corrosive atmospheres.
   4. 0.064 inch thick single skin.
   5. Blade Edging: Closed-cell neoprene.
   6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch- diameter; galvanized steel hex-shaped; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
   1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:
   1. Self-lubricating stainless-steel sleeve.
   2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   3. Thrust bearings at each end of every blade.

2.6 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc
   2. Hardcast, Inc.
   3. Nexus PDQ
   4. Ward Industries; a brand of Hart & Cooley, Inc

B. Description: Factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.7 DUCT LAGGING

A. Basis-of-Design Product: Subject to compliance with requirements, provide Kinetics Noise Control, Inc. KNM-100AL or comparable product by one of the following:
   1. Acoustical Surfaces, Inc.
   2. eNoise Control

3. Kintetics Noise Control, Inc
4. IES2000
5. Sound Seal

B. The barrier shall be constructed of a minimum 0.10” thick mass loaded, limp vinyl sheet bonded to a thin layer of reinforced aluminum foil on one side.

C. The barrier shall have a minimum nominal density of 1.0-psf.

D. Sound Transmission Loss (dB) when tested as a free hanging barrier:
1. 125 Hz: 13
2. 250 Hz: 17
3. 500 Hz: 21
4. 1000 Hz: 28
5. 2000 Hz: 33
6. 4000 Hz: 40

E. Surface Burning characteristics per ASTM E84: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.8 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Pottorff
2. Ventfabrics, Inc
3. Young Regulator Company

B. Description: Cable system designed for remote manual damper adjustment.

C. Cable: Steel.

D. Wall-Box Mounting: Recessed or surface, as called for on the drawings.

E. Wall-Box Cover-Plate Material: Steel.

2.9 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cesco Products; a division of MESTEK, Inc.
2. Ductmate Industries, Inc
3. Flexmaster U.S.A., Inc
4. Greenheck Fan Corporation
5. McGill AirFlow LLC
6. Nailor Industries Inc
7. NCA Manufacturing, Inc; a division of Metal Industries Inc
8. Pottorff
9. Ruskin Company

10. United Enertech
11. Ventfabrics, Inc
12. Ward Industries; a brand of Hart & Cooley, Inc

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
   1. Door:
      a. Double wall, rectangular.
      b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
      c. Vision panel.
      d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
      e. Fabricate doors airtight and suitable for duct pressure class.
   2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
   3. Number of Hinges and Locks:
      a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
      b. Access Doors up to 18 Inches Square: Continuous and two sash locks.
      c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.
      d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:
   1. Door and Frame Material: Galvanized sheet steel.
   2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
   3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
   4. Factory set at 3.0- to 8.0-inch wg.
   5. Doors close when pressures are within set-point range.
   6. Hinge: Continuous piano.
   7. Latches: Cam.
   8. Seal: Neoprene or foam rubber.
   9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.10 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 3M
   2. Ductmate Industries, Inc
   3. Flame Gard, Inc
   4. Ruskin Company

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0428-inch stainless steel.

D. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.11 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Inc
   2. Duro Dyne Inc.
   3. Hardcast, Inc.
   4. Ventfabrics, Inc
   5. Ward Industries; a brand of Hart & Cooley, Inc

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
   1. Minimum Weight: 26 oz./sq. yd..
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
   1. Minimum Weight: 24 oz./sq. yd..
   2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
   3. Service Temperature: Minus 50 to plus 250 deg F.

G. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
   1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
   2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.12 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Castco – Model SF-181M.
   2. Thermaflex – Model MKE
   3. JPL – Model AMR.

B. Insulated, Acoustical Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
   1. Pressure Rating: 6-inch wg positive and 1.0-inch wg negative.
   2. Maximum Air Velocity: 4000 fpm.
   3. Temperature Range: Minus 20 to plus 175 deg F.
   4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:
   1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
   2. Non-Clamp Connectors: Liquid adhesive plus sheet metal screws and tape.

D. Flexible Duct Elbow Supports:
   1. Universal-mount, 1-piece, fully adjustable, radius-forming brace to support 4-inch through 16-inch diameter flexible air ducts.
   2. Classified: UL 2043.
   3. Material: 100 percent recycled copolymer polypropylene.
   4. Support Frame Radius: 8 inches.
   5. Compliance for Flexible Duct Radius:
      a. SMACNA HVAC Duct Construction Standards.
      b. ASHRAE Advanced Energy Design Guides.
      c. ADC Flexible Duct Performance and Installation Standards.

2.13 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install control dampers in exhaust ductwork:
   1. For rooftop and base mounted fans, install damper at inlet of exhaust fans or in the exhaust duct close to exhaust fan unless otherwise indicated.
   2. For in-line exhaust fans, install damper in exhaust duct downstream of fan as close as possible to exhaust plenum/louver unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

   1. Install steel volume dampers in steel ducts.
   2. Install aluminum volume dampers in aluminum ducts.
   3. Install stainless steel volume dampers in stainless steel ducts.

E. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

F. Mark the locations of all above-ceiling duct mounted dampers with orange non-adhesive surveyors flagging tape.

G. Set dampers to fully open position before testing, adjusting, and balancing.

H. Install test holes at fan inlets and outlets and elsewhere as indicated.

I. Install fire and smoke dampers according to UL listing.

J. Duct Smoke Detectors:
   1. HVAC duct smoke detectors shall be furnished as specified elsewhere by Division 28 for installation under Division 23. All wiring for air duct detectors shall be provided under Division 28.
   2. Comply with NFPA 72 and IMC. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
   3. Verify proper length and orientation on the sampling tube. Confirm the sampling tube protrudes into the duct in accordance with system design and per manufacturer's instructions.
   4. Verify the smoke detector is rigidly mounted. Confirm that no penetrations in a return air duct exist in the vicinity of the detector. Confirm the detector is installed so as to sample the airstream at the proper location in the duct.
   5. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
   6. Where duct detectors are used to initiate the operation of smoke dampers, they should be located so that the detector is between the last inlet or outlet upstream of the damper and the first inlet or outlet downstream of the damper.

K. Connect ducts to duct silencers rigidly.

L. Duct Lagging:
   1. Install acoustical pipe and duct lagging in locations indicated. Comply with manufacturers written instructions for installation by using type of mounting accessories indicated or, if not indicated, as recommended by the manufacturer.
   2. Duct shall be wrapped with specified insulation prior to application of the duct lagging.
   3. Duct lagging material shall be cut to length, wrapped around the outside of the duct, and fastened with mechanical fasteners, bands or manufacturer's foil lag tape.
   4. Duct sound control lagging materials must be installed per the manufacturer’s installation guidelines.

M. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. Upstream and downstream from duct filters.
   3. At outdoor-air intakes and mixed-air plenums.
   4. At drain pans and seals.
   5. Downstream from control dampers, backdraft dampers, and equipment.
   6. Control devices requiring inspection.
   7. Elsewhere as indicated.

N. Install access doors with swing against duct static pressure.

O. Access Door Sizes:
   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.
   3. Head and Hand Access: 18 by 10 inches.
   4. Head and Shoulders Access: 21 by 14 inches.
   5. Body Access: 25 by 14 inches.
   6. Body plus Ladder Access: 25 by 17 inches.

P. Label access doors.

Q. Install flexible connectors to connect ducts to equipment.

R. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

S. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

T. Connect diffusers to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

U. Connect flexible ducts to metal ducts with draw bands or adhesive plus sheet metal screws.

V. Make bends in flexible ducts with minimum of 1-duct diameter centerline radius.

W. Where flexible ductwork is used as an elbow, provide flexible, durable duct elbow supports over outer jacket of flexible ducts to form smooth, 90-degree bends to eliminate flexible duct kinks and airflow restrictions.

X. Install duct test holes where required for testing and balancing purposes.

Y. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.
   2. Inspect locations of access doors and verify that purpose of access door can be performed.
   3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
   4. Inspect turning vanes for proper and secure installation.
   5. Operate remote damper operators to verify full range of movement of operator and damper.
   6. Test duct smoke detectors per NFPA 72. Detectors that use sampling tubes shall be tested to ensure that they will properly sample the airstream in the duct using a method acceptable to the manufacturer or in accordance with their published instructions. Preferred method is to use a manometer to measure the differential pressure between the two sampling tubes. Verifying the differential pressure is within the manufacturer documented acceptable levels.
   7. Test all new fire, smoke and combination fire/smoke dampers both at project completion as well as at the end of the one-year warranty period. Contractor shall provide the test results for both tests on the standard damper testing form.

END OF SECTION 233300

SECTION 233416 - HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: For each product.
   1. HVAC fans.

1.3 ACTION SUBMITTALS

A. Product Data:
   1. Include rated capacities, furnished specialties, and accessories for each fan.
   2. Certified fan performance curves with system operating conditions indicated.
   3. Certified fan sound-power ratings.
   4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   5. Material thickness and finishes, including color charts.
   6. Dampers, including housings, linkages, and operators.
   7. Fan speed controllers.

B. Shop Drawings:
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:
   1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
   2. Operating Limits: Classify according to AMCA 99.

B. Balance Quality:
   1. All wheels (rotors/impellers) shall be factory statically and dynamically balanced on precision electronic balancers to a Balance Quality Grade G6.3 per ANSI/AMCA Standard 204-05 or better.

C. Vibration Levels:
   1. Each fan assembly shall be vibration tested before shipping in accordance with AMCA 204-05.
   2. Each assembled fan shall be test run at the factory at the specified fan RPM and vibration signatures shall be taken on each bearing in three planes - horizontal, vertical, and axial.
   3. Unless otherwise indicated, the maximum allowable factory fan vibration shall be less than 0.15 in./sec peak velocity for rigidly mounted fans and 0.20 in./sec peak velocity for flexibly mounted fans. Values are peak velocity values, filter-in, at the fan rotational speed.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Capacities and Characteristics: Refer to drawings.

2.2 CENTRIFUGAL UPBLAST ROOF EXHAUSTER, DIRECT DRIVE (TYPE A)

A. Basis-of-Design Product: Subject to compliance with requirements, provide Greenheck CUE or comparable product by one of the following:
   1. American Coolair Corporation
   2. Greenheck Fan Corporation
   3. Loren Cook Company
   4. New York Blower Company (The)
   5. Twin City Fan & Blower

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, direct-driven centrifugal upblast roof exhauster, configured for vertical flow, consisting of wheel, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.

C. Housing: Heavy gauge spun aluminum construction of shroud, top cover, and motor bands. Roll edge beads.

1. Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Finish: Galvanized mill finish internal parts, and uncoated external aluminum parts exposed to weather.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, NEMA 4 with thermal-overload protection. Factory mount and wire through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum wire.
4. Motorized Damper: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan is not energized.
    a. Fabricate frame from galvanized steel.
    b. Fabricate blades from aluminum, mill finish, with vinyl edge seals.
    c. Damper actuator suitable for 24 VAC, single phase.
5. Pressure Probe: ¼ inch diameter in the fan venturi that allows hook-up to manometer.

G. Curb Cap: One-piece, weather-tight aluminum construction, pre-punched mounting holes for attachment to roof curb. Include flange to mate with fan unit inlet flange.
1. Provide electrical metal tubing (EMT) conduit into motor compartment, with watertight fitting at curb cap penetration.
2. Provide foam curb seal.

H. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
1. Configuration: Built-in cant and mounting flange.
2. Overall Height: 12 inches.
3. Pitch Mounting: Manufacture curb for roof slope, when required for level installation.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.4 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:
   1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

E. Curb Support: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," Low-Slope Membrane Roofing Construction Details Section, Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure fans on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support.

F. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch. Vibration-control devices are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

G. Install units with clearances for service and maintenance.

H. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete.
   3. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   4. Verify that cleaning and adjusting are complete.
   5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   6. Trim balance assembled fans to reduce vibration to acceptable operation in-situ START-UP vibration levels in accordance with AMCA Standard 204-05. The final assembly test run shall be provided BEFORE commissioning for service.
   7. Adjust belt tension.
   8. Adjust damper linkages for proper damper operation.
   9. Verify lubrication for bearings and other moving parts.
   10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   11. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
   12. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233416

SECTION 233713 - AIR DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Registers, grilles and diffusers.

B. Related Requirements:
   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.

PART 2 - PRODUCTS

2.1 AIR DEVICES, GENERAL

A. Basis-of-Design Product: Subject to compliance with requirements, provide Titus or comparable product by one of the following:
   1. Anemostat Products; a Mestek company
   2. Carnes Company
   3. Krueger
   4. METALAIRE, Inc
   5. Nailor Industries Inc
   6. Price Industries
   7. Titus
   8. Tuttle & Bailey

B. Provide air devices of the minimum sizes and quantities indicated and of the types specified.

C. Contractor shall carefully study the drawings and the field conditions to ascertain the air device requirements as to suitability, location, air capacity, required accessories, border and finish.

