PROJECT MANUAL



DISTRICT OF COLUMBIA COURTS

DC TO25 HEATING SYSTEM UPGRADE

Prepared for: DISTRICT OF COLUMBIA COURTS

ISSUED FOR BID

Project No: 15749

Issue date: JULY 3, 2025

Prepared by:

SMITHGROUP

TABLE OF CONTENTS

COVER SHEET
TABLE OF CONTENTS

NOTE: SECTIONS NOTED WITH ** ARE WRITTEN AND PROVIDED BY SMITHGROUP CONSULTANTS

DIVISION 02 - EXISTING CONDITIONS

SECTION 024119 - SELECTIVE STRUCTURE DEMOLITION

DIVISION 03 - CONCRETE

SECTION 033000 - CAST-IN-PLACE CONCRETE**

DIVISION 04 - MASONRY

SECTION 042200 - CONCRETE UNIT MASONRY

DIVISION 05 - METALS

SECTION 051200 - STRUCTURAL STEEL FRAMING**
SECTION 054300 - SLOTTED CHANNEL FRAMING

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

SECTION 061000 - ROUGH CARPENTRY

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

SECTION 070150 - CUTTING, PATCHING, AND REPAIRING OF EXISTING ROOFING
SECTION 076200 - SHEET METAL FLASHING AND TRIM
SECTION 078413 - PENETRATION FIRESTOPPING
SECTION 078443 - JOINT FIRESTOPPING
SECTION 079200 - JOINT SEALANTS
SECTION 079219 - ACOUSTICAL JOINT SEALANTS

DIVISION 08 - OPENINGS

SECTION 081113 - HOLLOW METAL DOORS AND FRAMES
SECTION 087100 - DOOR HARDWARE
SECTION 089116 – OPERABLE WALL LOUVERS

DIVISION 09 - FINISHES

SECTION 090190.52 - MAINTENANCE REPAINTING
SECTION 090561.13 - MOISTURE VAPOR EMISSION CONTROL
SECTION 092116.23 - GYPSUM BOARD SHAFT WALL ASSEMBLIES
SECTION 092216 - NON-STRUCTURAL METAL FRAMING
SECTION 092900 - GYPSUM BOARD
SECTION 095113 - ACOUSTICAL PANEL CEILINGS
SECTION 096513 - RESILIENT BASE AND ACCESSORIES
SECTION 096813 - TILE CARPETING
SECTION 099123 - INTERIOR PAINTING

DIVISION 21 - FIRE SUPPRESSION

SECTION 211313 – FIRE SPRINKLER SYSTEMS

DIVISION 22 - PLUMBING

SECTION 220413 - COMMON SUBMITTAL REQUIREMENTS FOR PLUMBING
SECTION 220516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING
SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING
SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING
SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING
SECTION 220523.13 - BUTTERFLY VALVES FOR PLUMBING PIPING
SECTION 220523.14 - CHECK VALVES FOR PLUMBING PIPING
SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
SECTION 220719 - PLUMBING PIPING INSULATION
SECTION 220800 - COMMISSIONING OF PLUMBING
SECTION 221116 - DOMESTIC WATER PIPING
SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES
SECTION 221316 - SANITARY WASTE AND VENT PIPING
SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES
SECTION 221319.13 - SANITARY DRAINS
SECTION 221413 – FACILITY STORM DRAINAGE PIPING
SECTION 223500 - DOMESTIC-WATER HEAT EXCHANGERS

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

SECTION 230100 - COMMON WORK RESULTS FOR HVAC
SECTION 230413 - COMMON SUBMITTAL REQUIREMENTS FOR HVAC
SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING
SECTION 230519 - METERS AND GAUGES FOR HVAC PIPING
SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING
SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
SECTION 230548.13 - VIBRATION CONTROLS FOR HVAC
SECTION 230553 - IDENTIFICATION FOR HVAC, PIPING AND EQUIPMENT
SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC
SECTION 230713 - DUCT INSULATION
SECTION 230716 - HVAC EQUIPMENT INSULATION
SECTION 230719 - HVAC PIPING INSULATION
SECTION 230800 - COMMISSIONING OF HVAC
SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC
SECTION 231123 - FACILITY NATURAL-GAS PIPING
SECTION 232113 - HYDRONIC PIPING
SECTION 232116 - HYDRONIC PIPING SPECIALTIES
SECTION 232123 - HYDRONIC PUMPS
SECTION 232213 – STEAM AND CONDENSATE HEATING PIPING
SECTION 232213 – STEAM AND CONDENSATE HEATING PIPING SPECIALTIES
SECTION 232513 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS
SECTION 232533 - HVAC MAKEUP-WATER FILTRATION EQUIPMENT
SECTION 233113 - METAL DUCTS
SECTION 233300 - AIR DUCT ACCESSORIES
SECTION 233400 - HVAC FANS
SECTION 233713.23 - AIR REGISTERS AND GRILLES
SECTION 235113.11 - DRAFT CONTROL FANS
SECTION 235123 - GAS VENTS
SECTION 235216 - CONDENSING BOILERS

DIVISION 26 - ELECTRICAL

SECTION 260400 - COMMON WORK RESULTS FOR ELECTRICAL
SECTION 260413 - COMMON SUBMITTAL REQUIREMENTS FOR ELECTRICAL
SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES
SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING
SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS
SECTION 260573 - POWER SYSTEM STUDIES
SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS
SECTION 260913 - ELECTRICAL POWER MONITORING AND CONTROL
SECTION 260923 – LIGHTING CONTROL DEVICES
SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS
SECTION 262300 – LOW-VOLTAGE SWITCHGEAR
SECTION 262413 - SWITCHBOARDS
SECTION 262416 - PANELBOARDS
SECTION 262726 - WIRING DEVICES
SECTION 262813 - FUSES
SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS
SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS
SECTION 264113 – LIGHTNING PROTECTION FOR STRUCTURES
SECTION 265100 – INTERIOR LIGHTING

END OF TABLE OF CONTENTS

SECTION 024119 - SELECTIVE STRUCTURE DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Demolition and removal of selected portions of building or structure.
2. Demolition and removal of selected site elements.
3. Salvage of existing items to be reused or recycled.

1.2 DEFINITIONS

A. Remove: Detach items from existing construction, including associated attachments, supports, bracing, etc., and legally dispose of them off-site unless indicated to be removed and salvaged or removed and reinstalled.

B. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to Owner ready for reuse.

C. Remove and Reinstall: Detach items from existing construction, prepare for reuse, and reinstall where indicated.

D. Existing to Remain: Existing items of construction that are not to be permanently removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.3 MATERIALS OWNERSHIP

A. Unless otherwise indicated, demolition waste becomes property of Contractor.

B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.
1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

1.4 PREINSTALLATION MEETINGS

A. Predemolition Conference: Conduct conference at Project site.
1. Inspect and discuss condition of construction to be selectively demolished.
2. Review structural load limitations of existing structure.
3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
5. Review areas where existing construction is to remain and requires protection.

1.5 INFORMATIONAL SUBMITTALS

A. Proposed Protection Measures: Submit report, including drawings, that indicates the measures proposed for protecting individuals and property , for environmental protection , for dust control and , for noise control. Indicate proposed locations and construction of barriers.

B. Schedule of Selective Demolition Activities: Indicate the following:
1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's on-site operations are uninterrupted.
2. Interruption of utility services. Indicate how long utility services will be interrupted.
3. Coordination for shutoff, capping, and continuation of utility services.
4. Use of elevator and stairs.
5. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.

C. Inventory: Submit a list of items to be removed and salvaged and deliver to Owner prior to start of demolition.

D. Predemolition Photographs or Video: Submit before Work begins.

E. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

F. Warranties: Documentation indicated that existing warranties are still in effect after completion of selective demolition.

1.6 CLOSEOUT SUBMITTALS

A. Inventory: Submit a list of items that have been removed and salvaged.

1.7 QUALITY ASSURANCE

A. Refrigerant Recovery Technician Qualifications: Certified by an EPA-approved certification program.

1.8 FIELD CONDITIONS

A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.

B. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.

C. Notify Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.

D. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.
1. Hazardous materials will be removed by Owner before start of the Work.
2. If suspected hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.

E. Storage or sale of removed items or materials on-site is not permitted.

F. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.
1. Maintain fire-protection facilities in service during selective demolition operations.

1.9 WARRANTY

A. Notify warrantor on completion of selective demolition, and obtain documentation verifying that existing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

B. Standards: Comply with ANSI/ASSE A10.6 and NFPA 241.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that utilities have been disconnected and capped before starting selective demolition operations.

B. Review record documents of existing construction provided by Owner. Owner does not guarantee that existing conditions are same as those indicated in record documents.

C. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.

D. When unanticipated mechanical, electrical, or structural elements that conflict with intended function or design are encountered, investigate and measure the nature and extent of conflict. Promptly submit a written report to Architect.

E. Engage a professional engineer to perform an engineering survey of condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during selective building demolition operations.
   1. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.
   2. Steel Tendons: Locate tensioned steel tendons and include recommendations for de-tensioning.

F. Survey of Existing Conditions: Record existing conditions by use of measured drawings preconstruction photographs .
   1. Comply with requirements specified in Section 013233 "Photographic Documentation."
   2. Inventory and record the condition of items to be removed and salvaged. Provide photographs of conditions that might be misconstrued as damage caused by salvage operations.
   3. Before selective demolition or removal of existing building elements that will be reproduced or duplicated in final Work, make permanent record of measurements, materials, and construction details required to make exact reproduction.

3.2 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.
   1. Comply with requirements for existing services/systems interruptions specified in Section 011000 "Summary."