D. Border types shall be compatible with Architectural ceiling type for the room for which the air device is located. All devices shall have plaster frames when installed in plaster or drywall construction.

E. Margins shall be as indicated or directed to suit field conditions.

F. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

G. Air devices shall be selected to provide draft-free air distribution over entire area served and sound rating shall not exceed Noise Criteria (NC) 25.

H. Air device finish shall be an anodic acrylic paint, baked at 315° F for 30 minutes.
   1. The pencil hardness must be HB to H.
   2. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film.
   3. The paint must pass a 250-hour ASTM D870 Water Immersion Test.

I. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.

2.2 TYPE A: LOUVERED FACE SUPPLY DIFFUSER, STEEL

A. Ceiling diffusers shall be TITUS Model TDCA (steel) or approved equal for adjustable discharge pattern. These diffusers shall consist of an outer frame assembly of the sizes and mounting types shown on the plans and outlet schedule.

B. A square or rectangular inlet shall be an integral part of the frame assembly and a transition piece shall be available to facilitate attachment of round duct. An inner core assembly consisting of fixed deflection louvers shall be available in one-, two-, three- or four-way horizontal discharge patterns.

C. Diffuser shall include adjustable vanes to provide full vertical projection as well as horizontal projection. The inner core assembly must be removable in the field without tools for easy installation, cleaning or damper adjustment.

D. Opposed blade volume damper shall not be provided. Throw Reducing Vanes (TRV) must be available to deflect a horizontal discharge airstream from each side of the TDC diffuser into diverging airstreams.

E. Molded insulation blanket shall be available. The insulation will be R-6, foil-backed, and provide an additional 1-inch gap around the neck to install insulated flex duct.

F. The grille finish shall be #26 white.

2.3 TYPE B: PERFORATED RETURN GRILLE, STEEL

A. Perforated ceiling diffusers shall be TITUS model PAR (steel, flush face) or approved equal for return of the sizes and mounting types shown on the plans and outlet schedule.

B. Diffusers shall have a perforated face with 3/16-inch diameter holes on ¼-inch staggered centers and no less than 51 percent free area. Perforated face shall be steel. The backpan shall be one piece stamped heavy gauge steel of the sizes and mounting types shown on the plans and outlet schedule. The diffuser neck shall have 1 1/8-inch depth for easy duct connection.

C. The perforated face must be easily unlatchable from the backpan.

D. Optional opposed blade volume damper shall not be provided.

E. The grille finish shall be #26 white.

2.4 TYPE C: PERFORATED EXHAUST GRILLE, ALUMINUM

A. Perforated ceiling diffusers shall be TITUS model PAR-AA (aluminum, flush face) or approved equal for return of the sizes and mounting types shown on the plans and outlet schedule.

B. Diffusers shall have a perforated face with 3/16-inch diameter holes on ¼-inch staggered centers and no less than 51 percent free area. Perforated face shall be aluminum. The backpan shall be one piece stamped heavy gauge steel of the sizes and mounting types shown on the plans and outlet schedule. The diffuser neck shall have 1 1/8-inch depth for easy duct connection.

C. The perforated face must be easily unlatchable from the backpan.

D. Optional opposed blade volume damper shall not be provided.

E. The grille finish shall be #26 white.

2.5 TYPE D: EXHAUST GRILLE, STEEL

A. Steel return grilles shall be TITUS Model 350R (¾-inch blade spacing) or approved equal of the sizes and mounting types shown on the plans and outlet schedule.

B. The fixed deflection blades shall be available parallel to the long dimension of the grille. Construction shall be of steel with a 1¼-inch wide border on all sides. Screw holes shall be countersunk for a neat appearance. Corners shall be welded with full penetration resistance welds.

C. Deflection blades shall be contoured to a specifically designed and tested cross-section to meet published test performance data. Blades shall be firmly held in place by mullions from behind the grille and fixed to the grille by welding in place. Blade deflection angle shall be available at 35°.

D. Optional opposed blade volume damper shall not be provided.

E. The grille finish shall be #26 white.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install air devices level and plumb.

B. Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install air devices with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Paint the ductwork behind registers with flat black enamel so that bright surface cannot be seen. Properly prime galvanized surface prior to painting.

3.3 ADJUSTING

A. After installation, adjust air devices to air patterns indicated, or as directed, before starting air balancing.

B. The position of the pattern controllers for linear supply diffusers shall be verified and adjusted during Testing, Adjusting and Balancing.

END OF SECTION 233713

SECTION 23 74 13 – PACKAGED OUTDOOR AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit unit performance data including: capacity, nominal and operating performance.

B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.

C. Submit drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.

E. Drawings submitted for approval shall be accompanied by a copy of the purchase agreement between the Contractor and an authorized service representative of the manufacturer for check, test and start up and first year service.

1.2 DELIVERY, STORAGE and HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory shipping covers in place until installation.

C. Units to be secured via base rail tie-down locations.

1.3 WARRANTY

A. Provide five (5) year parts and labor warranty for entire unit.

PART 2 - PRODUCTS

2.1 SUMMARY

A. The contractor shall furnish and install packaged outdoor air unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.

B. ACCEPTABLE MANUFACTURERS

1. Manufacturers: The basis of design is a dedicated outdoor air unit by Trane. Subject to compliance with requirements, acceptable manufacturers are: York, Daiken, and Carrier.

2.2 GENERAL UNIT DESCRIPTION

A. Unit(s) furnished and installed shall be packaged outdoor air unit(s) as scheduled on contract documents and described in these specifications. Unit(s) shall be designed for dehumidification, cooling and/or heating of 100% Outdoor Air. For dehumidification and cooling modes the evaporator temperature shall be monitored, reported at unit controller. Compressor controls shall modulate capacity to maintain evaporator leaving set point. Hot Gas Bypass shall not be used to control compressor capacity. Compressor Hot Gas Reheat (HGRH) shall be factory installed. To prevent rehydration of evaporator condensate the reheat coil face shall be located a minimum of 6” downstream from the leaving face of the evaporator coil. Heating system shall include modulating controls. Compressor on-off only or primary heating on-off only controls shall not be acceptable control strategies.

B. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

2.3 CABINET

A. Cabinet panels: 2” double-wall foamed panel construction throughout the indoor section of unit to provide nonporous, cleanable interior stainless steel surfaces. All interior seams exposed to airflow shall be sealed.

B. Insulation: 2” polyisocyanurate foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.

C. Cabinet base shall be double wall construction designed to prevent trapping or ponding of water within the unit base. Cabinet base pan shall be insulated with 2” thick polyisocyanurate foam. Foam insulation shall be fully enclosed with galvanized steel insulation cover. Insulation shall not be applied to underside of unit base.

D. Cabinet Base Rails: Side and end base rails shall include openings for forklift and tie-down access. To protect unit base from fork damage side rails shall include removable heavy gauge fork pockets.

E. Shipping anchors attach to and/or through unit base rails. Straps over unit shall not be used to secure unit for shipping.

F. Exterior Corrosion Protection: Exterior cabinet panels shall be a base coat of G-90 galvanized steel with exterior surfaces cleaned, phosphatized and finished with a weather-resistant baked enamel finish. Unit's surface shall be in compliance with ASTM B45 salt spray testing at a minimum of 672 hour duration.

G. Interior Corrosion Protection: Interior surfaces shall be a stainless steel. Cabinet shall include interior liner constructed of Type 304 stainless steel with sealed seams. All Unit Coils shall be coated. See coil coating requirements below.

H. Cabinet construction shall provide hinged panels providing easy access for all parts requiring routine service.

I. Cabinet top cover shall be one piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.

J. Hinged Access Panels: Water- and air-tight hinged access panels shall provide access to all areas requiring routine service including air filters, heating section, electrical and control cabinet sections, supply air fan section, evaporator and reheat coil sections. Insulated doors shall be constructed to allow the hinges to be reversed in the field.

1. Hold-open devices shall be factory installed on all hinged access doors. Chains shall not be used as hold-open devices.
2. Latches with locking hasp or tool operated closure devices shall be factory installed on all hinged access panels.

K. Drain Pan material shall be Type 430 Stainless steel drain and constructed to sloped in two directions to ensure positive drainage with corners exposed to standing water and drain fittings welded liquid tight to prevent leaks. Pan shall have a minimum depth of 2". Base of drain pan shall be insulated with 1" thick foam insulation.

L. Provide openings either on side of unit or thru the base for power, control and gas connections.

M. Unit shall be equipped with a 6" filter rack upstream of the evaporator. Frame shall be field-adjustable to match any filter combination specified in the following section.

2.4 FANS AND MOTORS

1. Supply fans shall be high efficiency backward curved impeller.
2. All Fan motors shall be an (ECM) electronic commutated motor with integrated power electronics for variable motor speed.
3. Outdoor fans shall be direct drive with premium efficiency motors, statically and dynamically balanced, draw through in the vertical discharge position.
4. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

2.5 AIR FILTERS

A. Pre-filter:

1. Comply with NFPA 90A.
2. Factory-fabricated, dry, extended-surface, self-supporting type.
3. Thickness: 2 inch.
4. Minimum MERV: 8, according to ASHRAE 52.2.
5. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.

B. Final Filter:

1. Comply with NFPA 90A.
2. Factory-fabricated, dry, extended-surface, self-supporting type.
3. Thickness: 2 inch.
4. Minimum MERV: 14, according to ASHRAE 52.2.
5. Media: Fibrous material coated with an antimicrobial agent and constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions.

C. Mounting Frames:

1. Panel filters arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or from access plenum.
2. Extended surface filters arranged for flat orientation, removable from access plenum.
3. Galvanized or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter.

2.6 DAMPERS

A. Unit shall include a motor operated outdoor air damper constructed of galvanized steel.

B. Damper blades shall be air foil design with rubber edge seals designed not to exceed a 4 CFM/SQ FT leakage rate exceeding ASHRAE 90.1 damper leakage requirements.

C. Damper actuator shall be factory mounted and wired sealed spring return and either two-position or fully modulating.

2.7 DEHUMIDIFICATION/COOLING

A. Compressors

1. Provide dual-digital scroll type compressors – minimum 2 digital scrolls.
2. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
3. Internal overloads shall be provided with the scroll compressors.
4. Each compressor shall have a crankcase heater to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
5. Each compressor shall be mounted on rubber vibration isolators, to reduce the transmission of noise.
6. Provide each unit with two hermetically sealed independent refrigerant circuits factory-supplied completely piped with liquid line filter-drier, liquid line charging port, suction and liquid line pressure ports, sight glass, and thermal expansion valve.
7. Provide each circuit with automatic reset high and low pressure and high temperature switches for safety control.

B. Coils

1. Evaporator, Condenser and Hot Gas Reheat coils shall be constructed with copper tubes mechanically bonded to configured aluminum plate fins.
2. Coils shall be factory leak tested in accordance ANSI/ASHRAE 15-1992 at a minimum pressure of 500 PSIG.
3. The condenser coil shall have a fin designed for ease of cleaning.
4. Evaporator coil shall include (six / four) rows of cooling interlaced for superior sensible and latent cooling with a maximum of 12 FPI for ease of cleaning.
5. Reheat coil shall be fully integrated into the supply airstream and be capable of delivering design supply air temperature.
6. To prevent re-hydration of condensate from evaporator coil, the evaporator coil face and the hot gas reheat coil face shall be separated by a minimum of six inches.
7. Coil Coating for condenser, evaporator, HGRH coils: Coil will have a flexible epoxy polymer e-coat uniformly applied to all coil surface areas with no material bridging between fins. The coating process will ensure complete coil encapsulation and a uniform dry film thickness from 0.6 – 1.2 mills on all surface areas including fin edges and meet 5b rating cross hatched adhesion per ASTM B3359- 93.Corrosion durability will be confirmed through testing with no less than 5,000 hours salt spray resistance per ASTM B117-90 using scribed aluminum test school coupons.
8. The unit(s) must comply per above - spray coatings not acceptable
9. Condenser coil hail guards shall be factory installed.

C. Condenser Section

1. Outdoor Fans: Shall be direct drive vertical discharge design with low-noise corrosion resistant glass reinforced polypropylene props, powder coated wire discharge guards and electro-plated motor mounting brackets.
2. Fans shall be statically and dynamically balanced.

D. Compressor Capacity Control – DUAL DIGITAL SCROLL COMPRESSORS

1. (Mechanical Control: shall be equipped with Refrigerant Capacity Control (RCC) to modulate compressor capacity during Dehumidification or Cooling modes to maintain evaporator Dehumidification or Cooling setpoint and prevent evaporator frosting or freezing. Hot gas by pass shall not be an acceptable compressor capacity control strategy. The RCC setpoint is factory set, and field adjustable, to maintain desired suction pressure and compressor discharge pressure.

2.8 HEATING

A. Modulating Indirect Gas Fired Heating System

1. Completely assembled and factory installed heating system shall be located in the primary heating position located downstream of the indoor fan assembly and be integral to unit and approved for use downstream from refrigerant cooling coils in units mounted outdoors. Threaded gas connection shall terminate at manual shut-off valve. Provide capability for sidewall or thru-base gas piping.
2. Heaters shall include high turn-down burners firing into individual stainless steel tubular heat exchangers. Heat exchangers shall be constructed of type 439 stainless steel and be a high efficiency dimpled tubular design capable of draining internal condensate. Units with multiple heaters shall include one fully modulating high turndown heater with additional on-off heater sections. Total heater turndown shall be of 10:1.
3. Heater outdoor air inlet shall be hooded and include internal baffle system to prevent rain blow thru. To prevent recirculation of flue gas and to prevent flue gas condensate from draining onto and obstructing the heater air inlet the inlet shall be hooded and shall be located a minimum of 11” beneath the flue outlet. Inlet hood shall include bird screen.
4. Heater flue outlet(s) shall include hooded outlet with wire cloth all constructed of Type 430 stainless steel. Hooded outlet shall be sealed to prevent flue gas recirculation.
5. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, continuous air proving monitoring following ignition and continuous electronic flame supervision.
6. Unit controls shall monitor heat output and shall discontinue all heating attempts and or unit operation in the event the heating section fails to ignite or fails to maintain programmed supply air temperature/time.

7. Inducer fan shall be direct drive high pressure centrifugal type with two speeds and shall include built- in thermal overload protection.
8. Limit controls: High temperature automatic reset limits shall be located on blower wall and in indoor fan chamber to shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow, or loss of indoor airflow.
9. Flame roll-out safeties shall provide continuous monitoring of proper burner operation.

2.9 ELECTRICAL RATINGS AND CONNECTIONS

A. All high voltage power components such as fuses, switches and contactors shall include a service personnel protection barrier or shall be a listed as touch-safe design.

B. Field wiring access to be provided thru unit base into isolated enclosure with removable cover.

C. Power wiring to be single point connection.

D. Wiring internal to the unit shall be colored and numbered for identification.

E. Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.

F. Factory wired main power disconnect and overcurrent device shall be rated for total unit connected power

G. SCCR rating shall be a minimum of 65kA

H. Factory wired Voltage/Phase monitor shall be included as standard. In the event of any of the following, the units will be shut down and a fault code will be stored in the monitor for the most recent 25 faults. Upon correction of the fault condition the unit will reset and restart automatically.

1. Phase Unbalance Protection: Factory set 2%
2. Over/Under/Brown Out Voltage Protection: +/-10% of nameplate voltage
3. Phase Loss/Reversal

I. Factory to mount and wire optional 120 volt convenience outlet. Field wiring of convenience outlet not acceptable.

J. All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.

2.10 UNIT CONTROLS

A. Controls and Building Management System Integration: All controls for the variable refrigerant system and ventilation air units shall be provided by the

equipment manufacturer. Control wiring will be provided as specified under section 23 09 00. Equipment controls shall utilize BACnet communication protocol and will be compatible with the automation system. Equipment manufacturer shall provide all programming, checkout commissioning and startup of the VRF system and ventilation air systems. A BACnet Network Automation Engine for communication of the VRF system will be provided by the controls contractor as specified under section 23 09 00. VRF and ventilation air equipment manufacturer is responsible for providing BACnet controls. Equipment manufacturer shall provide onsite technical personnel to assist and support controls contractor in integrating the VRF system.

B. Units shall be configured as follows, depending unit type and application.

1. Dedicated-Outside Air Unit with active dehumidification-reheat for neutral discharge air control with unit conditioning modes to maintain discharge air setpoints.

C. Additional Operational Modes

1. System Sensors shall include: Factory installed and wired Outdoor Air Temperature, Outdoor Air Humidity and Evaporator Leaving Air Temperature and factory furnished, field installed Discharge Air Temperature.

D. System controls shall include:

1. Anti-cycle timing.
2. Minimum compressor run/off-times.

2.11 MANUFACTURER'S FIELD SERVICES

A. Unit start-up shall be completed by an Employee of the Factory and must be a factory-certified technician.

1. Manufacturer must have twenty factory-authorized and factory-trained technicians within a 50 mile radius of job site.

B. The contractor shall furnish manufacturer complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.

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

3.2 INSTALLATION

A. Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.

B. Curb Support: Install roof curb on roof structure according to "The NRCA Roofing Manual."

1. Install and secure units on curbs and coordinate roof penetrations and flashing with roof construction.
2. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07 72 00 "Roof Accessories."
3. Coordinate size, location, and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.

C. Restrained Curb Support: Install restrained vibration isolation roof-curb rails on roof structure according to "The NRCA Roofing Manual."

D. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.

E. Comply with requirements for gas-fired furnace installation in NFPA 54, "National Fuel Gas Code."

F. Install separate devices furnished by manufacturer and not factory installed.

G. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

H. Install drain pipes from unit drain pans to storm drain.

1. Drain Piping: Drawn-temper copper water tubing complying with ASTM B 88, Type L, with soldered joints.
2. Pipe Size: Same size as condensate drain pan connection.

3.3 CONNECTIONS

A. Where installing piping adjacent to units, allow space for service and maintenance.

B. Duct Connections:

1. Comply with requirements in Section 23 31 13 "Metal Ducts."
2. Drawings indicate the general arrangement of ducts.
3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 23 33 00 "Air Duct Accessories."

C. Electrical Connections: Comply with requirements for power wiring, switches, and motor controls in electrical Sections.

1. Install electrical devices furnished by unit manufacturer but not factory mounted.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
3. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and record the following:
   a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
   b. Cooling coil entering-air, dry- and wet-bulb temperatures.
   c. Condenser coil entering-air dry-bulb temperature.
   d. Condenser coil leaving-air dry-bulb temperature.

4. Simulate maximum cooling demand and inspect the following:
   a. Compressor refrigerant suction and hot-gas pressures.
   b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.

5. Inspect casing insulation for integrity, moisture content, and adhesion.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean coils and inspect for construction debris.
10. Retain first three subparagraphs below for units with furnace.
11. Retain first subparagraph below for units with restrained vibration isolation roof-curb rails.
12. Inspect and adjust vibration isolators and seismic restraints.
13. Verify bearing lubrication.

14. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
15. Adjust fan belts to proper alignment and tension.
16. Start unit.
17. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
18. Operate unit for run-in period.
19. Calibrate controls.
20. Adjust and inspect high-temperature limits.
21. Retain first subparagraph below for units designed to operate, at least part-time, with less than 100 percent outdoor air.
22. Inspect outdoor-air dampers for proper stroke.
23. Verify operational sequence of controls.
24. Measure and record the following airflows. Plot fan volumes on fan curve.
    a. Supply-air volume.
    b. Retain first subparagraph below for units designed to operate, at least part-time, with less than 100 percent outdoor air.
    c. Outdoor-air flow.

B. After startup, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace components that do not properly operate and repeat startup procedures as specified above.

D. Prepare written report of the results of startup services.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 23 74 13

SECTION 23 82 19 - FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Ducted fan coil units and accessories.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings:

   1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

   1. Suspended ceiling components.
   2. Structural members to which fan coil units will be attached.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Items penetrating finished ceiling, including the following:

      a. Lighting fixtures.
      b. Air outlets and inlets.
      c. Speakers.
      d. Sprinklers.
      e. Access panels.
      f. Baggage belt systems.

   6. Perimeter moldings.

B. Seismic Qualification Certificates: For fan coil units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Coil Unit Filters: Furnish two (2) spare filters for each filter installed.

1.7 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.8 COORDINATION

A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTED FAN COIL UNITS

A. Provide Carrier, Trane, McQuay, or York (JCI) fan coil units, having capacities as scheduled on the drawings. Fan coil units shall be factory-assembled, vertical, draw-thru type for suspended ceiling mounting with full access to internal components. Unit shall be complete with water coils, fan(s), motor, belt drive, drain pan, and filter.

B. Fan Coil Unit Configurations: Row split.

1. Number of Heating Coils: One with two-pipe system.
2. Number of Cooling Coils: One with two-pipe system.

C. Coil Section Insulation: 1/2-inch-thick, foil-faced glass fiber complying with ASTM C1071 and attached with adhesive complying with ASTM C916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.

D. Main and Auxiliary Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1.

E. Chassis: Galvanized steel where exposed to moisture.

F. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
2. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

G. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.

H. MERV Rating: 7 when tested according to ASHRAE 52.2.

1. Pleated Cotton-Polyester Media: 90 percent arrestance and MERV 7.

I. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

J. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

1. Motors: Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
2. Two-way, modulating control valve for chilled-water coil.

3. Two-way, modulating control valve for heating coil.
4. Hose Kits: Minimum 400-psig working pressure and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.

    a. Length: 24 inches.
    b. Minimum Diameter: Equal to fan coil unit connection size.

5. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
6. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
7. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig working pressure at 250 deg F; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig.
8. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
9. Wrought-Copper Unions: ASME B16.22.

K. Control devices and operational sequence are specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC Piping and Equipment."

L. Basic Unit Controls:

1. Control voltage transformer.
2. Wall-mounting thermostat with the following features.

    a. Heat-cool-off switch.
    b. Fan on-auto switch.
    c. Fan-speed switch.
    d. Automatic changeover.
    e. Adjustable deadband.
    f. Exposed set point.
    g. Exposed indication.
    h. Degree F indication.

3. Unoccupied-period-override push button.
4. Data entry and access port.

    a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
    b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

M. DDC Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
2. Unoccupied-Period-Override Operation: Two hours.

3. Unit Supply-Air Fan Operation:

    a. Occupied Periods: Fan runs continuously.
    b. Unoccupied Periods: Fan cycles to maintain room setback temperature.

4. Hydronic-Cooling-Coil Operation:

    a. Occupied Periods: Modulate control valve to maintain room temperature.
    b. Unoccupied Periods: Close control valve.

N. Interface with DDC System for HVAC Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation.
3. Provide BACnet interface for central DDC system for HVAC workstation for the following functions:

    a. Adjust set points.
    b. Fan coil unit start, stop, and operating status.
    c. Data inquiry, including supply- and room-air temperature.
    d. Occupied and unoccupied schedules.

O. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.

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

3.2 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.

C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.

a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 23 33 00 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

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

D. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION 23 82 19

DOCUMENT 260500 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Provide complete, tested and fully functional electrical systems as shown on the Drawings and as specified herein.

B. Electrical equipment and installed systems shall be suitable for the intended application, shall be safe for the intended use, shall be fully rated for the available fault current, and shall conform to local building codes and statutory requirements.

1.2 RELATED DOCUMENTS

A. The Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

B. Electrical requirements specified in this Section apply to electrical equipment and materials described in other Sections of Division 26.

1.3 SCOPE OF WORK

A. The work includes, but is not limited to, the following:

1. Basic electrical materials and methods
2. Grounding System
3. Electrical identification
4. Wire and cable
5. Raceways, boxes, and fittings
6. Lighting Controls
7. Receptacles and Equipment Connections
8. Interior Lighting
9. Fire Alarm System
10. Seismic Restraints for Electrical
11. Building expansion/seismic joint accommodation equipment
12. Fire Rated Penetration Systems
13. Low Voltage Systems Raceway Distribution System
14. Coordination Drawings
15. Thorough cleaning of all equipment prior to energization
16. Protection of all equipment under this Division until the final acceptance of the job

B. Coordinate Division 26 requirements with work in other Divisions.

C. Submit preconstruction submittals, shop drawings, product data, samples, design data, test reports, certificates, manufacturer's instructions, manufacturer's field reports, operation and maintenance data, closeout submittals and other specified documents to the Engineer for review and approval as described in Division 1, in this Section, and in other Sections of Division 26.

D. The following principal items of work will be performed under other Sections unless otherwise noted:

1. Finish painting of all exposed raceways, boxes, hangers, apparatus, etc., except as otherwise specifically mentioned herein.
2. Cutting and patching referred to in Division 1.