B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.
   1. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
   2. Disconnect, demolish, and remove fire-suppression systems, plumbing, and HVAC systems, equipment, and components indicated to be removed.
      a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
      b. Equipment to Be Removed: Disconnect and cap services and remove equipment.
      c. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
      d. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.

C. Refrigerant: Remove refrigerant from mechanical equipment to be selectively demolished according to 40 CFR 82 and regulations of authorities having jurisdiction.

3.3 PREPARATION

A. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
   1. Comply with requirements for access and protection specified in Section 015000 "Temporary Facilities and Controls."

B. Temporary Facilities: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
   1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
   2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
   3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
   4. Cover and protect furniture, furnishings, and equipment that have not been removed.
   5. Comply with requirements for temporary enclosures, dust control, heating, and cooling specified in Section 015000 "Temporary Facilities and Controls."

C. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.

1. Strengthen or add new supports when required during progress of selective demolition.

3.4 SELECTIVE DEMOLITION, GENERAL

A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:
   1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
   2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
   3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
   4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain fire watch and portable fire-suppression devices during flame-cutting operations.
   5. Maintain adequate ventilation when using cutting torches.
   6. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
   7. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
   8. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
   9. Dispose of demolished items and materials promptly. Comply with requirements in Section 017419 "Construction Waste Management and Disposal."

B. Reuse of Building Elements: Project has been designed to result in end-of-Project rates for reuse of building elements as follows. Do not demolish building elements beyond what is indicated on Drawings without Architect's approval.

C. Removed and Salvaged Items:
   1. Clean salvaged items.
   2. Pack or crate items after cleaning. Identify contents of containers.
   3. Store items in a secure area until delivery to Owner.
   4. Transport items to Owner's storage area designated by Owner.
   5. Protect items from damage during transport and storage.

D. Removed and Reinstalled Items:
   1. Clean and repair items to functional condition adequate for intended reuse.
   2. Pack or crate items after cleaning and repairing. Identify contents of containers.
   3. Protect items from damage during transport and storage.
   4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

E. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

3.5 SELECTIVE DEMOLITION PROCEDURES FOR SPECIFIC MATERIALS

A. Concrete: Demolish in small sections. Using power-driven saw, cut concrete to a depth of at least 3/4 inch **(**19 mm**)** at junctures with construction to remain. Dislodge concrete from reinforcement at perimeter of areas being demolished, cut reinforcement, and then remove remainder of concrete. Neatly trim openings to dimensions indicated.

B. Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals using power-driven saw, then remove concrete between saw cuts.

C. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain, using power-driven saw, then remove masonry between saw cuts.

D. Resilient Floor Coverings: Remove floor coverings and adhesive according to recommendations in RFCI's "Recommended Work Practices for the Removal of Resilient Floor Coverings." Do not use methods requiring solvent-based adhesive strippers.

3.6 DISPOSAL OF DEMOLISHED MATERIALS

A. General: Except for items or materials indicated to be recycled, reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill.
   1. Do not allow demolished materials to accumulate on-site.
   2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
   3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
   4. Comply with requirements specified in Section 017419 "Construction Waste Management and Disposal."

B. Burning: Do not burn demolished materials.

C. Disposal: Transport demolished materials off Owner's property and legally dispose of them.

3.7 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

END OF SECTION

SECTION 033000 – CAST IN PLACE CONCRETE

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 the work of this Section.

1.2 SUMMARY

A. Section includes but is not limited to the following as shown on the drawings and as specified herein:

1. Equipment pads as required.
2. Furnishing and installing all required anchors and inserts.
3. Supply, fabricate and place all required reinforcing bars, mesh and other reinforcement for concrete where shown, called for, and/or required complete with proper supporting devices.
4. Finishing of all concrete work as hereinafter specified.
5. Curing and protection of all concrete work.
6. All other work and materials as may be reasonably inferred and needed to make the work of this section complete.

1.3 SUBMITTALS

A. Product Data: Submit data for proprietary materials and items, including the following:

1. Reinforcement
2. Admixtures
3. Patching compounds
4. Mechanical splice couplers.
5. Others items as requested by Architect.

B. Shop Drawings; Reinforcement: Submit original shop drawings for fabrication, bending, and placement of concrete reinforcement. Comply with ACI 315 "Details and Detailing of Concrete Reinforcement" showing bar sizes, lengths, materials, grades, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, location of splices, lengths of lap splices, details of mechanical splice couplers, and supports for concrete reinforcement. Include special reinforcement required for openings through concrete structures. The shop drawings shall be prepared only by competent detailers, checked by the contractor prior to submission.

C. Scaling of the Architect’s or Engineer of Record’s drawings is not permitted. This applies to hard paper, electronic, and all other versions.

D. Laboratory Test Reports: Submit laboratory test reports for concrete materials, mix design test and microwave test.

E. Material Certificates: Provide materials certificates in lieu of materials laboratory test reports when permitted by Architect. Manufacturer and Contractor, certifying that each material item complies with, or exceeds, specified requirements shall sign material certificates. Provide certification from admixture manufacturers that chloride content complies with specification requirements.

F. Certification that pozzolanic materials conforms to ASTM C 618-01 (noting class C or class F), ASTM C 989 or ASTM C1240.

G. Certified recycled steel content. Provide cut sheets clearly indicating whether the rebar used meets the minimums for post-consumer OR post-industrial recycled contents. Or, if cut sheets are not available, obtain a written affidavit from the manufacturer stating the recycled content percentage and if the recycled content is post-consumer or post-industrial.

H. Formwork: Specify whether reusable, permanent, salvaged or new wood forms are to be used.

I. Recycled Aggregate: Provide laboratory reports indicating that aggregate conforms to ASTM C33 for structural concrete or ASTM D1241-00 for sub-base material. Provide cut sheets clearly indicating the source, total weight and volume of the recycled aggregate. If aggregate provided is a mix of virgin and recycled aggregates obtain a written affidavit from the manufacturer stating the recycled content percentage

J. VOC content for curing compounds, sealants and release agents: Provide a cut sheet and a Material Safety Data Sheet (MSDS) for each curing compound, sealant, hardener and release agent used highlighting VOC contents. VOC content must be less than or equal to limits stated under “PRODUCTS”.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

B. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M, "Structural Welding Code - Reinforcing Steel."

D. Codes and Standards: Comply with provisions of following codes, specifications, and standards, except where more stringent requirements are shown or specified:

1. District of Columbia Building Code, Latest Edition
2. ACI 117 “Standard Specifications for Tolerances for Concrete Construction and Materials and Commentary.”
3. ACI 211.1 “Standard Practice for Selecting Proportions for Normal, Heavyweight and mass concrete.”
4. ACI 211.2, “Standard Practice for Selecting Proportions for Structural Lightweight Concrete.”
5. ACI 214R, “Evaluation of Strength Test Results of Concrete.”
6. ACI 232.2R, “Use of Fly Ash in Concrete.”
7. ACI 233R, “Guide to Use of Slag Cement in Concrete and Mortar.”
8. ACI 234, “Guide for the Use of Silica Fume in Concrete.”
9. ACI 301 “Specifications for Structural Concrete.”
10. ACI 302.1R “Guide for Concrete Floor and Slab Construction.”
11. ACI 304R, “Guide for Measuring, Mixing, Transporting and Placing Concrete.”
12. ACI 305R “Hot Weather Concreting.”
13. ACI 306R-10 “Guide to Cold Weather Concreting.”
14. ACI 308.1 “Standard Specification for Curing Concrete.”
15. ACI 309R, “Guide for Consolidation of Concrete.”
16. ACI 311.4R, “Guide for Concrete Inspections.”
17. ACI 315, “Details and Detailing of Concrete Reinforcement.”
18. ACI 318 “Building Code Requirements for Structural Concrete and Commentary.”
19. ACI 347 “Guide to Formwork of Concrete.”
20. Concrete Reinforcing Steel Institute, (CRSI) “Manual of Standard Practice.”
21. CRSI-WCRSI, “Placing Reinforcing Bars.”
22. AWS D1.4, “Structural Welding Code Reinforcing Steel.”
23. The ACI Field Reference Manual, SP-15 shall be kept at the job site, and the practices set forth therein shall be strictly adhered to.

24. ASTM Standards as applicable in the building code of the local jurisdiction and as noted in this specification.
25. AASHTO T 318, “Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying.”

E. Concrete Testing Service: Owner will engage a testing laboratory acceptable to Architect and Engineer of Record to perform material evaluation tests and to design concrete mixes.

F. Materials and installed work may require testing and retesting at anytime during progress of work. Tests, including retesting of rejected materials for installed work, shall be done at Contractor's expense.

1.5 PROJECT CONDITIONS

A. The Contractor, before commencing work, shall examine all adjoining work on which this work is in any way dependent for proper installation and workmanship according to the intent of this specification, and shall report to the Architect or Engineer of Record any condition which prevents this contractor from performing first class work.

B. Protect adjacent finish materials against spatter during concrete placement.

C. Provide all barricades and safeguards at all pits, holes, shaft and stairway openings, etc., to prevent injury to workmen and others within and about the premises. Also provide all safeguards as required by the Building Code, OSHA, or any other departments having jurisdiction. Take full responsibility for all safety precautions and methods.

D. Procedure of Work: The contractor shall keep themself constantly informed as to the progress of the work in the field, materials and workers ready to start work immediately when conditions of preceding work are available or ready, wholly or in part, so as not to delay the progress of building work or to interfere with the progress of work of other contractors, and in any event the contractor shall, within 24 hours after notice from the Owner, proceed with such work as directed to maintain the uninterrupted progress of the work.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement.