1.4 PROJECT CONDITIONS

A. Ambient temperature, humidity, and elevation ranges: Equipment other than transformers shall be rated for continuous operation at full rated load without derating, under the following conditions:

1. Ambient Temperature: 0 to 40 deg C.
2. Humidity: Less than 90 percent (non-condensing).
3. Altitude: Not exceeding 3300 feet (1000 m).

B. Product Selection for Restricted Space: Drawings show allowable space to scale for anticipated equipment sizes. Comply with NEC requirements for working clearances and with manufacturer's recommendations for access for maintenance. Notify the Engineer if insufficient space is available for available products.

1.5 DEFINITIONS

A. In addition to the Definitions in Specification Division 1, the following definitions apply to Division 26:

1. AHJ: The statutory Authority Having Jurisdiction as defined in NEC Article 100 for enforcement of legally required compliance to local codes, standards, and ordinances.
2. ANSI: American National Standards Institute
3. AEIC: Association of Edison Illuminating Companies
4. ASQ: American Society for Quality
5. AWG: American Wire Gauge
6. CFR: Code of Federal Regulations
7. Cable: an assembly of insulated conductors
8. Control panel: an electrical enclosure housing control logic devices and an operator control interface
9. Commissioning: the process of testing system performance after the sequential steps of installation, testing, energization, startup (including initial adjustment and de-bugging) and functional testing of individual pieces of equipment have all been completed

10. Contract: as used in the Electrical Specification, includes all Contract documents including Specifications and Appendices, Drawings, Addenda, and Change Orders
11. ICEA: Insulated Cable Engineers Association
12. Equipment: a general term including materials, fittings, devices, appliances, fixtures, apparatus, and the like, used as part of, or in connection with, an electrical installation (OSHA Section 29 CFR 1910.399(46) definition)
13. FM: Factory Mutual, Inc.
14. Field wiring: on-site installation of raceways & conductors to connect equipment in accordance with approved drawings
15. Field test: electrical test carried out on-site
16. Fail-safe: selection of control devices and contacts in a manner which results in safe shutdown of the equipment whenever one of the following events occurs:

    a. Loss of remote control RUN command (normal configuration: contacts close to run equipment)
    b. Intentional and unintentional disconnection of device (normal configuration: contacts open to shut down equipment)
    c. High contact resistance or high resistance connection
    d. Loss of 4-20mADC signal
    e. Definite-time sequence takes too long, e.g., reduced voltage motor starter fails to make transition from START mode to RUN mode after a reasonable time
    f. Defined sequence does not occur, e.g., there is no flow from a motor driven pump within a reasonable time after the motor starter contactor is energized.

17. Furnish and install: same as “Provide” below.
18. Functional testing: verification of the satisfactory performance of control logic, with due attention to equipment protective devices, for example, overload relays, temperature switches, pressure switches, flow switches, and similar devices, under actual operating conditions
19. HV: high voltage, operating voltage over 600V (NEC definition)
20. IEEE: Institute of Electrical and Electronics Engineers, Inc.
21. ISO: International Standards Organization
22. Lineup: with respect to switchgear, switchboards, and motor control centers, a contiguous group of vertical sections with common main busbars, and including bus tie breaker sections and control sections
23. LV: low voltage, operating voltage under 600V (NEC definition)
24. Megger: insulation tester with megohm scale
25. NEC: NFPA 70, the National Electrical Code
26. NETA: InterNational Electrical Testing Association, Inc.
27. NICET: National Institute for Certification in Engineering Technologies
28. NFPA: National Fire Protection Association
29. NRTL: Nationally recognized testing laboratory as defined in 29 CFR 1910.7 as it applies to testing and inspecting for safety in the workplace (OSHA definition)
30. Nonconformity: The nonfulfillment of a specified requirement (ASQ definition)
31. “Or approved equal”: proposed “equal” product shall be in conformance with all specified requirements, shall be equivalent in materials of construction to specified manufacturers’ products, shall have equal or superior performance in

the conditions anticipated for use of the product in this project, and shall be approved by the Engineer

32. OSHA: Occupational Safety and Health Act
33. Panel: with respect to circuit breaker and fuse power distribution centers, panel is equivalent to “distribution board”, e.g., lighting panel; with respect to control panels, refers either to the entire control panel itself or to a steel plate used for mounting devices inside the control panel
34. Provide: Throughout the Specification, use of this term includes project administration, quality assurance, human resources, tools & equipment, logistics and scheduling, submittals of shop drawings & samples for approval, managing suppliers, purchasing, manufacturing, factory testing, release for shipment, packing, delivery, storage, submittal of coordinated & dimensioned installation drawings for approval, installation, surface preparation & finishes, site testing, startup & commissioning, on-site supervision by equipment manufacturers’ representatives, spare parts & tools, Operations and Maintenance (O&M) Manuals, training, guarantees and warrantees, other work described in individual Sections of the Specification, and the Contractor’s duties, responsibilities, risks, and liabilities under the Contract.
35. Punch list: document containing detailed descriptions of non-conformities
36. Quality: conformance to specified requirements.
37. RMS: root mean square
38. Raceways: cable ladder and tray, conduit, duct, wireway, and associated boxes and fittings which enclose, support, and protect wires and cables
39. Shop drawings: a complete package of manufacturer’s equipment drawings, bill of materials, catalog data sheets, performance curves, calculations, and other data provided to demonstrate conformance to the equipment specification
40. Substitution: an alternative, nonconforming product proposed by the Contractor in lieu of a specified, conforming product
41. Substantial Completion: an electrical system may be considered substantially complete when the equipment has passed the specified tests required prior to energization, has been energized, has passed the Electrical Acceptance Tests, and all related Specification requirements have been met except for well-defined minor items which, in the opinion of the Engineer, may be repaired or replaced prior to Final Acceptance without adversely affecting process performance.
42. Terminal box: an electrical enclosure containing labeled terminal blocks for connection of wiring
43. UL: Underwriters Laboratories, Inc.
44. VFC: variable frequency controller
45. VFD: variable frequency drive, the combination of VFC and inverter-duty motor that drive mechanical loads using the principle of variable frequency motor control
46. Wiring: conductors and connections to equipment terminals. ‘Wiring’ and ‘cabling’ shall be considered equivalent terms. Fiber optic cables shall be included in the scope of electrical wiring.

1.6 REFERENCE STANDARDS

A. Notwithstanding revision dates shown in this and other Sections of Division 26, the codes and standards applicable to this project shall be those in effect at the time of bid submittal, except for NFPA 70 NEC, which shall be the version acceptable to the AHJ.

1.7 QUALITY ASSURANCE

A. In consultation with the equipment and materials Suppliers, the Contractor shall prepare and submit a Compliance Statement as described in “SUBMITTALS” below with each submittal requiring approval.

B. The Engineer’s approval of a submittal shall not relieve the Contractor of any Contractor responsibilities under the Contract. Approval of a submittal that is incomplete, or one that has nonconformities that are not described in the Compliance Statement that is specified to be included with each submittal, followed by the discovery of unapproved nonconformities, will result in replacement of the non-conforming items at no additional cost to the Owner. Substitutions require the approval of the Engineer.

C. Manufacturers of electrical equipment shall have quality certification to ISO 9000:2000 or an equivalent Quality Management System acceptable to the Engineer.

D. Equipment, materials, and installation shall conform to NEC requirements and shall be NRTL-listed and labeled.

E. On-site testing prior to energization and electrical acceptance testing shall be performed as specified in other Sections.

F. Manufacturers, manufacturer’s representatives, subcontractors, supervisors, installers, and testing agencies shall have qualifications and experience as described in other Sections of the Specification. Qualifications and experience submittals for firms and individuals shall be submitted, re-submitted, or updated whenever requested by the Owner’s Representative.

1.8 SAFETY IN THE WORKPLACE

A. Electrical equipment and materials, and the Contractor’s installation practices, shall conform to the following:

1. Current edition of OSHA sections of the Code of Federal Regulations (CFR): Part 29 CFR 1910 for General Industry and Part 19 CFR 1926 for Construction Activities
2. NFPA 70, the National Electrical Code
3. Current edition of NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces

B. These regulations and standards impose obligations on equipment manufacturers to obtain NRTL certification, listing, and labeling to comply with OSHA (Occupational Safety and Health Act) and Department of Labor regulations.

C. All electrical equipment for which NRTL test procedures have been established shall be certified, listed, and labeled, or otherwise determined to be safe for its intended use, by a NRTL. The absence of a specific reference to NRTL-listing in other Sections shall not relieve the Contractor of the requirement to provide NRTL-listed equipment, and to

obtain certification as required by the AHJ in cases where NRTL listing and labeling is not a manufacturer's standard offering for a particular product.

D. Equipment shall not be modified in any manner adversely affecting safety for the intended use, nor shall any equipment be modified on-site without the approval of the manufacturer.

E. Equipment sound levels shall not exceed limits established by reference standards and local regulations. In the absence of reference standards and local regulatory requirements, sound pressure levels shall not exceed 85 dB (A) measured three feet from the equipment.

F. Equipment with moving parts shall be fully guarded in compliance with OSHA rules and regulations.

1.9 INSPECTIONS BY THE AHJ

A. The Contractor shall make arrangements for electrical inspection of the project by the AHJ. Upon completion of the work, final certificate of approval documents shall be submitted to the Engineer for forwarding to the Owner. This certificate shall be submitted prior to request for final payment. The Contractor shall pay all fees required for inspection.

1.10 WORKMANSHIP AND MATERIALS

A. Materials and equipment shall be new and undamaged, shall be marked by the manufacturer, and shall be delivered to the construction site in the original factory packaging.

B. Materials and equipment shall be installed in accordance with the Drawings, the Specification, and the manufacturer's installation, operation, and maintenance instructions. In the event of apparent conflicts or discrepancies, the Engineer shall be informed of the apparent conflict or discrepancy in writing, and will instruct the Contractor how to proceed.

1.11 RESOURCES AND CONSTRUCTION SCHEDULE

A. The Contractor shall provide sufficient resources, including qualified and experienced project managers, electrical engineers, superintendents, technicians, supervisors, electricians, tools and construction equipment to complete the electrical work in accordance with the activity durations and sequences shown on the Construction Schedule for this project.

B. The construction schedule shall include the following activities and milestones, in realistic sequence, for each transformer, circuit breaker panelboard and exterior lighting:

1. Review of shop drawings

2. Approval of shop drawings (milestone)
3. Factory testing
4. Request for release of shipment documentation
5. Shipping
6. Delivery to site (milestone)
7. Formwork ready for sleeves, openings, and inserts
8. Equipment installation (including “remote” sites)
9. Tests on completion of installation (prior to energization)
10. Energization (milestone)
11. Functional testing
12. Acceptance testing
13. Installation, testing, and commissioning complete (milestone)

C. The construction schedule shall include the following activities and milestones, in the following sequence, for electrical raceways and wiring in each building and structure:

1. Review of Contractor’s dimensioned layout and coordination drawings
2. Approval of Contractor’s dimensioned layout and coordination drawings (milestone)
3. Materials delivery to site (milestone)
4. Foundations ready for grounding electrode installation
5. Imbedded raceway installation
6. Room ceiling, wall, and floor finishing complete (ready for exposed raceway installation)
7. Surface raceway installation
8. Wire & cable installation
9. Tests on completion of installation (prior to energization)
10. Wire and cable testing complete (milestone)

1.12 CONTRACT DRAWINGS AND SPECIFICATIONS

A. The Electrical Drawings provide scaled layouts of representative equipment and key building dimensions, for example, structural gridlines, but do not include “approved for construction” dimensions for equipment.

B. All electrical systems, mounting hardware, labor and other items indicated on the Electrical Drawings, schedules and/or specifications shall be included in the Contractor’s bid, unless specifically indicated otherwise. The specifications, schedules, diagrams, details and plans are complementary and what is indicted on any is as binding as if indicated on all. Where conflict exists between what is shown and what is specified, the more stringent shall govern.

C. The drawings are diagrammatic and are not intended to show each and every conductor, fitting, device, conduit, or complete detail of all the work to be performed, but are for the purpose of illustrating the type system and special conditions necessary for the experienced electrician to take off their material and lay out the work. The Contractor shall be responsible for making such measurements as may be necessary at the Project and adapting the work to project conditions.

D. Drawings shall not be scaled. Refer to architectural and structural drawings for building construction and dimensions and to room finish schedule or architectural drawings for material, finish and construction method of walls, floor and ceiling in order to insure proper rough-in and installation of work.

1.13 COORDINATION OF WORK

A. Work under this Division shall be performed in conjunction with the work of other trades. Coordinate electrical installation work with the overall construction schedule. Examine the plans and specifications prior to commencement of work and become familiar with all phases of work involved prior to commencing installation work.

B. The Contractor shall be responsible for coordinating dimensions of equipment and working clearances in accordance with NEC, and in all cases bring to the attention of the Engineer any discrepancies on the plans and in the specifications prior to installation. Any work that installed without proper coordination shall be removed and reinstalled at the Contractor's expense. The layout for sleeves, chases, openings, etc., must be arranged prior to construction in order to prevent unnecessary cutting. Examine Architectural drawings for doors swings, countertop heights, built-in furniture and casework, and other factors affecting electrical outlet locations prior to roughing-in raceways, boxes, fittings, and outlets.

1.14 CODES AND STANDARDS

A. All equipment and materials shall be manufactured, tested, and installed in accordance with the National Electrical Code (NEC) and all applicable portions of local codes, in accordance with the requirements of the AHJ.

B. In addition, work shall be in accordance with the versions of the following referenced standards in effect at the time of bid opening:

1. American Association for Laboratory Accreditation (A2LA)
2. American Society for Testing and Materials (ASTM)
3. American National Standards Institute (ANSI)
4. Americans with Disabilities Act (ADA)
5. Code of Federal Regulations (29 CFR 1903, 1910, and 1926)
6. Factory Mutual Engineering & Research (FME&R)
7. Illuminating Engineering Society of North America (IESNA)
8. Insulated Cable Engineers Association (ICEA)
9. International Organization for Standardization (ISO)
10. National Electrical Manufacturers Associates (NEMA)
11. Institute of Electrical and Electronic Engineers (IEEE)
12. National Fire Protection Association (NFPA)
13. Occupational Safety and Health Act (OSHA)
14. Underwriters Laboratory, Inc. (UL) and other NRTL standards and test procedures

1.15 SUBMITTALS

A. Submittals shall conform to requirements described in Division 1 Section “Submittal Procedures”.

B. Compliance Statement: with each submittal, include a Compliance Statement listing each Specification Section, and Part 1, 2, and 3 Sub-Sections, stating, paragraph-by-paragraph, compliance with the Specification, each minor nonconformity that is within the intent of the Specification, and proposed nonconformities. Provide short description of minor nonconformities, and detailed explanation of other nonconformities.

C. Submittal Format

1. Each submittal shall be accompanied by a transmittal letter showing the submittal category and Specification Section reference number(s). Submittals shall be 3-hole punched and neatly bound.
2. Submittals shall have a complete Table of Contents with tabs corresponding to the Table of Contents headings.
3. Submittal transmittal letters shall clearly identify the reason for submittal, e.g., for approval, as manufactured, or as-built / record.
4. Each page of each submittal shall be numbered. Page numbers shall be listed on the Table of Contents. Content shall be printed on 8½ x 11 inch paper, or 11 x 17 paper (folded). Larger size drawings shall be folded and placed in labeled individual clear plastic pockets.
5. Product Data shall be clearly marked to show which items are proposed for this project. Information that does not apply to this project shall be crossed out.

D. Submittal Categories

1. Preconstruction Submittals, including proposed substitutions, supplier and manufacturer qualifications and experience, construction scheduling, preliminary harmonics analysis for variable frequency controllers
2. Shop Drawings, including equipment drawings, seismic bracing details, and Coordination Drawings
3. Product Data, marked to indicate precisely which items are proposed for this project
4. Samples, labeled by name, Specification Section and sub-clause, and mounted on sample boards
5. Design Data, including manufacturer’s design calculations
6. Test Reports, including prototype tests, factory tests, field tests, acceptance tests, and functional tests
7. Certificates, including seismic qualification certification, welding certificates, factory training certificates for manufacturer’s representatives
8. Manufacturer’s Instructions, including unloading, hoisting, rigging, short term storage, long term storage, method of field assembly, and installation instructions
9. Manufacturer’s Field Reports, including inspections and training records
10. Operation and Maintenance Manuals, including manufacturer’s standard published literature and specially prepared descriptions of operation
11. Closeout Submittals, including black line paper copy of Record Drawings marked in red illustrating changes during construction
12. Spare Parts and Special Tools List

E. In the absence of contradictory instructions in Division 1 Section “Submittal Procedures”, Shop Drawings and Coordination Drawings shall be marked with revision blocks to indicate status as follows:

1. FOR APPROVAL
2. AS MANUFACTURED (incorporates Engineer’s comments)
3. AS BUILT / RECORD (incorporates on-site modifications)

F. Product Data Sheets: Submit a list of manufacturers with catalog numbers and product data sheets for the following materials miscellaneous equipment, and obtain approval before the items in question are ordered or installed.

1. Grounding Systems
2. Raceways, Boxes, and Fittings
3. Wire and Cable (600 V and less)
4. Fire Rated Penetration Systems
5. Electrical Identification
6. Hangers and Supports
7. Seismic Restraints
8. Lighting Control Devices
9. Wiring Devices
10. Lighting Fixtures
11. Fire Alarm System

G. Record Drawings: Maintain a full size paper set of “black-line” working drawings throughout the project, and shall carefully record in red ink the actual locations including dimensions to locate each piece of electrical equipment, raceways, boxes, & fittings, and electrical outlets. Upon Substantial Completion of the work, deliver the marked-up set of prints to the Engineer. The Engineer reserves the right to withhold final payment until "As-Built" drawings are received.

H. Operation and Maintenance Manuals: Prior to acceptance of the finished project, provide copies of electrical Operation and Maintenance Manuals in conformance with Division 1 Section “Operation and Maintenance Data”. O&M Manuals shall be organized according to Division 26 Section numbers. Each copy shall be bound in a durable, 3-ring hardback binder, with data sheets individually punched and reinforced to prevent tearout. Data sheets shall be grouped, and binder dividers shall be provided to match the Table of Contents. Each Manual shall have an identifying label on the spine and front cover and shall include the following:

1. List of all O&M Manuals in the front of each manual.
2. Table of Contents for each manual and each binder
3. Copy of each of the following:

    a. Preconstruction Submittals
    b. Shop Drawings
    c. Product Data
    d. Design Data
    e. Test Reports
    f. Certificates
    g. Manufacturer’s Instructions

h. Manufacturer's Field Reports
i. Operation and Maintenance Data
j. Closeout Submittals
k. Panelboard directories (as-built)

1.16 OUTAGES

A. Electrical outages: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service if required by the Specification.

1. Notify the Owner a minimum of 14 days in advance of proposed interruption of electrical service.
2. Submit step-by-step sequence and schedule for proposed interruption, and if required, proposed method of providing temporary electrical service, to the Owner for approval.
3. Confirm approved interruption of electrical service one week in advance of Owner-approved date.
4. All work requiring an outage shall be done at night, from after the last plane arrival until 4am.
5. Do not proceed with interruption of electrical service without written permission from the Owner.

1.17 TEMPORARY LIGHTING AND POWER

A. Refer to Division 1.

B. The Contractor shall provide all temporary electric service for power and lighting including panels, feeders, lighting, outlets, branch circuits, etc.

C. The Owner's electrical power shall not be used without permission of the Owner.

D. All temporary work shall be in accordance with the NEC, OSHA, and NFPA safety requirements and shall be completely removed upon completion of the project.

PART 2 - PRODUCTS AND EXECUTION

2.1 EQUIPMENT AND MATERIALS

A. Provide equipment and materials in compliance with other Sections of Division 26. The requirements in this Section apply to all Sections in Division 26.

2.2 ELECTRICAL IDENTIFICATION

A. Electrical equipment, raceways, boxes, fittings, wires and cables shall be marked in the field in accordance with Division 26 Section "Electrical Identification".

2.3 ELECTRICAL ENCLOSURES

A. In the absence of other specified NEMA enclosure ratings in other Sections of the Specification, electrical enclosures shall have degree of protection ratings suitable for the intended application (e.g., watertight, dust-tight, explosion-proof) and environmental conditions. Electrical equipment enclosures shall have the following NEMA 250 ratings:

1. NEMA 3R: Electrical enclosures located outdoors in non-corrosive areas shall be NEMA 3R painted steel.
2. NEMA 4X: Outdoor enclosures in corrosive areas, including areas exposed to cooling tower mist, shall be NEMA 4X stainless steel.

2.4 ELECTROMAGNETIC INTERFERENCE

A. Power conversion equipment, including variable frequency controllers, battery-powered inverters, computer power supplies, frequency converters, and Uninterruptible Power Supplies, shall be fitted with EMI (electromagnetic interference), RFI (radio frequency interference) and telephone interference filters to limit interference effects on other equipment in the area in accordance with IEEE standards and recommendations applicable to the equipment.

2.5 DISSIMILAR METALS

A. Dissimilar metals shall not be connected, spliced, or joined except where specifically approved in writing by the Engineer. Copper busbars, aluminum busbars, and copper-to-aluminum busbar connections shall be tin-plated at joints and at cable lugs. Bolted electrical conductor connections shall be made with silicone-bronze bolts, nuts, and washers. Belleville washers & tin-plated flat washers shall be used at aluminum-to-copper and aluminum-to-aluminum busbar joints.

2.6 FIRE RATED PENETRATION SYSTEMS

A. Provide UL Listed fire penetration systems in openings in rated floors, walls, and other elements of construction. Provide UL listed fire penetration systems at all new and existing pipe penetrations of new and existing rated construction within the area of work. Coordinate work of this section with all other trades necessary for the proper installation of the fire rated penetration systems.

B. Submit shop drawings showing each condition requiring penetration seals in dictating proposed UL systems materials, anchorage, methods of installation, and actual adjacent construction. Submit a copy of UL illustration of each proposed system indicating manufacturer approved modifications. Submit copies of manufacturer's specifications, recommendations, inspection requirements, installation instructions, and maintenance data for each type of material required. Include letter indicating that each material complies with the requirements and is recommended for the applications shown.

C. All fire penetration systems shall reference ASTM E814/UL 1479 - Fire Test of Through - Penetration Fire Stops.

D. All systems shall be UL tested and listed in the UL Fire Resistance Directory.

E. Submit copies of written guarantee agreeing to repair or replace joint sealers which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated. The guarantee period shall be one (1) year from date of substantial completion.

F. 3M products have been specified as the penetration fire stop basis of design. Other manufacturer's systems are acceptable providing they meet the requirements set forth in this specification. The fire rated penetration systems shall be the products of one manufacturer to the maximum extent possible. The products of more than one manufacturer shall not be used as a combined seal.

G. Provide materials classified by UL to provide fire stopping equal to time rating, both "F" and "T" ratings, of construction being penetrated. Provide asbestos free materials that comply with applicable codes and have been tested under positive pressure in accordance with UL 1479 or ASTM E814. Systems shall be smoke and air tight.

H. Deliver material undamaged in manufacturer's clearly labeled, unopened containers identified with brand, type, grade, and UL label where applicable. Coordinate delivery with scheduled installation date to allow minimum storage time at site. Store material in clean, dry ventilated location. Protect from soiling, abuse, and moisture. Follow manu-facturer's instruction.

I. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.

J. Furnish adequate ventilation if using solvent. Furnish forced air ventilation during installation if required by manufacturer. Keep flammable materials away from sparks or flame. Provide masking and drop cloths to prevent contamination of adjacent surfaces by fire stopping resistance.

K. Clean surfaces to be in contact with penetration seal materials, of dirt, grease, oil, loose, materials, rust, or other substances that may affect proper fitting, adhesion of the required fire resistance.

L. Install penetration seal materials in accordance with printed instructions of the UL Fire Re-sistance Directory and in accordance with manufacturer's instructions. Seal holes or voids made by penetrations to ensure an effective smoke barrier. Where floor openings without penetrating items are more than four (4) inches in width and subject to traffic or loading, install fire stopping materials capable of supporting same loading as floor. Protect materials from damages on surfaces subject to traffic.

M. Clean up spills of liquid components. Neatly cut and trim materials as required. Remove equipment, materials, and debris, leaving area in undamaged, clean condition.

N. Examine penetration sealed areas to ensure proper installation before concealing or enclosing areas. Keep areas of work accessible until inspection by applicable code authorities. Perform under this section patching and repairing of fire stopping caused by cutting or penetration by local inspectors and other trades.

O. Fire Rated Pathway for Low Voltage Systems: All data, video and communications cable bundles shall utilize an enclosed fire-rated pathway device wherever cables penetrate rated area separation walls. The fire-rated pathway shall contain a built-in fire sealing system sufficient to maintain the hourly fire rating of the barrier being penetrated. The self-contained sealing system shall automatically adjust to the installed cable loading and shall permit cables to be installed, removed, or retrofitted without the need to remove or reinstall firestop materials. The fire rated pathways shall consist of three inch square chases gangable up to three pathways at any location. The pathway shall be UL classified and/or FM systems approved and tested to the requirements of ASTM E814 (UL 1479). Specified Technologies, Inc. EZ-Path. Refer to architectural drawings for location of the rated area separation walls.