B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

PART 2 - PRODUCTS

2.1 REINFORCING MATERIALS

A. Reinforcing Bars: ASTM A615/A615M, Grade 60 deformed. All reinforcing bars shall be Grade 60 unless otherwise noted. Provide Grade 75, Grade 80, or Grade 100 reinforcing bars where indicated on the contract documents.

B. Mechanical Splice Couplers: ACI 318/ACI 318M, same material of reinforcing bar being spliced. Provide mechanical couplers as an alternate to standard tension lap splices where indicated on the contract documents and in areas of rebar congestion. A mechanical splice coupler shall develop in tension or compression, as required, at least 1.25 times the yield strength of the bar being spliced.

C. Steel Wire and Welded Wire Reinforcement: ASTM A 1064. Galvanized at exterior locations, conditions permanently exposed to weather and/or water, and where noted on drawings (plan and/or sections).

D. Cement: Portland cement (ASTM C 150, Types I, II, or I/II) or Portland limestone cement (ASTM C 595). Total percentage of Portland Cement is NOT to exceed 75% of the cementitious content of each mix, except mixes assigned to exposure class F3. Use one brand of cement throughout project, unless otherwise acceptable to Architect. Provide supplementary cementitious materials in mixes per sections below.

a. Fly Ash: Cast-in-place concrete shall incorporate fly ash as a replacement for at least 25% (by weight) of the Portland cement. All design mixes must be reviewed and approved by the Engineer of Record. Where concrete is assigned to exposure class F3, limit the replacement of Portland cement with fly ash (by weight) to 25% max.
b. Ground Granulated Blast Furnace Slag (GGBF): Cast-in-place concrete shall incorporate GGBF as a replacement for at least 40% (by weight) of the Portland cement. All design mixes must be reviewed and approved by the Engineer of Record. Where concrete is assigned to exposure class F3, limit the replacement of Portland cement with GGBF slag (by weight) to 50% max.
c. Post-Consumer Recycled Ground Glass Pozzolan (GGP): Cast-in-place concrete shall incorporate GGP as a replacement for at least 25% (by weight) of the Portland cement. All design mixes must be reviewed and approved by the Engineer of Record.
d. Pozzolans and Slags: These must be completely accounted for in the design mix. Mix design must meet minimum design requirements set in the contract documents. Additional admixtures may be required to meet early strength requirements and alternative cementitious material goals. If a "blended cement" is used which already contains a certain percentage of Pozzolans or Slags this content may offset or entirely satisfy the minimum percentage required.
    1) Coal Fly Ash: ASTM C 618 (Class C or Class F): ASTM C 618 (Note: Class F fly Ash will require higher amounts or air entraining ad-mixtures than class C).
    2) Blast Furnace Slag: ASTM C989
    3) Ground Glass Pozzolan: ASTM C1866
    4) Silica Fume: ASTM C 1240
    5) Rice Hull (or “husk”) Ash: ASTM C 618 Blended hydraulic cement, as defined by ASTM C 595 or ASTM C 1157

E. Normal Weight Aggregates: ASTM C 33, and as herein specified. Provide aggregates from a single source for exposed concrete.

1. Local aggregates not complying with ASTM C 33 but which have shown by special test or actual service to produce concrete of adequate strength and durability may be used when acceptable to Architect.
2. Normal weight Fine Aggregate: washed, inert, natural or manufactured or combination thereof, sand conforming ASTM C33 gradation.
3. Normal weight Coarse Aggregate: well graded crushed stone or washed gravel conforming to ASTM C33, sizes 57 for foundations and 67 for slabs and structure.

    a. Recycled crushed concrete aggregate in concrete mixes is only to be used with approval of Engineer of Record. Recycled aggregate shall be used only as a substitute for coarse aggregate and must also be washed and well-graded, conforming to ASTM C33.
    b. For sub-base, slabs on grade and non-structural applications and Recycled Aggregate Materials are NOT required to meet the ASTM C 33 standard. In addition to concrete rubble, glass, porcelain, and tire chips can be used as filler material. Any inert material conforming to ASTM D1241 is acceptable for the applications described in this paragraph.

F. Water: Free from oils, acids, alkali, organic matter and other deleterious material to conform to ASTM C94. ASTM C94 for gray water use in the production of ready mixed concrete per approval by the Engineer of Record.

G. Air Entraining Admixture: ASTM C 260.

1. Liquid air entrainment: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

    a. “Air Mix” Euclid Chemical Co.
    b. “AEA-92” Euclid Chemical Co.

c. “Darex AEA” GCP Applied Technologies
d. “MasterAir AE200” Master Builders Solutions

H. Water-Reducing Admixture: ASTM C 494.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

a. “MasterPolyheed 997” Master Builders Solutions
b. “Eucon MR” Euclid Chemical Co.
c. “WRDA 64” GCP Applied Technologies

I. Prohibited Admixtures: Calcium chloride, thyocyanates or admixtures containing more than 0.05 percent chloride ions are not permitted.

J. Certification: Written conformance to the above-mentioned requirements and the chloride ion content of admixtures will be required from the admixture manufacturer prior to mix design review by the Engineer of Record.

K. Contractor will be required to provide information demonstrating successful use in prior placement involving all admixtures.

2.2 GROUT

A. Non-Shrink, Non-Metallic Grout: The non-shrink grout shall be a factory pre-mixed grout and shall conform to ASTM C1107, "Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-Shrink)." In addition, the grout manufacturer shall furnish test data from an independent laboratory indicating that the grout when placed at a fluid consistency shall achieve 95% bearing under a 4' x 4' base plate.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

a. "NS Grout" Euclid Chemical Co.
b. "Five Star Grout" Five Star
c. "Masterflow 713" Sika Chemical Co.

B. High Flow Grout: Where high fluidity and/or increased placing time is required, use high flow grout. The factory pre-mixed grout shall conform to ASTM C1107, "Standard Specification for Packages Dry, Hydraulic-Cement Grout (Non-shrink)." In addition, the grout manufacturer shall furnish test data from an independent laboratory indicating that the grout when placed at a fluid consistency shall achieve 95% bearing under a 18" x 36" base plate.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

a. "Hi-Flow Grout" Euclid Chemical Co.
b. "Masterflow 928" Sika Chemical Co.
c. “Five Star Fluid Grout 100” Five Star

2.3 RELATED MATERIALS

A. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.

B. Moisture-Retaining Cover: One of the following, complying with ASTM C 171.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Waterproof paper
   b. Polyethylene film
   c. Polyethylene-coated burlap

C. Curing Compounds: The compound shall conform to ASTM C 309. Limit VOC content to 130 g/L. Use water-based curing compound. For surfaces receiving both a curing compound and additional flooring, verify that the curing compound and additional flooring are compatible.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

   a. “SealTight 1100” W.R. Meadows
   b. “Kurez W VOX” Euclid Chemical Co.

D. Curing & Sealing Compounds: Only specify for slabs that will remain exposed, i.e. will not receive additional flooring. The compound shall conform to ASTM C1315. Limit VOC content to 130 g/L. Use water-based curing compound.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

   a. “Super Diamond Clear VOX” Euclid Chemical Co.
   b. “VOCOMP-25” W.R. Meadows

E. Curing, Sealing, & Hardening Compounds: For use on concrete surfaces that will remain exposed. Slabs that will receive additional flooring do not require sealing or hardening. Sealers and hardeners must not yellow under ultra violet light after 500 hours of test in accordance with and have a maximum moisture loss of 0.039 grams per sq. cm. when applied at a coverage rate of 250 sq. ft. per gallon. Limit VOC content to 130 g/L. Use water- or vegetable-based product.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

   a. “Kure-N-Harden” BASF

F. For concrete floors subjected to heavy vehicular traffic use a Liquid Sealer/Densifier: The product must be a high performance, deeply penetrating concrete densifier conforming to ASTMC836; odorless, colorless, VOC - compliant, non-yellowing siliconate based solution designed to harden, dustproof and protect and to resist black rubber tire marks on concrete surfaces. The compound must contain a minimum of 20% solids content of which 50% is siliconate

G. Evaporation Retardant:

1. Products Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

   a. "Eucobar" Euclid Chemical Co.
   b. "MasterKure ER 50" Master Builders Solutions

H. Certify that all curing compounds, sealers and hardeners are compatible with all adhesive products intended for attaching co-lateral floor material. In conformance with ASTM F 710, coordination with flooring manufacturer is required to insure concrete coatings will not obstruct the bond between the concrete and the adhesive. Insure coatings and adhesives are “benignly compatible” -- in other words, do not combine substances whose constituents are reactive. Reactivity releases VOCs and /or other toxic fumes.

I. Bonding Admixture: The compound shall be a latex, non-rewettable type.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

a. "Flex-Con" Euclid Chemical Co.
b. "SBR Latex" Euclid Chemical Co.

J. High Strength Polymer Repair Mortar: For form and pouring or large horizontal repairs, provide the flowable on-part, high strength repair mortar.

1. Products: subject to compliance with requirements, provide the following or equal approved by Engineer of Record:

a. "Eucocrete or EucoRepair SCC" Euclid Chemical Co.
b. "Euco Speed MP" (Cold Weather) Euclid Chemical Co.
c. “Emaco R” Master Builders Solutions

K. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

a. “Daraweld C” GCP Applied Technologies
b. “Acrylic Bonding Agent J40” Dayton Superior
c. Eucoweld 2.0 Euclid Chemical Co.

L. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:

1. Type IV for bonding hardened concrete to hardened concrete, and Type V for bonding freshly mixed concrete to hardened concrete.