2.7 WARRANTIES

A. Warranties for equipment and materials shall conform to Division 2 “Product Requirements”.

B. Provide an on-site parts and labor warranty for a minimum period of one year after Substantial Completion for all equipment and materials. In cases where the manufacturer offers a longer warranty period, the longer warranty period shall apply as described by the manufacturer.

C. All components of electrical systems that are not fully functional at the time of Substantial Completion shall have warranties extended to provide minimum one year coverage of fully operational equipment unless otherwise approved by the Owner’s Representative.

PART 3 - EXECUTION

3.1 DELIVERY AND HANDLING

A. Equipment delivered to site shall be handled in accordance with manufacturer’s recommendations by experienced riggers, crane operators, and fork lift truck operators.

3.2 STORAGE AND PROTECTION OF EQUIPMENT

A. All electrical equipment to be used in construction shall be properly stored and protected against the elements. General construction materials shall be stored in

covered trailers. Switchgear, unit substations, motor controllers, panelboards, emergency lighting, solid state equipment, engine generator shall be stored in a clean, dry, indoor location, under cover, until the building is weathertight and the area where the equipment is to be installed has been completed to the satisfaction of the Engineer, including completion of overhead work by other trades.

B. Equipment enclosures exposed to construction damage such as paint spots, spackling, waterproofing, insulation etc. shall be covered and protected against damage.

3.3 INSPECTIONS PRIOR TO COVERING-UP

A. Raceways embedded in concrete or otherwise concealed shall be inspected in the presence of the Engineer's Representative prior to placement of concrete. Sufficient time shall be allowed to make corrections if required.

3.4 ON-SITE INSPECTIONS AND NONCONFORMITIES

A. Equipment shall be inspected on delivery to site for physical damage and for compliance with the Specification and approved equipment shop drawings.

B. Installed equipment, raceways, and wiring shall be inspected on completion of installation for compliance with the Specification and approved installation drawings.

C. A Punch List will be prepared by the Owner's Representative during inspections and testing, and issued to the Contractor for corrective action.

D. Conform to Division 1 Section "Contract Closeout".

E. Repairs, replacement, and other corrective action that requires de-energizing any part of the Electrical Power Distribution and Control System shall be completed prior to the scheduled date for substantial completion of the project.

3.5 CUTTING AND PATCHING

A. Conform to Division 1 Section "Cutting and Patching".

3.6 PENETRATIONS AND SEALING

A. Sleeves and rectangular openings shall be provided for raceways provided under this Contract, and for raceways for future equipment where future equipment is shown on the Drawings. Sleeves and rectangular openings for the passage of raceways and conductors shall be sealed after the raceways and conductors have been installed. Spare sleeves and rectangular openings shall also be sealed.

B. Penetration of Waterproof Construction: Coordinate the work to minimize penetration of waterproof construction, including roofs and exterior walls. Where penetrations are necessary, provide sleeves and sealing fittings to make each penetration watertight.

Conduit sleeves and openings shall be sealed watertight with mechanical seals. Watertightness shall not rely on caulking.

3.7 ELECTRICAL SAFETY AND TEST EQUIPMENT

A. Maintain the following test instruments and calibration certificates less than 12 months old on-site as a minimum:

1. True RMS digital volt-ohm meter with resistance scale
2. Clip-on ammeter with range from 1 to 600 amps
3. 500V DC battery-powered megger insulation tester

B. Provide electrical safety equipment, including personal protective equipment, hot sticks, HV gloves, electrical blankets, test instruments, lighting, ventilation, and instructions in the use of safety equipment, and perform the work under this Contract in accordance with applicable safety rules and regulations. The Contractor's attention is directed to safety issues related to confined spaces as defined in OSHA regulations.

3.8 CLEANING AND PAINTING

A. Conform to Division 1 Section "Closeout Procedures".

B. After installation and wiring work is completed, all dust and debris shall be removed from the interior and exterior of each electrical equipment enclosure and motor by vacuum-cleaning with circuits de-energized. Do not use compressed air for cleaning. Vacuum cleaner wands and brushes shall be non-conducting. Anti-static protection shall be provided for static-sensitive devices.

C. Clean and remove all rust, scale, oil, grease, and dirt from panelboard enclosures, conduits, pull, junction and terminal boxes, fittings and hangers, leaving surfaces in condition for final surface preparation and painting under Division 9.

D. All ferrous materials that are concealed, or exposed in unfinished areas, including fittings, hangers, junction, pull and terminal boxes, that are not plated or painted with a factory-applied finish, shall be painted under this Section with one coat of zinc-chromate primer and one (1) finish coat of enamel paint approved by the Engineer. Nonferrous materials shall be cleaned only and left unpainted.

E. Equipment furnished with a factory finish coat shall have finish carefully touched-up where it is scratched or otherwise damaged. Touch-up work shall be match the color and type of the original finish.

3.9 LOAD BALANCING

A. Single phase circuits in single and three-phase fuse and circuit breaker distribution boards and lighting panels shall be balanced initially based on the load calculations. Load currents shall be measured under actual operating conditions, and under

conditions described by the Engineer. Circuiting shall be re-arranged as necessary to obtain current balancing within 10% on each busbar.

B. Contractor shall submit a test report to the Engineer, including any issues observed and recommendations for review and approval.

END OF DOCUMENT 260500

DOCUMENT 260519 - LOW-VOLTAGE ELECTRICAL POWER 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Connectors, splices, and terminations rated 600 V and less.

1.3 DEFINITIONS

A. RoHS: Restriction of Hazardous Substances.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

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

1. Alpha Wire Company.
2. American Bare Conductor.
3. Belden Inc.
4. Cerro Wire LLC.
5. Encore Wire Corporation.
6. General Cable Technologies Corporation.
7. Okonite Company (The).
8. Service Wire Co.
9. Southwire Company.
10. WESCO.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.

3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.
2. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
3. Type XHHW-2: Comply with UL 44.

2.2 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

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

1. 3M Electrical Products.
2. AFC Cable Systems; a part of Atkore International.
3. Gardner Bender.
4. Hubbell Power Systems, Inc.
5. Ideal Industries, Inc.
6. ILSCO.
7. NSi Industries LLC.
8. O-Z/Gedney; a brand of Emerson Industrial Automation.
9. Service Wire Co.
10. TE Connectivity Ltd.
11. Thomas & Betts Corporation; A Member of the ABB Group.

C. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper.
2. Type: Two hole with standard barrels.
3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. PV Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway. MC cable is **not allowed** on this project.

F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

G. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

G. Each branch circuit shall have an individual neutral conductor. Increasing the neutral conductor size, or “super neutral,” is not allowed for multiple branch circuits.

H. Feeders and branch circuits shall have a ground conductor.

I. Install no more than 3 phase wires in any feeder or branch circuit conduit.

J. Wire size on 120 Volt, 20 ampere branch circuit home run conductors over 75 feet in length (from closest wiring device at the home run designation to the associated panelboard shown on the electrical drawing sheets), shall be increased to No. 10 AWG (minimum) to limit excessive voltage drop.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. Perform each of the following visual and electrical tests:

    a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
    b. Test bolted connections for high resistance using one of the following:

        1) A low-resistance ohmmeter.
        2) Calibrated torque wrench.
        3) Thermographic survey.

    c. Inspect compression-applied connectors for correct cable match and indentation.
    d. Inspect for correct identification.

e. Inspect cable jacket and condition.
f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
g. Continuity test on each conductor and cable.
h. Uniform resistance of parallel conductors.

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF DOCUMENT 260519

DOCUMENT 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Equipment Grounding Conductors.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

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

1. Advanced Lightning Technology, Ltd.
2. Burndy; Part of Hubbell Electrical Systems.
3. Dossert; AFL Telecommunications LLC.
4. ERICO; a brand of nVent.
5. Fushi Copperweld Inc.
6. Galvan Industries, Inc.; Electrical Products Division, LLC.
7. Harger Lightning & Grounding.
8. ILSCO.

9. O-Z/Gedney; a brand of Emerson Industrial Automation.
10. Robbins Lightning, Inc.
11. Siemens Industry, Inc., Energy Management Division.
12. Thomas & Betts Corporation; A Member of the ABB Group.

2.3 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, 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.

D. Grounding system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

G. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF DOCUMENT 260526

DOCUMENT 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Sockets.
e. Eye nuts.
f. Fasteners.
g. Anchors.
h. Saddles.
i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.

2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Ductwork, piping, fittings, and supports.
3. Structural members to which hangers and supports will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Projectors.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."

2. Component Importance Factor: 1.5.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.

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

   a. Allied Tube & Conduit; a part of Atkore International.
   b. B-line, an Eaton business.
   c. CADDY; a brand of nVent.
   d. Flex-Strut Inc.
   e. Gripple Inc.
   f. GS Metals Corp.
   g. G-Strut.
   h. Haydon Corporation.
   i. Metal Ties Innovation.
   j. Thomas & Betts Corporation; A Member of the ABB Group.
   k. Unistrut; Part of Atkore International.
   l. Wesanco, Inc.

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Galvanized steel.

4. Channel Width: Selected for applicable load criteria.

5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

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

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

        1) Hilti, Inc.
        2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        3) MKT Fastening, LLC.
        4) Simpson Strong-Tie Co., Inc.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

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

        1) B-line, an Eaton business.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti, Inc.
        4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F 3125/F 3125M,Grade A325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.

2. NECA 101

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

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT IMC and RMC may be supported by openings through structure members, according to NFPA 70.

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

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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

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

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

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

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

B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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

END OF DOCUMENT 260529

DOCUMENT 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Metal wireways and auxiliary gutters.
3. Boxes, enclosures, and cabinets.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

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

a. AFC Cable Systems; a part of Atkore International.
b. Allied Tube & Conduit; a part of Atkore International.
c. Anamet Electrical, Inc.
d. Electri-Flex Company.
e. O-Z/Gedney; a brand of Emerson Industrial Automation.
f. Picoma Industries, Inc.
g. Republic Conduit.
h. Southwire Company.
i. Thomas & Betts Corporation; A Member of the ABB Group.
j. Western Tube and Conduit Corporation.
k. Wheatland Tube Company.

2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.

4. ARC: Comply with ANSI C80.5 and UL 6A.
5. IMC: Comply with ANSI C80.6 and UL 1242.
6. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

a. Comply with NEMA RN 1.
b. Coating Thickness: 0.040 inch, minimum.

7. EMT: Comply with ANSI C80.3 and UL 797.

8. FMC: Comply with UL 1; zinc-coated steel.
9. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
10. Color Coding: All conduit shall be provided with factory applied colors to match MUSC/MUHA standard:

    a. Blue: BAS Low Voltage Controls
    b. Red: Fire Alarm Conduit
    c. Orange: Critical Branch
    d. Yellow: Life Safety Branch
    e. Green: Equipment Branch
    f. White: Nurse Call Systems
    g. Brown: Telecommunications and other Low Voltage Systems
    h. Normal Power conduits shall not used colored conduit

B. Metal Fittings:

1. Comply with NEMA FB 1 and UL 514B.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fittings, General: Listed and labeled for type of conduit, location, and use.

4. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
5. Fittings for EMT:

    a. Material: Steel.
    b. Type: Compression.

6. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
7. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. B-line, an Eaton business.
2. Hoffman; a brand of nVent.
3. MonoSystems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.3 BOXES, ENCLOSURES, AND CABINETS

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

1. Adalet.
2. Crouse-Hinds, an Eaton business.
3. EGS/Appleton Electric.
4. Erickson Electrical Equipment Company.
5. FSR Inc.
6. Hoffman; a brand of nVent.
7. Hubbell Incorporated.
8. Hubbell Incorporated; Wiring Device-Kellems.
9. Kraloy.
10. Milbank Manufacturing Co.
11. MonoSystems, Inc.
12. O-Z/Gedney; a brand of Emerson Industrial Automation.
13. RACO; Hubbell.
14. Spring City Electrical Manufacturing Company.
15. Stahlin Non-Metallic Enclosures.
16. Thomas & Betts Corporation; A Member of the ABB Group.
17. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:

1. Material: Cast metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

K. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

L. Gangable boxes are prohibited.

M. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

N. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-40-PVC.

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:

    a. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface raceways only where indicated on Drawings.

3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for

aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches of enclosures to which attached.

L. Stub-Ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

M. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

N. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

O. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

P. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

Q. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

R. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

S. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

T. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

U. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

V. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    d. Attics: 135 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least

0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

Y. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to top of box unless otherwise indicated.

Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

AA. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

BB. Locate boxes so that cover or plate will not span different building finishes.

CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

EE. Set metal floor boxes level and flush with finished floor surface.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF DOCUMENT 260533

DOCUMENT 260548 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic and wind forces required to select seismic and wind restraints and for designing vibration isolation bases.

a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Seismic- and Wind-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to

ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: See structural drawings.
2. Building Classification Category: See structural drawings.
3. Minimum 10 lb/sq. ft. multiplied by maximum area of component projected on vertical plane normal to wind direction and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: See structural drawings.

2. Assigned Seismic Use Group or Building Category as Defined in the IBC: See structural drawings.

    a. Component Importance Factor: 1.5.
    b. Component Response Modification Factor: See structural drawings
    c. Component Amplification Factor: See structural drawings

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): See structural drawings.
4. Design Spectral Response Acceleration at 1.0-Second Period: See structural drawings.

2.2 RESTRAINT CHANNEL BRACINGS

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

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Unistrut; Part of Atkore International.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

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

1. CADDY; a brand of nVent.
2. Gripple Inc.
3. Kinetics Noise Control, Inc.
4. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A 603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

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

1. B-line, an Eaton business.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. TOLCO; a brand of NIBCO INC.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

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

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.6 ADHESIVE ANCHOR BOLTS

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

1. Hilti, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

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

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

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

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

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

F. Drilled-in Anchors:

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

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to

equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.

C. Seismic controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF DOCUMENT 260548

DOCUMENT 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Tapes and stencils.
4. Signs.
5. Cable ties.
6. Paint for identification.
7. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 70.

B. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

C. Comply with ANSI Z535.4 for safety signs and labels.

D. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.

1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
2. Colors for 208/120-V Circuits:

    a. Phase A: Black.
    b. Phase B: Red.
    c. Phase C: Blue.

3. Colors for 480/277-V Circuits:

    a. Phase A: Brown.
    b. Phase B: Orange.
    c. Phase C: Yellow.

4. Color for Neutral: White.
5. Color for Equipment Grounds: Green.
6. Colors for Isolated Grounds: Green with white stripe.

C. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

D. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

E. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

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

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services, Inc.
d. Panduit Corp.
e. Seton Identification Products.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

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

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services, Inc.
d. Panduit Corp.
e. Seton Identification Products.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

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

a. Brady Corporation.
b. Marking Services, Inc.
c. Panduit Corp.
d. Seton Identification Products.

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.

3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

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

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services, Inc.
d. Panduit Corp.
e. Seton Identification Products.

2. Minimum Nominal Size:

a. 1-1/2 by 6 inches for raceway and conductors.
b. 3-1/2 by 5 inches for equipment.
c. As required by authorities having jurisdiction.

2.4 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

C. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

D. Underground-Line Warning Tape:

1. Tape:

a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
b. Printing on tape shall be permanent and shall not be damaged by burial operations.
c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

2. Color and Printing:

a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.

b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE" Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE"

2.5 SIGNS

A. Laminated Acrylic or Melamine Plastic Signs:

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

   a. Brady Corporation.
   b. Carlton Industries, LP.
   c. emedco.
   d. Marking Services, Inc.

2. Engraved legend.
3. Thickness:

   a. For signs up to 20 sq. in., minimum 1/16 inch thick.
   b. For signs larger than 20 sq. in., 1/8 inch thick.

   c. Engraved legend with white letters on a dark gray background.
   d. Self-adhesive.
   e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 CABLE TIES

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

1. HellermannTyton.
2. Ideal Industries, Inc.
3. Marking Services, Inc.
4. Panduit Corp.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 Deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

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

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

I. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

J. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

K. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

L. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

M. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

N. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

P. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

Q. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

R. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

2. Install underground-line warning tape for direct-buried cables and cables in raceways.

S. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

T. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

U. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.

V. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

D. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use self-adhesive vinyl tape to identify the phase.

1. Locate identification 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.

E. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

F. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

G. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

H. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

I. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

a. Controls with external control power connections.

K. Operating Instruction Signs: Self-adhesive labels.

L. Equipment Identification Labels:

1. Indoor Equipment: Laminated acrylic or melamine plastic sign.
2. Outdoor Equipment: Laminated acrylic or melamine sign.
3. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
e. Enclosed switches.
f. Enclosed circuit breakers.
g. Enclosed controllers.
h. Variable-speed controllers.
i. Push-button stations.
j. Power-transfer equipment.
k. Contactors.
l. Remote-controlled switches, dimmer modules, and control devices.
m. Monitoring and control equipment.

END OF DOCUMENT 260553

DOCUMENT 260590 - SELECTIVE ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Electrical demolition.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work: As specified in individual Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify field measurements and circuiting arrangements are as shown on Drawings.

B. Verify that abandoned wiring and equipment serve only abandoned facilities.

C. Demolition Drawings are based on casual field observation and existing record documents. Report discrepancies to Architect/Engineer before disturbing existing installation.

D. Beginning of demolition means installer accepts existing conditions.

3.2 PREPARATION

A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.

B. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Demolish and extend existing electrical work under provisions of Division 01, Division 02, and this Division.

B. Remove, relocate, and extend existing installations to accommodate new construction.

C. Remove abandoned wiring to source of supply.

D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.

E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed.

F. Repair adjacent construction and finishes damaged during demolition and extension work. T-bar ceiling tiles damaged under normal construction conditions or having voids where junction boxes were removed shall be replaced by the Contractor.

G. Maintain access to existing electrical installations which remain active.

H. Extend existing installations using materials and methods as specified.

I. Where materials or equipment are to be turned over to Owner or reused and installed by the Contractor, it shall be the Contractor’s responsibility to maintain condition of materials and equipment equal to the existing condition of the equipment before the work began. Repair or replace damaged materials or equipment at no additional cost to the Owner.

3.4 EXISTING PANELBOARDS

A. Where existing circuits are indicated to be reused, use sensing measuring devices to verify circuits feeding Project area or are not in use.

B. Provide new updated directories where more than three circuits have been modified or rewired.

3.5 CLEANING AND REPAIR

A. A. Clean and repair existing materials and equipment which remain or are to be reused.

3.6 INSTALLATION

A. A. Install relocated materials and equipment under the provisions of Division 01.

END OF DOCUMENT 260590

DOCUMENT 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Indoor occupancy and vacancy sensors.

B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which equipment will be attached.
3. Items penetrating finished ceiling, including the following:

a. Luminaires.

b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Control modules.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's warranties.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Faulty operation of lighting control devices.

2. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCYAND VACANCY SENSORS

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

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Intermatic, Inc.
4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. Lutron Electronics Co., Inc.
7. Sensor Switch, Inc.
8. WattStopper; a Legrand® Group brand.

B. General Requirements for Sensors:

1. Ceiling-mounted, solid-state indoor occupancy sensors.
2. Dual technology.
3. Separate power pack.
4. Hardwired connection to switch.

5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:

    a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    c. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Sensor is powered from the power pack.

8. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
9. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

10. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
11. Bypass Switch: Override the "on" function in case of sensor failure.
12. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.

C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.

2.2 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

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

3.2 SENSOR INSTALLATION

A. Comply with NECA 1.

B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.3 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF DOCUMENT 260923

DOCUMENT 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Standard-grade receptacles, 125 V, 20 A.
2. GFCI receptacles, 125 V, 20 A.
3. Toggle switches, 120/277 V, 20 A.
4. Occupancy sensors
5. Wall-box dimmers.
6. Wall plates.

1.3 DEFINITIONS

A. AFCI: Arc-fault circuit interrupter.

B. BAS: Building automation system.

C. EMI: Electromagnetic interference.

D. GFCI: Ground-fault circuit interrupter.

E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

F. RFI: Radio-frequency interference.

G. SPD: Surge protective device.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. Comply with NEMA WD 1.

D. Devices for Owner-Furnished Equipment:

1. Receptacles: Match plug configurations.

E. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.

F. Wall Plate Color: For plastic covers, match device color.

G. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A

1. Products: Subject to compliance with requirements, provide one of the following:

a. Eaton (Arrow Hart); Commercial Grade Receptacles 20A-125V NEMA 5-20R - BR20.
b. Hubbell Incorporated; Wiring Device-Kellems; HBL 5362.
c. Leviton Manufacturing Co., Inc.; 5891 (single), 5352 (duplex).
d. Pass & Seymour/Legrand (Pass & Seymour); 5361 (single), 5362 (duplex).

2. Description: Two pole, three wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 and FS W-C-596.

2.3 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A

1. Products: Subject to compliance with requirements, provide the following:

a. Eaton (Arrow Hart); SGF20.
b. Hubbell Incorporated; Wiring Device-Kellems; GFRST20.
c. Leviton Manufacturing Co., Inc.; G5362.
d. Pass & Seymour/Legrand (Pass & Seymour); 2097.

2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Non-feed through.
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

B. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A

1. Products: Subject to compliance with requirements, provide one of the following:

a. Eaton (Arrow Hart); WRSGF20.
b. Hubbell Incorporated; Wiring Device-Kellems; GFTWRST20.
c. Leviton Manufacturing Co., Inc.; G5362.
d. Pass & Seymour/Legrand (Pass & Seymour); 2097TRWR.

2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-15R.
4. Type: Non-feed through.
5. Standards: Comply with UL 498 and UL 943 Class A.

6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.4 HOSPITAL-GRADE, TAMPER RESISTANT DUPLEX RECEPTACLES, 125V, 20A

1. Products: Subject with requirements, provide one of the following:

a. Eaton (Arrow Hart);
b. Hubbell Incorporated; Wiring Devices-Kellems;
c. Leviton Manufacturing Co. Inc.;
d. Pass & Seymour/Legrand (Pass & Seyour);

2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Standards: Comply with NEMA WD 1, UL 498 Supplement sd, and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.

2.5 TOGGLE SWITCHES, 120/277 V, 20 A

A. Single-Pole Switches, 120/277 V, 20 A

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Eaton (Arrow Hart); AH1221 AC Quiet Toggle Switches.
   b. Hubbell Incorporated; Wiring Device-Kellems; HBL1221.
   c. Leviton Manufacturing Co., Inc.; 1221-2.
   d. Pass & Seymour/Legrand (Pass & Seymour); CSB20AC1.

2. Standards: Comply with UL 20 and FS W-S-896.

B. Three-Way Switches, 120/277 V, 20 A

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Eaton (Arrow Hart); AH1223.
   b. Hubbell Incorporated; Wiring Device-Kellems; HBL1223.
   c. Leviton Manufacturing Co., Inc.; 1223-2.
   d. Pass & Seymour/Legrand (Pass & Seymour); CSB20AC3.

2. Comply with UL 20 and FS W-S-896.

C. Four-Way Switches, 120/277 V, 20 A

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Eaton (Arrow Hart); AH1224.
   b. Hubbell Incorporated; Wiring Device-Kellems; HBL1224.
   c. Leviton Manufacturing Co., Inc.; 1224-2.
   d. Pass & Seymour/Legrand (Pass & Seymour); CSB20AC4.

2. Standards: Comply with UL 20 and FS W-S-896.

2.6 OCCUPANCY SENSORS

A. Wall Switch Sensor Light Switch, Dual Technology:

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

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual (ultrasonic and passive infrared) technology.
3. Standards: Comply with UL 20.

4. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
5. Adjustable time delay of five minutes.

6. Able to be locked to Automatic or manual-On mode.
7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc.

2.7 DIMMERS

A. Wall-Box Dimmers:

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

a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Lutron Electronics Co., Inc.
e. Pass & Seymour/Legrand (Pass & Seymour).

2. Description: Modular, full-wave, solid-state dimmer switch with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

3. Control: Continuously adjustable slider; with single-pole or three-way switching.
4. Standards: Comply with UL 1472.
5. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.8 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

2. Material for Finished Spaces: 0.035-inch-thick, satin-finished, Type 302 stainless steel.

3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.

6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Test Instruments: Use instruments that comply with UL 1436.

B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

C. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

D. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

E. Wiring device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF DOCUMENT 262726

DOCUMENT 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following types of LED luminaires:

1. LED lighting fixtures.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.

4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project IES LM-79 and IES LM-80.

    a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which equipment and or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:

    a. Other luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Ceiling-mounted projectors.