M. Water: Potable.

2.4 PROPORTIONING AND DESIGN OF MIXES

A. Preparation of Design Mixes

1. All mix designs shall be proportioned in accordance with Section 26.4.3.1(b) of ACI 318 and prepared by a licensed testing laboratory approved by the owner, but paid for by the contractor. Submit mix designs on each class of concrete for review.
2. If previously used mixes are submitted, all materials shall be from the same sources and with the same brand names as the previously utilized mix.
3. If trial batches are used, the mix design shall be prepared by an independent testing laboratory and shall achieve an average compressive strength 1200 psi higher than the specified strength. This over-design shall be increased to 1.10f'c+700 psi when concrete strengths greater than 5000 psi are used.
4. The proposed mix designs shall be accompanied by complete standard deviation analysis or trial mixture test data.

B. Submit each proposed mix to the Architect and Structural Engineer for review at least 5 days prior to the pre-concrete conference. Do not begin concrete production until Architect and Engineer of Record has reviewed and approved mixes.

1. Submit Test reports for any pozzolans or slags indicating compliance with ASTM C 618, ASTM C 989, or ASTM C1866 respectively.

2. Provide cut sheets clearly indicating the percentages of pozzolans or slags used in the mix design as replacement for Portland cement. Or, if cut sheets are not available, obtain a written affidavit from the manufacturer stating the percentage.
3. Test reports for recycled aggregate indicating compliance with ASTM C 33. Provide cut sheets clearly indicating the percentage of aggregates used that are recycled. Or, if cut sheets are not available, obtain a written affidavit from the manufacturer stating the recycled content percentage and source or sources of the material.
4. Provide cut sheets clearly indicating the percentage of sub-base and filler aggregate materials that are recycled. Or, if cut sheets are not available, obtain a written affidavit from the manufacturer stating the recycled content percentage and source or sources of the material.

C. Design mixes to provide concrete with strength as indicated on drawings and schedules.

D. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to Owner and as accepted by Architect and Engineer of Record. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Architect and Engineer of Record before using in work.

E. Admixtures:

1. Use water-reducing admixture or high range water-reducing admixture (superplasticizer) in all concrete as required for placement and workability.
2. Use non-corrosive, non-chloride accelerating admixture in concrete slabs placed at ambient temperatures below 50°F (10°C).
3. Use high-range water-reducing admixture in pumped concrete, architectural concrete, parking structure slabs, fiber concrete, concrete required to be watertight, concrete with ultimate strength of 5,000 psi or more, and concrete with water/cement ratios below 0.50.
4. Use admixtures for water-reducing and set-control in strict compliance with manufacturer's directions.

F. Water-Cement Ratio: Provide concrete for following conditions with maximum water-cement (W/C) ratios as follows:

1. Concrete for architecturally exposed structural elements or architecturally exposed surfaces: W/C 0.40.
2. All other concrete: no maximum W/C ratio.
3. Refer to the concrete mix design table in the structural drawings for other W/C ratio requirements based on exposure class, element type, etc.
4. Refer to the requirements for concrete by exposure class in ACI 318 for balance of info related to maximum W/C ratios, minimum f'c values, and additional requirements.

G. Slump Limits: Proportion and design mixes to result in concrete slump at point of placement as follows:

1. Ramp slabs and sloping surfaces: Not more than 3".
2. Reinforced foundation systems, including mud slabs below hydrostatic slabs: Not less than 1" and not more than 3".
3. Concrete containing HRWR admixture (superplasticizer): Not more than 9" unless otherwise approved by the architect.
4. Other Concrete: Not less than 1" or more than 4".

H. Chloride Ion Level: Chloride ion content shall be tested by the laboratory making the trial mixes. The total chloride ion content of the mix including all constituents shall not exceed the limitations set forth in Table 19.3.2.1 of ACI 318.

2.5 CONCRETE MIXING

A. Ready-Mix Concrete: Comply with requirements of ASTM C 94, and as herein specified.

B. Provide batch ticket for each batch discharged and used in work, indicating project identification name and number, date, mix type, mix time, quantity, and amount of water introduced.

C. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C 94 may be required. When air temperature is between 85°F (30°C) and 90°F (32°C), reduce maximum mixing and delivery time from 1-1/2 hours to 75 minutes, and when air temperature is above 90°F (32°C), reduce maximum mixing and delivery time to 60 minutes.

D. No water shall be added after mixing to concrete containing HRWR (Superplasticizer). If loss of slump occurs, the concrete treated with HRWR may be redosed as long as a "flash set" has not occurred. Redosage procedures must be discussed and approved by the Engineer of Record and the manufacturer.

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate the installation of joint materials and vapor retarders with placement of forms and reinforcing steel.

3.2 INSPECTION

A. Examine all work prepared by others to receive work of this section and report any defects affecting installation to the Contractor for correction. Commencement of work will be construed as complete acceptance of preparatory work by others.

3.3 CONCRETE

A. Concrete shall develop the minimum compressive strengths shown on drawings at 28 days when sampled and tested in accordance with ASTM C 31 and C 39 with the maximum slump in accordance with the approved mix design.

B. Concrete shall be in accordance with the requirements and specifications of "Building Code Requirements for Structural Concrete" as modified by the building code noted above.

C. Fly Ash Concrete & Slag Concrete: Concrete mixes containing high volumes of fly ash or Slag have slower set times and may take up to 56 days to reach full strength. The Engineer of Record, agency responsible for concrete mix design, the architect and the concrete subcontractor must coordinate to ensure that the form stripping schedule is consistent with the ability of the structure to support itself and all imposed construction loads.

3.4 INSTALLATION TOLERANCES

A. Comply with ACI 117

3.5 INSTALLATION OF EMBEDDED ITEMS

A. General: Set and build into work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete. Use setting drawings, diagrams, instructions and directions provided by suppliers of items to be attached thereto.

3.6 CONCRETE PLACEMENT

A. Ready-mix concrete shall comply with the requirements of ASTM C 94 and ACI 304. All plant and transporting equipment shall comply with the concrete plant standards and truck mixer and agitator standards of the National Ready Mix Concrete Association.

B. Cold weather mixing procedures shall be submitted to the architect for approval.

C. Placement of structural concrete with a least dimension greater than or equal to 4 feet shall be considered “mass concrete” per ACI definition. Contractor shall adhere to mass concrete procedures and recommendations of ACI 301 and ACI 211.

D. Notify Architect and Owner’s Inspector at least 36 hours (1 1/2 regular working days) before each pour so that forms and reinforcing may be examined. Do not place concrete until inspection has been made or waived.

E. Preplacement Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast-in. Notify other crafts to permit installation of their work; cooperate with other trades in setting such work. Moisten wood forms immediately before placing concrete where form coatings are not used.

1. Apply temporary protective covering to lower 2' of finished walls adjacent to poured floor slabs and similar conditions, and guard against spattering during placement.

F. General: Comply with ACI 304 “Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete,” and as herein specified.

1. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as herein specified. Deposit concrete as nearly as practicable to its final location to avoid segregation.

G. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers not deeper than 18" and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints. Use internal vibrators penetrating both the top and preceding layers.

H. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping. Use equipment and procedures for consolidation of concrete in accordance with ACI recommended practices.

I. Use and type of vibrators shall conform to ACI 309 “Recommended Practice for Consolidation of Concrete.” Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than visible effectiveness of machine. Place vibrators to rapidly penetrate placed layer and at least 6" into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of mix.

J. Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.

3.7 FINISH OF FORMED SURFACES

A. Concrete mixes containing pozzolans or slags do not set at the same rate or with the same bleed water characteristic as plain Portland cement. Therefore attention must be directed to the proper procedures. Refer to ACI 232.2R and ACI 301.

B. Rough Form Finish: For formed concrete surface not exposed-to- view in the finish work or by other construction, unless otherwise indicated. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective areas repaired and patched and fins and other projections exceeding 1/4" in height rubbed down or chipped off.

C. Smooth Form Finish: For formed concrete surfaces exposed-to-view, or that are to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete, such as waterproofing, damp-proofing, painting or other similar system. This is as-cast concrete surface obtained with selected form facing material, arranged orderly and symmetrically with a minimum of seams. Repair and patch defective areas with fins or other projections completely removed and smoothed. Follow all requirements in ACI 301, Chapter 10 for smooth form finish. Surface preparation for surfaces receiving waterproofing must be approved by the waterproofing manufacturer prior to construction.

3.8 CONCRETE CURING AND PROTECTION

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

1. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.
2. Begin final curing procedures immediately following initial curing and before concrete has dried. Continue final curing for at least 7 days in accordance with ACI 301 procedures. Avoid rapid drying at end of final curing period.
3. In order to avoid plastic or drying shrinkage cracks during warm, dry or windy weather, ACI 302 and ACI 308 shall be followed using wind breaks and sun shades when recommended.
4. Care must be taken to store water based curing and sealing compounds where they will not freeze. In most cases, they cannot be reconstituted after thawing.

B. Curing Methods: Perform curing of concrete by moisture curing, moisture-retaining cover curing, curing and sealing compound, and by combinations thereof, as herein specified.

1. Provide moisture curing by following methods.

    a. Keep concrete surface continuously wet by covering with water.
    b. Continuous water-fog spray.
    c. Covering concrete surface with specified absorptive cover, thoroughly saturating cover with water and keeping continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4" lap over adjacent absorptive covers.

2. Provide moisture-retaining cover curing as follows:

    a. Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3" and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3. Provide curing and sealing compound to exposed interior slabs not receiving additional flooring. A clear curing and sealing compound shall be used on exterior slabs, sidewalks and curbs not receiving a penetrating sealer.
4. Use the specified curing compound on surfaces to be covered with finish or coating material applied directly to concrete, such as liquid densifier/sealer, waterproofing, dampproofing, membrane roofing, flooring, painting, and other coatings and finish materials. Apply compound in accordance with manufacturer’s direction.

C. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by application of the specified curing compound or a continuous moist curing method approved by the architect.

D. Certify that all curing compounds, sealers and hardeners are compatible with all adhesive products intended for attaching co-lateral floor material. In conformance with ASTM F710, coordination with flooring manufacturer is required to insure concrete coatings will not obstruct the bond between the concrete and the adhesive. In addition, insure coatings and adhesives are “benignly compatible” -- in other words, do not combine substances whose constituents are reactive.

3.9 MISCELLANEOUS CONCRETE ITEMS

A. Filling-In: Fill-in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place and cure concrete as herein specified, to blend with in- place construction. Provide other miscellaneous concrete filling shown or required to complete work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections and terminations slightly rounded.

C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations, as shown on drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.

3.10 CONCRETE SURFACE REPAIRS

A. Prior to all repairs, an as-built condition sketch and method of repair must be submitted to the Architect and Engineer of Record for review and approval.

B. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removal of forms, when acceptable to Architect.

C. Cut out honeycomb, rock pockets, voids over 1/4" in any dimension, and holes left by tie rods and bolts, down to solid concrete but, in no case to a depth of less than 1". Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with a bonding grout containing the specified bonding admixture. Place patching mortar after while bonding grout is still tacky.

D. Repair finished unformed surfaces that contain defects, which affect durability of concrete. Surface defects, as such, include crazing, cracks in excess of 0.01" wide or which penetrate to reinforcement or completely through non-reinforced sections regardless of width, spalling, pop-outs, honeycomb, rock pockets, and other objectionable conditions.

E. Correct high areas in unformed surfaces by grinding, after concrete has cured at least 14 days.

3.11 WORK IN CONNECTION WITH OTHER TRADES AND CONTRACTS

A. Provide all chases, pipe slots, etc., required for the mechanical trades (see mechanical drawings), constructed as shown on the approved shop drawings.

B. Coordinate all penetrations, cutting, and patching with waterproofing contractor.

3.12 CUTTING AND PATCHING

A. Contractor for concrete work shall be responsible for all cutting, removing and patching work where concrete surfaces are not installed within the limits shown on the drawings or specified herein. All such work shall meet with the approval of the Architect or Engineer of Record.

B. Where cutting and patching is required to accommodate the work of other subcontractors, such cutting shall be done at the expense of said subcontractors but shall be performed by the contractor for concrete work.

C. The location and extent of cutting in completed concrete work and the patching thereof shall meet with the approval of the Architect or Engineer of Record.

3.13 QUALITY CONTROL TESTING DURING CONSTRUCTION

A. The Owner will employ a testing laboratory to perform tests and to submit test reports.

B. Provide special inspections per the applicable Building Code and the requirements of all applicable ACI standards.

C. Sampling and testing for quality control during placement of concrete may include the following, as directed by Architect.

1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
2. Slump: ASTM C 143; one test at point of discharge for each truck; additional tests when concrete consistency seems to have changed.
3. Air Content: ASTM C 173, volumetric method for lightweight or normal weight concrete; ASTM C 231 pressure method for normal weight concrete; one for each truck of air-entrained concrete.
4. Concrete Temperature: Test hourly when air temperature is 40°F (4°C) and below, and when 80°F (27°C) and above; and each time a set of compression test specimens made.
5. Compression Test Specimen: ASTM C 31; one set of 5 standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory cured test specimens except when field-cure test specimens are required.
6. Compressive Strength Tests: ASTM C 39; one set for each day's pour exceeding 25 cu. yds. plus additional sets for each 50 cu. yds. over and above the first 25 cu. yds. of each concrete class placed in any one day; one specimens tested at 7 days, three specimens tested at 28 days, and one specimens retained in reserve for later testing if required.
    a. When frequency of testing will provide less than 5 strength tests for a given class of concrete, conduct testing from at least 5 randomly selected batches or from each batch if fewer than 5 are used.
    b. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.
    c. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength, and no individual strength test result falls below specified compressive strength by more than 500 psi.
7. Water Cementitious Ratio Test: Check water content of concrete in accordance with AASHTO T 318 “Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying”. Frequency of this test shall be the same as that of compressive strength tests, noted above.
8. Floor Preparation to Receive Resilient Flooring: For any concrete that receives resilient flooring, test concrete in accordance with ASTM F 710 prior to acceptance by owner.
9. Test results will be reported in writing to Architect, Engineer of Record, and Contractor within 24 hours after tests. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials; compressive breaking strength and type of break for both 7-day tests and 28-day tests.
    a. Non Compliance: All test reports indicating non-compliance shall be faxed immediately to all parties on the test report distribution list and the hard copies submitted on different colored paper.
    b. Nondestructive Testing: Windsor probes, sonoscope, or other non-destructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.

10. Additional Tests: The testing service will make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by Architect. Testing service may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed. Contractor shall pay for such tests when unacceptable concrete is verified.

END OF SECTION

SECTION 042200 - CONCRETE UNIT MASONRY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Concrete masonry units.
2. Mortar and grout.
3. Steel reinforcing bars.
4. Masonry-joint reinforcement.
5. Miscellaneous masonry accessories.

1.2 DEFINITIONS

A. CMU(s): Concrete masonry unit(s).

B. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For the following:
1. Masonry Units: Show sizes, profiles, coursing, and locations of special shapes.
2. Reinforcement: show locations, bar size/spacing, and splice lengths.
3. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.

C. Samples for Initial Selection:
1. Weep holes/vents.

D. Samples for Verification: For each type and color of the following:
1. CMUs.
2. mortar. Make Samples using same sand and mortar ingredients to be used on Project.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Material Certificates: For each type and size of the following:
1. Masonry units.
a. Include data on material properties material test reports substantiating compliance with requirements. Include statement on susceptibility to ASR.
2. Cementitious materials. Include name of manufacturer, brand name, and type.
3. Mortar admixtures.
4. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.
5. Grout mixes. Include description of type and proportions of ingredients.
6. Reinforcing bars.
7. Joint reinforcement.
8. Anchors, ties, and metal accessories.

C. Mix Designs: For each type of mortar[**and grout**]. Include description of type and proportions of ingredients.
1. Include test reports for mortar mixes required to comply with property specification. Test according to ASTM C 109/C 109M for compressive strength, ASTM C 1506 for water retention, and ASTM C 91/C 91M for air content.
2. Include test reports, according to ASTM C 1019, for grout mixes required to comply with compressive strength requirement.

D. Statement of Compressive Strength of Masonry: For each combination of masonry unit type and mortar type, provide statement of average net-area compressive strength of masonry units, mortar type, and resulting net-area compressive strength of masonry determined according to TMS 602/ACI 530.1/ASCE 6.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM C 1093 for testing indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Deliver preblended, dry mortar mix in moisture-resistant containers. Store preblended, dry mortar mix in delivery containers on elevated platforms in a dry location or in covered weatherproof dispensing silos.

E. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.8 FIELD CONDITIONS

A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.
   1. Extend cover a minimum of 24 inches **(**600 mm**)** down both sides of walls, and hold cover securely in place.

B. Do not apply uniform floor or roof loads for at least 12 hours and concentrated loads for at least three days after building masonry walls or columns.

C. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.
   1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
   2. Protect sills, ledges, and projections from mortar droppings.
   3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
   4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.

D. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.
   1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F **(**4 deg C**)** and higher and will remain so until masonry has dried, but not less than seven days after completing cleaning.

E. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, from single source from single manufacturer for each product required.

B. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from single manufacturer for each cementitious component and from single source or producer for each aggregate.

2.2 UNIT MASONRY, GENERAL

A. Masonry Standard: Comply with TMS 602/ACI 530.1/ASCE 6 except as modified by requirements in the Contract Documents.

B. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated. Do not use units where such defects are exposed in the completed Work and will be within 20 feet **(**6 m**)** vertically and horizontally of a walking surface.

C. Fire-Resistance Ratings: Comply with requirements for fire-resistance-rated assembly designs indicated.
   1. Where fire-resistance-rated construction is indicated, units shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction.

2.3 CONCRETE MASONRY UNITS

A. Shapes: Provide shapes indicated and as follows, with exposed surfaces matching exposed faces of adjacent units unless otherwise indicated.
   1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
   2. Provide square-edged units for outside corners unless otherwise indicated.

B. CMUs: ASTM C 90.
   1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 2000 ps .
   2. Density Classification: Lightweight Medium weight Normal weight unless otherwise indicated.
   3. Size (Width): Manufactured to dimensions 3/8 inch **(**10 mm**)** less-than-nominal dimensions.
   4. Exposed Faces: Provide color and texture matching the range represented by Architect's sample.
   5. Faces To Receive Plaster: Where units are indicated to receive a direct application of plaster, provide textured-face units made with gap-graded aggregates.

2.4 MORTAR AND GROUT MATERIALS

A. Portland Cement: ASTM C595 Type ILProvide natural color or white cement as required to produce mortar color indicated.

B. Hydrated Lime: ASTM C 207, Type S.

C. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.

D. Aggregate for Mortar: ASTM C 144.
   1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
   2. For joints less than 1/4 inch **(**6 mm**)** thick, use aggregate graded with 100 percent passing the No. 16 **(**1.18-mm**)** sieve.

E. Aggregate for Grout: ASTM C 404.

F. Water: Potable.

2.5 REINFORCEMENT

A. Uncoated Steel Reinforcing Bars: ASTM A 615/A 615M , Grade 60 **(**Grade 420**)**.

B. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells and to hold reinforcing bars in center of cells. Units are formed from 0.148-inch **(**3.77-mm**)** steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Heckmann Building Products Inc.; No. 376 Rebar Positioner.
      b. Hohmann & Barnard, Inc.; #RB or #RB-Twin Rebar Positioner.
      c. Wire-Bond; O-Ring or Double O-Ring Rebar Positioner.

C. Masonry-Joint Reinforcement, General: Ladder type complying with ASTM A 951/A 951M.
   1. Interior Walls: Hot-dip galvanized carbon steel.
   2. Wire Size for Side Rods: [0.148-inch **(**3.77-mm**)**] diameter.
   3. Wire Size for Cross Rods: [0.148-inch **(**3.77-mm**)**] diameter.
   4. Spacing of Cross Rods: Not more than 16 inches **(**407 mm**)** o.c.
   5. Provide in lengths of not less than 10 feet **(**3 m**)**, with prefabricated corner and tee units.

2.6 TIES AND ANCHORS

A. General: Ties and anchors shall extend at least 1-1/2 inches **(**38 mm**)** into masonry but with at least a 5/8-inch **(**16-mm**)** cover on outside face.

B. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated:
   1. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A 82/A 82M, with ASTM A 153/A 153M, Class B-2 coating.

C. Adjustable Anchors for Connecting to Structural Steel Framing: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.
   1. Anchor Section for Welding to Steel Frame: Crimped 1/4-inch- (6.35-mm-) diameter, hot-dip galvanized steel wire. Mill-galvanized wire may be used at interior walls unless otherwise indicated.
   2. Tie Section: Triangular-shaped wire tie made from [0.187-inch- (4.76-mm-)] [0.25-inch- (6.35-mm-)] diameter, hot-dip galvanized steel wire. Mill-galvanized wire may be used at interior walls unless otherwise indicated.

D. Adjustable Anchors for Connecting to Concrete: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.
   1. Connector Section: Dovetail tabs for inserting into dovetail slots in concrete and attached to tie section; formed from 0.060-inch- (1.52-mm-) thick steel sheet, galvanized after fabrication.
      a. 0.064-inch- (1.63-mm-) thick, galvanized-steel sheet may be used at interior walls unless otherwise indicated.
   2. Tie Section: Triangular-shaped wire tie made from [0.187-inch- (4.76-mm-)] [0.25-inch- (6.35-mm-)] diameter, hot-dip galvanized steel wire. Mill-galvanized wire may be used at interior walls unless otherwise indicated.
   3. Corrugated-Metal Ties: Metal strips not less than 7/8 inch (22 mm) wide with corrugations having a wavelength of 0.3 to 0.5 inch (7.6 to 12.7 mm) and an amplitude of 0.06 to 0.10 inch (1.5 to 2.5 mm) made from 0.060-inch- (1.52-mm-) thick steel sheet, galvanized after fabrication ith dovetail tabs for inserting into dovetail slots in concrete.
      a. 0.064-inch- (1.63-mm-) thick, galvanized sheet may be used at interior walls unless otherwise indicated.

E. Partition Top Anchors: 0.105-inch- (2.66-mm-) thick metal plate with a 3/8-inch- (9.5-mm-) diameter metal rod 6 inches (152 mm) long welded to plate and with closed-end plastic tube fitted over rod that allows rod to move in and out of tube. Fabricate from steel, hot-dip galvanized after fabrication.

F. Rigid Anchors: Fabricate from steel bars 1-1/2 inches (38 mm) wide by 1/4 inch (6.35 mm) thick by 24 inches (610 mm) long, with ends turned up 2 inches (51 mm) or with cross pins unless otherwise indicated.
   1. Corrosion Protection: Hot-dip galvanized to comply with ASTM A 153/A 153M.

2.7 EMBEDDED FLASHING MATERIALS

A. Masonry flashing shall be metal, except as otherwise noted. Metal flashing shall be through-wall, where feasible, except where otherwise clearly shown or noted. Through-wall flashing shall be 2-piece, except where otherwise clearly shown or noted.

B. Application: Unless otherwise indicated, use the following:
   1. Where flashing is indicated to receive counterflashing, use metal flashing.
   2. Where flashing is indicated to be turned down at or beyond the wall face, use metal flashing.
   3. Where flashing is fully concealed, use metal flashing.

C. Single-Wythe CMU Flashing System: System of CMU cell flashing pans and interlocking CMU web covers made from UV-resistant, high-density polyethylene. Cell flashing pans have integral weep spouts designed to be built into mortar bed joints and that extend into the cell to prevent clogging with mortar.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Mortar Net USA, Ltd.; Blok-Flash.

D. Adhesives, Primers, and Seam Tapes for Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.

2.8 MISCELLANEOUS MASONRY ACCESSORIES

A. Compressible Filler: Premolded filler strips complying with ASTM D 1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene urethane or.

B. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D 2000, Designation M2AA-805 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.

C. Bond-Breaker Strips: Asphalt-saturated felt complying with ASTM D 226/D 226M, Type I (No. 15 asphalt felt).

2.9 MORTAR AND GROUT MIXES

A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.
   1. Do not use calcium chloride in mortar or grout.
   2. Use portland cement-lime masonry cement or mortar unless otherwise indicated.
   3. For exterior masonry, use portland cement-lime masonry cement or mortar.
   4. For reinforced masonry, use portland cement-lime masonry cement mortar cement mortar.
   5. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.

B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.

C. Mortar for Unit Masonry: Comply with ASTM C 270, Proportion Specification. Provide the following types of mortar for applications stated unless another type is indicated or needed to provide required compressive strength of masonry.
   1. For interior nonload-bearing partitions, Type O may be used instead of Type N.

D. Colored-Aggregate Mortar: Produce required mortar color by using colored aggregates and natural color or white cement as necessary to produce required mortar color.
   1. Mix to match Architect's sample.

E. Grout for Unit Masonry: Comply with ASTM C 476.
   1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with TMS 602/ACI 530.1/ASCE 6 for dimensions of grout spaces and pour height.
   2. Proportion grout in accordance with ASTM C 476, Table 1 or paragraph 4.2.2 for specified 28-day compressive strength indicated, but not less than 3500 psi **(**14 MPa**)**.
   3. Provide grout with a slump of [8 to 11 inches **(**200 to 280 mm**)**] [10 to 11 inches **(**250 to 280 mm**)**] as measured according to ASTM C 143/C 143M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
   1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
   2. Verify that foundations are within tolerances specified.
   3. Verify that reinforcing dowels are properly placed.
   4. Verify that substrates are free of substances that would impair mortar bond.

B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping.

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

3.2 INSTALLATION, GENERAL

A. Build chases and recesses to accommodate items specified in this and other Sections.

B. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match construction immediately adjacent to opening.

C. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

3.3 TOLERANCES

A. Dimensions and Locations of Elements:
   1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch **(**12 mm**)** or minus 1/4 inch **(**6 mm**)**.
   2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch **(**12 mm**)**.

3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch (6 mm) in a story height or 1/2 inch (12 mm) total.

B. Lines and Levels:
1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 feet (6 mm in 3 m), or 1/2-inch (12-mm) maximum.
2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2-inch (12-mm) maximum.
3. For vertical lines and surfaces do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2-inch (12-mm) maximum.
4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2-inch (12-mm) maximum.
5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2-inch (12-mm) maximum.
6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), or 1/2-inch (12-mm) maximum.
7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch (1.5 mm).

C. Joints:
1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm), with a maximum thickness limited to 1/2 inch (12 mm).
2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch (3 mm).
3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch (9 mm) or minus 1/4 inch (6 mm).
4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm).

3.4 LAYING MASONRY WALLS

A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.

B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in bond pattern indicated on Drawings; do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners, jambs or other penetrations.

C. Lay concealed masonry with all units in a wythe in running bond or bonded by lapping not less than [2 inches (50 mm)] [4 inches (100 mm)]. Bond and interlock each course of each wythe at corners. Do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners, jambs or other penetrations.

D. Stopping and Resuming Work: Stop work by stepping back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.

E. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.

F. Fill space between steel frames and masonry solidly with mortar unless otherwise indicated.

G. Fill cores in hollow CMUs with grout 24 inches (600 mm) under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.

H. Build nonload-bearing interior partitions full height of story to underside of solid floor or roof structure above unless otherwise indicated.
1. Install compressible filler in joint between top of partition and underside of structure above.

2. Fasten partition top anchors to structure above and build into top of partition. Grout cells of CMUs solidly around plastic tubes of anchors and push tubes down into grout to provide 1/2-inch (13-mm) clearance between end of anchor rod and end of tube. Space anchors 48 inches (1200 mm) o.c. unless otherwise indicated.
3. Wedge nonload-bearing partitions against structure above with small pieces of tile, slate, or metal. Fill joint with mortar after dead-load deflection of structure above approaches final position.
4. At fire-rated partitions, treat joint between top of partition and underside of structure above to comply with Section 078443 "Joint Firestopping."

3.5 MORTAR BEDDING AND JOINTING

A. Lay hollow CMUs as follows:
1. Bed face shells in mortar and make head joints of depth equal to bed joints.
2. Bed webs in mortar in all courses of piers, columns, and pilasters.
3. Bed webs in mortar in grouted masonry, including starting course on footings.
4. Fully bed entire units, including areas under cells, at starting course on footings where cells are not grouted.

B. Lay solid CMUs with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.

C. Rake out mortar joints at pre-faced CMUs to a uniform depth of 1/4 inch (6 mm) and point with epoxy mortar to comply with epoxy-mortar manufacturer's written instructions.

D. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.

E. Cut joints flush for masonry walls to receive plaster or other direct-applied finishes (other than paint) unless otherwise indicated.