7. Moldings.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of luminaire.

E. Product Test Reports: For each type of luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

F. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, product(s) indicated on Drawings.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

C. Ambient Temperature: 41 to 104 deg F.

1. Relative Humidity: Zero to 95 percent.

D. Altitude: Sea level to 1000 feet.

2.3 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI.

C. Recessed luminaires shall comply with NEMA LE 4.

2.4 MATERIALS

A. Lamps:

1. CRI of minimum 80.
2. Dimmable from 100 percent to 0 percent of maximum light output.
3. Internal driver.

4. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

B. Housings:

1. Extruded-aluminum housing and heat sink.
2. With integral mounting provisions.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

D. Diffusers and Globes:

1. Prismatic acrylic.

2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

3. Glass: Annealed crystal glass unless otherwise indicated.

4. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.

E. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

F. Steel:

1. ASTM A 36/A 36M for carbon structural steel.
2. ASTM A 568/A 568M for sheet steel.

G. Stainless Steel:

1. 1. Manufacturer's standard grade.
2. 2. Manufacturer's standard type, ASTM A 240/240 M.

H. Galvanized Steel: ASTM A 653/A 653M.

I. Aluminum: ASTM B 209.

2.5 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

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

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaires:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaires:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaires:

1. Ceiling Mount:

   a. Pendant mount with 5/32-inch- diameter aircraft cable supports adjustable to 10 feet in length.

2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
4. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
5. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.

2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.

3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."

3.7 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF DOCUMENT 265119

DOCUMENT 265213 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.

1. Include data on features, accessories, and finishes.
2. Include physical description of the unit and dimensions.
3. Battery and charger for light units.
4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.
5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.

a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
4. Structural members to which equipment will be attached.
5. Size and location of initial access modules for acoustical tile.
6. Items penetrating finished ceiling including the following:

a. Other luminaires.
b. Air outlets and inlets.
c. Speakers.
d. Ceiling-mounted projectors.
e. Sprinklers.
f. Access panels.

7. Moldings.

B. Product Certificates: For each type of luminaire.

C. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Provide seismic qualification certificate for each piece of equipment.

D. Product Test Reports: For each luminaire for tests performed by manufacturer and witnessed by a qualified testing agency.

E. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.9 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Power Unit Batteries: Five years from date of Substantial Completion. Full warranty shall apply for the entire warranty period.
2. Warranty Period for Self-Powered Exit Sign Batteries: Five years from date of Substantial Completion. Full warranty shall apply for the entire warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

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. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body.

1. Emergency Connection: Operate one lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.

    a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.

6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.3 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

3. Master/Remote Sign Configurations:

a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in battery for power connection to remote unit.
b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

2.4 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Conduit: Electrical metallic tubing, minimum 3/4 inch in diameter.

2.5 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.

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

3.2 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.

D. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

E. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

F. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.

2. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service:

1. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:

1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.

a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

2. Conduct short-duration tests on all emergency lighting.

END OF DOCUMENT 265213

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Magnetic door holders.
7. Remote annunciator.
8. Addressable interface device.
9. Cellular/IP Communicator.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. NICET: National Institute for Certification in Engineering Technologies.

1.4 SYSTEM DESCRIPTION

A. Noncoded addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.6 ACTION SUBMITTALS

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

B. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
2. Include voltage drop calculations for notification appliance circuits. Load notification appliance circuits to 60% of rated capacity to allow for additional devices or resetting candela output of devices provided.
3. Include battery-size calculations. Load notification appliance circuits to 60% of rated capacity to allow for additional devices or resetting candela output of devices provided.
4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include CAD generated 1/8”=1’-0” floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits. Submitting marked up copies of the design drawings or additional information superimposed over the design drawings is not acceptable. Submittals that include the design drawings will be rejected.
6. Provide CAD generated riser diagram showing all system devices interconnected for this specific project. Generic schematic wiring diagrams are not acceptable.

C. General Submittal Requirements:

1. Submissions to Authorities Having Jurisdiction: In addition to distribution requirements for submittals specified in Division 1 Section Submittals, send submittal to Architect for review and comment. Once the submittal has been approved by the Architect, send the submission to Town of Kiawah Fire Marshal Office. After the Fire Marshal’s comments have been corrected, submit to the Architect. Resubmit if required to make clarifications or revisions to obtain approval.
2. Shop Drawings shall be prepared by persons with the following qualifications:

a. Trained and certified by manufacturer in fire-alarm system design.
b. NICET-certified fire-alarm technician, Level III minimum.
c. Licensed or certified by authorities having jurisdiction.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," deliver copies to authorities having jurisdiction and include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

    a. Frequency of testing of installed components.
    b. Frequency of inspection of installed components.
    c. Requirements and recommendations related to results of maintenance.
    d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.

3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 1 unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than 1 unit of each type.
5. Keys and Tools: One extra set for access to locked and tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system.

1.10 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.11 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, manufacturer offering products that may be incorporated into the Work is limited to, the following, no substitutions:

1. Fire Lite MS-4 (connect to existing Fire Alarm Panel), Inc.; a Honeywell company.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Verified automatic alarm operation of smoke detectors.
6. Automatic sprinkler system water flow.
7. Heat detectors in elevator shaft and pit.
8. Fire-extinguishing system operation.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
9. Activate emergency lighting control.
10. Activate emergency shutoffs for gas and fuel supplies.
11. Record events in the system memory.
12. Record events by the system printer.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Low-air-pressure switch of a dry-pipe sprinkler system.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal ac voltage at fire-alarm control unit.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.
9. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.

    a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
    b. Include a real-time clock for time annotation of events on the event recorder and printer.

2. Addressable initiation devices that communicate device identity and status.

    a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
    b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.

3. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 3 line(s) of 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Circuits:

1. ~~Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.~~

   a. ~~Initiating Device Circuits: Style D.~~
   b. ~~Notification Appliance Circuits: Style Z.~~
   c. ~~Signaling Line Circuits: Style 6 Style 7.~~
   d. ~~Install no more than 50 addressable devices on each signaling line circuit.~~

2. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class B.

   a. Initiating Device Circuits: Style B.
   b. Notification Appliance Circuits: Style Y.
   c. Signaling Line Circuits: Style 4.5.
   d. Install no more than 50 addressable devices on each signaling line circuit.

3. Serial Interfaces: Two RS-232 ports for printers.

D. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

E. Notification Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

F. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.

G. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

I. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

J. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

K. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.

L. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Sounder Base: Low frequency sounder bases are UL listed for low frequency operation and comply with NFPA 72 requirements for sleeping spaces.
6. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
7. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
8. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
    b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).
    c. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.6 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.

C. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

1. Rated Light Output:

a. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.

3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, red.

2.8 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.9 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall.

2.11 CELLULAR/IP COMMUNICATOR

A. The Cellular/IP Communicator shall connect directly to the primary and secondary analog fire alarm control panel telephone ports.

B. The communicator shall communicate to GSM (cellular) networks in the area including 2G, 3G and 4G. The multi-GSM platform technology automatically detects and

chooses the best network in the area based on signal strength and immediately self-adjusts for operation.

1. Supports both dynamic (DHCP) or Public and Private Static IP addressing.
2. Communicates over any type of customer-provided Ethernet 10/100 Base network connection (LAN or WAN), DSL modem or cable modem.
3. Data transmits over standard contact-ID protocol is secured with industry's advanced encryption standard (AES 256-bit).
4. Dual path communications: Uses Internet or GSM as primary.
5. User programmable.
6. Diagnostic LEDs: Signal strength and status indicator.
7. IP and GSM tested every day.
8. All circuits shall be power limited, per UL864 requirements.

C. Functional Performance: When a fire alarm condition (Alarm, Supervisory or Trouble) is detected, the Fire Alarm Control Panel goes off-hook to dial the central station. The communicator Dialer Capture Module detects the off-hook condition and provides the fire panel with a dial tone. When the fire panel detects the dial tone, it begins dialing the central station. The Dialer Capture Module considers the three second period after dialing as the number dialing has been completed. After the dialing is completed, the Dialer Capture Module returns a handshake to the fire panel. The fire panel then sends the contact ID reports to the Dialer Capture Module, which in turn sends a kiss-off after the report is successfully received from the fire panel. The Dialer Capture Module sends the contact ID reports to the communications module. When all the reports are sent, the fire panel goes on-hook. The communications module then transmits the messages to the central station (either over the internet or the GSM network).

2.12 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by manufacturer of device.
2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. All fire alarm wiring shall be installed in EMT in accordance with the requirements of Section 260533 Raceways for Electrical Systems. All conduits shall be red in color. All device back boxes shall be red in color. All junction box covers shall be red in color, labeled in accordance with the requirements of Section 260553 Identification for Electrical Systems.

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Equipment Mounting: Install fire-alarm control unit on concrete base with tops of cabinets not more than 72 inches (1830 mm) above the finished floor. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install seismic bracing. Comply with requirements in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

D. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

E. Smoke- or Heat-Detector Spacing:

1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet (9 m).
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B in NFPA 72.
5. HVAC: Locate detectors not closer than 5 feet (1.5 m) from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

G. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

H. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

I. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

J. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling.

L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

M. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

N. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.

3.3 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated air-conditioning duct systems.
2. Alarm-initiating connection to elevator recall system and components.
3. Alarm-initiating connection to activate emergency lighting control.
4. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
5. Supervisory connections at valve supervisory switches.
6. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
7. Supervisory connections at elevator shunt trip breaker.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.5 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.6 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Architect and authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Contractor/Manufacturer Representative Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
    b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.

6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. The engineer shall then be informed by written notification that the system is complete per specifications and plans, that the 100% system test was completed and is ready for the Engineer's acceptance test.

G. Fire-alarm system will be considered defective if it does not pass tests and inspections.

H. The contractor shall notify the Engineer two (2) weeks in advance to schedule the Engineer's acceptance test of the completed system.

I. Engineer of Record Test and Inspections:

1. The Engineer, in the presence of the contractor and an authorized factory-trained representative of the manufacturer, shall perform an acceptance test to verify compliance with the plans, specifications and applicable codes.
2. The contractor shall assist the engineer with the test.
3. The test shall be directed and controlled by the Engineer.
4. The contractor shall provide two-way radios, ladders and any other materials needed to test the system (smoke candles, test smoke, etc.).

J. After the Engineers acceptance test has been successfully completed and all deficiencies have been corrected, the installing contractor shall provide specific documentation for the fire alarm system. This documentation shall include but is not limited to the following:

1. System Status and Program Printout.
2. System Operation Matrix.
3. As-Built Drawings.
4. Two Bound Copies of General System Information for the Owner.
5. Site Specified Programming, on a Diskette or CD as Appropriate.
6. For buildings with a smoke control or smoke purge system, an HVAC balance report in the smoke control/purge mode.

K. After testing and correction of deficiencies have been completed the contractor shall provide site specified FACP programming on a diskette or CD as appropriate for review. This process shall be repeated until there are no further errors or corrections to the database.

L. Prepare test and inspection reports.

M. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.7 FINAL DOCUMENTATION

A. After all system corrections have been made provide to the engineer the following documentation.

1. Riser diagram(s) showing all fire alarm panels, power booster panels, fire alarm devices and terminal boxes. The diagram shall represent how the devices are connected to the fire alarm system and shall be suitable for trouble shooting the fire alarm system connections.
2. Documentation shall be provided in CAD file format compatible with the engineer's CAD files for the project.
3. The contractor shall make all corrections to the file(s) as directed by the engineer.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system. Contractor shall be responsible for coordinating the presence of all interested parties for the training sessions.

3.9 TRAINING:

A. Training shall cover the following topics at a minimum:

1. Preventative maintenance service techniques and schedules, including historical data trending of alarm and trouble records.
2. Overall system concepts, capabilities, and functions. Training shall be in-depth, so that the owner shall be able to add or delete devices to the system and to take any device out of service and return any device to service without need for Manufacturer's approval.
3. Explanation of all control functions, including training to program and operate the system software.
4. Methods and means of troubleshooting and replacement of all field wiring and devices.
5. Methods and procedures for troubleshooting the main fire alarm control panel, including field peripheral devices as to programming, bussing systems, internal panel and unit wiring, circuitry and interconnections.
6. Manuals, drawings, and technical documentation. Actual system software used for training shall be provided on Compact Disk (CD) and shall be left with the Owner at the completion of training for the Owner's use in the future. Provide 3 hard copies of all documentation.
7. Classes and testing necessary to license attendees to program and service the fire alarm system, including hardware and software. Certification shall be such as to allow attendees direct access to factory technical support.
8. Training classes shall be recorded using a video camera and microphone. Provide 3 copies of the video tapes to the owner at the completion of training for the Owner's use in the future.

END OF SECTION 283111