F. Cut joints flush where indicated to receive air barriers, dampproofing or waterproofing unless otherwise indicated.

3.6 MASONRY-CELL FILL

A. Pour loose-fill insulation lightweight-aggregate fill into cavities to fill void spaces. Maintain inspection ports to show presence of fill at extremities of each pour area. Close the ports after filling has been confirmed. Limit the fall of fill to one story high, but not more than 20 feet (6 m).

3.7 MASONRY-JOINT REINFORCEMENT

A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch (16 mm) on exterior side of walls, 1/2 inch (13 mm) elsewhere. Lap reinforcement a minimum of 6 inches (150 mm).
1. Space reinforcement not more than 16 inches (406 mm) o.c.
2. Space reinforcement not more than 8 inches (203 mm) o.c. in foundation walls and parapet walls.
3. Provide reinforcement not more than 8 inches (203 mm) above and below wall openings and extending 12 inches (305 mm) beyond openings in addition to continuous reinforcement.

B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.

C. Provide continuity at wall intersections by using prefabricated T-shaped units.

D. Provide continuity at corners by using prefabricated L-shaped units.

E. Cut and bend reinforcing units as directed by manufacturer for continuity at corners, returns, offsets, column fireproofing, pipe enclosures, and other special conditions.

3.8 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE

A. Anchor masonry to structural steel and concrete, where masonry abuts or faces structural steel or concrete, to comply with the following:
1. Provide an open space not less than [1/2 inch (13 mm)] [1 inch (25 mm)] [2 inches (50 mm)] wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.
2. Anchor masonry with anchors embedded in masonry joints and attached to structure.
3. Space anchors as indicated, but not more than 24 inches (610 mm) o.c. vertically and 36 inches (915 mm) o.c. horizontally.

3.9 CONTROL AND EXPANSION JOINTS

A. General: Install control- and expansion-joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.

B. Form control joints in concrete masonry using one of the following methods:
1. Fit bond-breaker strips into hollow contour in ends of CMUs on one side of control joint. Fill resultant core with grout, and rake out joints in exposed faces for application of sealant.
2. Install preformed control-joint gaskets designed to fit standard sash block.
3. Install interlocking units designed for control joints. Install bond-breaker strips at joint. Keep head joints free and clear of mortar, or rake out joint for application of sealant.
4. Install temporary foam-plastic filler in head joints, and remove filler when unit masonry is complete for application of sealant.

3.10 LINTELS

A. Providelintels where shown and where openings of more than 8 inches **(**305 mm**)** for brick-size units and 12 inches **(**610 mm**)** for block-size units are shown without structural steel or other supporting lintels.

B. Provide minimum bearing of 8 inches **(**200 mm**)** at each jamb ,except lintels with a span of under 32" may bear only 6".

3.11 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner will engage special inspectors to perform tests and inspections and prepare reports. Allow inspectors access to scaffolding and work areas as needed to perform tests and inspections. Retesting of materials that fail to comply with specified requirements shall be done at Contractor's expense.

3.12 REPAIRING, POINTING, AND CLEANING

A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.

B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.

C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.

D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
3. Protect adjacent stone and nonmasonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.
4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
5. Clean concrete masonry by applicable cleaning methods indicated in NCMA TEK 8-4A.

3.13 MASONRY WASTE DISPOSAL

A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.

B. Waste Disposal as Fill Material: Dispose of clean masonry waste, including excess or soil-contaminated sand, waste mortar, and broken masonry units, by crushing and mixing with fill material as fill is placed.
1. Crush masonry waste to less than 4 inches **(**100 mm**)** in each dimension.
2. Mix masonry waste with at least two parts of specified fill material for each part of masonry waste. Fill material is specified in Section 312000 "Earth Moving."
3. Do not dispose of masonry waste as fill within 18 inches **(**450 mm**)** of finished grade.

C. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above or recycled, and other masonry waste, and legally dispose of off Owner's property.

END OF SECTION

SECTION 051200 – STRUCTURAL STEEL FRAMING

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 but is not limited to the following as shown on the drawings and as specified herein:

1. Furnish and deliver for installation by others, anchor bolts, bearing plates and loose lintels with complete instructions and templates to facilitate installation.
2. Furnish and erect all struts, columns, bearing plates, beams, steel trusses, girders, bracing, hangers and all related connections (bolted and welded).
3. Openings (unreinforced and reinforced) in structural steel to accommodate mechanical and electrical work.
4. Shop painting and field touch-up painting.
5. Erection bracing and supports, including steel wedges, shims or nuts required for leveling base plates.
6. Lintels and angles attached to structural steel as shown on drawings.
7. Unless specifically excluded, furnish and install all other items for structural steel work indicated on the drawings, specified, or obviously needed to make the work of this Section complete.
8. Waste Management

B. Related Work Specified Elsewhere

1. Installation of anchor bolts furnished under this section.
2. Installation of loose lintels furnished under this section.
3. Miscellaneous metal work
4. Field painting of structural steel, except as specified herein.
5. Fireproofing systems.

1.3 DEFINITIONS

A. Structural Steel: Elements of structural-steel frame, as classified by AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

1.4 PERFORMANCE REQUIREMENTS

A. Connections: Provide details of all connections required by the drawings to be completed by structural steel fabricator (including comprehensive engineering analysis by a qualified professional engineer) to withstand loads indicated and comply with other information and restrictions indicated, unless noted otherwise.

1. Select and complete connections using schematic details indicated and AISC 360.
2. Use design method indicated on structural drawings.
3. Moment Connections: Fully restrained unless otherwise noted on drawings.

1.5 SUBMITTALS

A. Product Data: Submit data for each type of product indicated in the contract documents.

B. Shop Drawings: Submit shop drawings in accordance with the specifications as follows:

1. Show clearly all work, including relationship of structural steel to the adjacent work of other trades and to significant lines of finishes of other trades.
2. Do not fabricate or deliver work to the site before drawings reviewed by the Architect and Engineer of Record have been returned.
3. Before preparing steel shop drawings, submit proposed submittal schedule for review by Architect and Engineer of Record.
4. Before preparing steel shop drawings, submit for review a set of job standards showing all necessary joint details with full particulars of connection pieces, shop and field welds, and holes for erection bolts and permanent bolts. These shall include any moment and shear connections. Appropriate marks for designating all types and sizes of joint details shall be included. After approval of these job standards, the erection plans are to be submitted and shall be marked to indicate unmistakably the type and size of joint to be used for every beam connection. Do not order steel in advance of approval of the job standards and the erection plans with joint marks, except at own risk
5. Submit calculations for design of connections on job standards and all other connections such as moment and brace frames. Calculations shall be signed and sealed by a Professional Engineer licensed in the state in which the project is located.
6. Prepare remainder of steel shop drawings after approval of job standards and erection plans. Drawings submitted prior to approval of job standards will be returned without review.
7. Prepare shop drawings in conformance with the applicable procedures shown in "*Detailing for Steel Construction*," latest edition, published by AISC. Prepare shop drawings under the supervision of competent engineering personnel, licensed by the state in which the construction is to take place. During the preparation of shop drawings, and prior to submittal, coordinate and cross check all shop drawings, including those prepared by subcontractors, for compliance with the Contract Documents.
8. Indicate clearly the size and grade of steel for each component. Identify rolled shapes, tubes and plates by using the standard designations used in "Steel Construction Manual" Latest Edition, by AISC.
9. Indicate welds and nondestructive tests by using the symbols conforming to AWS A2.4 "Symbols for Welding and Nondestructive Testing." Where necessary for clarity, indicate welding procedure designations or other data in the tail of the welding symbol.
10. Show explicitly the type of connection used in each location, including the grade, size, and number of bolts; the type, number, position, designation and orientation of each washer; and the size of each hole, whether slotted or round. Ensure that adequate wrench clearance for correct bolt tightening is provided and note special bolt tightening sequences where applicable and necessary.
11. Show holes required for securing work specified in other sections to structural steelwork, as well as all holes required for passage through structural steelwork of work of other trades. Provide field work drawings for all such holes not shown in shop or erection drawings. Addition of, or change in size or location of openings will not be permitted without prior approval.
12. Use bolted connections wherever possible; avoid field welding unless otherwise noted on drawings.
13. Make details in such a way as to avoid having steel, connections, bracing, bolts, etc., interfere with architectural details or in any way reduce the areas of shafts, openings, clearances, etc.
14. Detail and schedule cleaning and painting data and requirements, including specific indication of "no-paint" areas.
15. The use of the Architect’s or Engineer of Record's electronic drawing files as a base for the erection shop drawings will be permitted at the request of the structural steel detailer upon completion and return of the waiver form. The use of the Architect’s or Engineer of Record's electronic drawing files as a base for shop drawing details will not be permitted. The structural steel detailer will be responsible for compatibility of the files with his hardware or software. The electronic files are not to be considered the contract documents, the design team makes no representation regarding the accuracy or completeness of the electronic files given to the structural steel detailer and their use will be at the structural steel detailer’s sole risk and without liability to the design team. The structural steel detailer shall remove the project title box and all references to the structural drawings including drawing numbers and structural drawing sections and details. The structural steel detailer shall also remove all reference to work not included in the steel contract.
16. Scaling of the Architect’s or Engineer of Record’s drawings is not permitted. This applies to hard paper,

electronic, and all other versions.

17. Show clearly the size and location of each member and the erection mark assigned to each member. Show each field connection with all data and details necessary for assembling the structure. Direct special attention to the possible need for special guying, bracing, or shoring to prevent deformation of existing or new structure due to stresses caused by erection procedures and equipment, by construction loadings, and by forces of natural phenomena.
18. Prepare, keep up-to-date, and submit a complete drawing index cross-referencing each assigned piece mark with the drawing number in which the piece is detailed. Detail drawings submitted without an up-to-date index and the applicable erection drawing(s) showing the location of each piece will be deemed an incomplete submission and will not be accepted as subject to any agreed shop drawing review schedule.
19. Submit, in writing, any proposed deviations from the Contract Documents, prior to the submission of shop drawings showing the proposed deviation. Submit requests for deviations on the steelwork subcontractor's letterhead. Deviations not identified, or identified only in letters of transmittal or in shop drawings or both, without the required written request, may not be accepted, and shall be sufficient cause for the architect to return each shop drawing containing such deviations without further action. Acceptance of shop drawings containing deviations not detected by the architect during shop drawing review shall not relieve the steelwork subcontractor from responsibility to conform strictly to the Contract Documents.
20. Prior to resubmission of shop drawings with additions or corrections, circle or bubble and identify all changes. Drawings submitted without each change being clearly identified are subject to return for resubmission.
21. Prior to making shop drawings for any portion of the work involving alterations to an existing structure, make all necessary field observations, measurements and surveys of existing conditions. If probes are required to accomplish such measurements, give timely notice where probes will be required.

C. Submit certified copies of each survey conducted by a surveyor licensed by the state in which the construction is to take place and employed by the structural steel subcontractor. Survey shall show elevations and locations of base plates and anchor bolts to receive structural steel, and final elevations and locations for major members. Indicate discrepancies between actual installation and Contract Documents.

D. Reports:

1. Submit certified copies of mill test reports for all steel furnished. Perform mechanical and chemical tests for all material regardless of thickness or use.
2. Submit certification of recycled steel content. Certification shall clearly indicate post-consumer AND post-industrial recycled steel content for the particular member or members used.
3. Submit producer’s literature or Material Test Reports (MTR’s) which indicate original EAF steelmaking production for all structural steel framing products listed on the Structural Drawings.
4. Submit one of the following as evidence of sustainable fabrication:
    a. Evidence of the following sustainable steel fabrication activities:
        1) A sustainability policy including a commitment to tracking energy consumption and waste output and a sustainability goal
        2) The completion of steel sustainability education in the areas of construction material sustainability and sustainable steel fabrication
    b. Evidence of status as an AISC Sustainability Partner in the partner program as indicated at aisc.org/partnerprogram
5. Submit anchor bolt checking certification as required.
6. Submit qualification certificates of all welders who will perform work on the project.
7. Submit survey of erected steelwork as required.

E. Submit verification of bio-degradable or low VOC, and low Hazardous Air Pollutants (HAPS) cleaning solutions. Provide a cut sheet for all cleaning solutions used in the surface preparation of steel components. Highlight VOC limits and chemical component limits.

F. Environmental Product Declarations (EPD):

1. Provide a product-specific third-party verified Type III Environmental Product Declaration (EPD) conforming to ISO 14025 with a Global Warming Potential (GWP) no greater than the following limits

for the following structural steel framing products listed on the Structural Drawings:

a. Hot-rolled sections: 1.25 kgCO2e/kg of steel
b. Plate: 1.84 kgCO2e/kg of steel
c. Hollow structural sections (HSS): 2.14 kgCO2e/kg of steel

2. EPDs including information for more than one producer's or manufacturer's facility are acceptable as long as each location's global warming potential (GWP) information is reported separately.
3. If multiple EPDs are submitted for the same structural steel products, provide a means to map EPDs to the corresponding products.
4. EPDs must be current and developed in accordance with the current or prior version of the North American Product Category Rule (PCR) for Steel Construction Products.
5. Hot-rolled sections, steel plate, and hollow structural sections (HSS) are subject to this informational submittal only if they are the primary member within a fabricated steel assembly. "Piece parts," such as connection and stiffening material, are not subject to this informational submittal.
6. Steel products that are recovered from an existing site and reused in the project are exempt from this requirement.

1.6 QUALITY ASSURANCE

A. Except as modified by this specification, comply with the applicable provisions and recommendations of the following codes and standards:

1. District of Columbia Building Code, Latest Edition
2. AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings".
3. AISC "Code of Standard Practice for Steel Buildings and Bridges" latest edition.
4. AISC "Seismic Provisions for Structural Steel Buildings", latest edition.
5. Industrial Fasteners Institute "Handbook of Bolt and Bolted Joints" latest edition.
6. RCSC "Specifications for Structural Joints Using High-Strength Bolts."
7. ASTM Standards as applicable in the building code of the local jurisdiction and as noted in this specification.
8. AWS D1.1, "Structural Welding Code."
9. AWS A5.18 & A5.28, Structural Welding Code for GMAW
10. SSPC "Painting Manual, Volume 2, Systems and Specifications.", Latest edition.

B. Qualifications for welding work shall be as follows:

1. Qualify welding procedures and welding operators in accordance with the AWS "Standard Qualification Procedure."

a. Include amended requirements of the building code as noted above.

2. Submit certification that all welders to be employed in work are AWS qualified. If re-certification of welders is required, retesting will be responsibility of structural steel subcontractor.

a. Include licensing requirements as per the building code noted above and local jurisdiction.

1.7 TESTING AND INSPECTION

A. Special Inspection as required by the applicable Building Code of all structural steelwork in the shop and field will be performed by an inspection agency retained by the Owner at no expense to the Contractor. The inspection agency shall work under the direction of the Owner. Contractor shall provide the inspection agency with the following:

1. Schedule of all work in both shop and field with at least ten days' written notice before commencement of either activity.

2. A complete set of approved shop and erection drawings.
3. Cutting lists, order sheets, material bills, shipping bills and mill test reports.
4. Information as to time and place of all rollings and shipment of material to shops.
5. Representative sample pieces as requested by the testing agency.
6. Full and ample means and assistance for testing all material.
7. Proper facilities, including scaffolding, temporary work platforms, etc., for inspection of the work in the mills, shop and field.

B. Each person installing connections shall be assigned an identifying symbol or mark and all shop and field connections shall be so identified so that the inspector can refer back to the person making the connection.

C. The following minimum criteria shall be adhered to in testing of welds and bolts:

1. All welds and bolts shall be examined by visual means.
2. 25% of all welds, selected randomly, shall be measured.
3. Bolted joints shall be verified per the RCSC “Specification for Structural Joints Using High-Strength Bolts,” Section 9, based on installation method.
4. All welds subject to tensile stress shall be examined by the Ultrasonic Method for 100% of their length.
5. 10% of all manual fillet welds shall be tested by the magnetic particle method.
6. 1'-0" at each end of automatic fillet welds shall be tested by the magnetic particle method.
7. 100% of groove welds shall be tested by the ultrasonic method.

D. Shop inspection will include examination of steel for straightness and alignment, fissures, mill scale, and other defects and deformities, as described in ASTM A6, examination of fabricated pieces for conforming to approved shop drawings, testing of bolts and welds, and inspection of shop painting. All shop welds shall be visually inspected and spot tested using Ultrasonic Method ASTM E 114 and AWS, Chapter 6, Part C. All inspected welds shall be identified by the inspector.

E. Field inspection will include examination of erected steel for welding, proper fitting and tensioning of bolts, alignment, trueness and plumbness, touching-up of shop coat, level of billets and base plates.

F. Inspection of welding will be such as to assure that the work is within the quality requirements specified below and elsewhere in this section of the specifications and will include:

1. Ascertainment that the electrodes and flux used for the SAW, GMAW and FCAW welding processes conform to the requirements of this section of the specifications.
2. Ascertainment that the approved welding procedures and sequence are followed without deviation, unless specific approval for change is obtained from the Engineer of Record.
3. The testing agency shall be prepared to utilize the following approved methods of testing:

    a. Liquid penetrant inspection: ASTM E 165.
    b. Magnetic particle: ASTM E 1444.
    c. Radiographic inspection: ASTM E 94 and E 1032.
    d. Ultrasonic inspection: ASTM E 114 and AWS, Chapter 6, Section C.

G. When defects are revealed, additional inspection by whatever method is deemed necessary by the inspector, shall be performed to the extent necessary to assure that the full amount of defect has been located. No further work shall be done on the assembly or sub-assembly in question until all the necessary corrections have been made. Defects shall be repaired, using the same welding procedure that was used initially in making the weld, unless otherwise approved by the Engineer of Record. Inspection of the repaired weld shall be by the same method that was used to reveal the defect. A second repair of a defective area shall not be made without approval of the Engineer of Record.

H. Apparatus and procedures for measuring required tension in pretensioned and slip-critical high strength bolted connections shall be furnished and maintained by the steel contractor, in accordance with the RCSC “Specification for Structural Joints Using High-Strength Bolts,” and shall be approved by the inspection agency. The inspection agency shall observe the pre-installation verification testing required and shall ensure by routine observation that the bolted installations conform to the approved pretensioning method being used.

The steel contractor shall provide a laborer and scaffolding as required for the testing of connections by the inspection agency, and shall, at his own expense, furnish such facilities and provide such assistance as may be required for proper inspection.

I. A distinguishing mark will be placed on all work that has been inspected and approved. Material or work that is not acceptable will be designated by words such as "REJECT" or "REPAIR" marked directly on the material or work.

J. Inspection of Shop Painting:

1. Visually evaluate surface preparation by comparison with pictorial standards in accordance with SSPC-Vis 1.
2. Measure dry film thickness of each coat with a magnetic film thickness gauge in accordance with SSPC-PA 2.
3. Visually inspect dried film for runs, sags, dry spray, overspray and missed areas.
4. Repair defective or damaged areas in accordance with painting requirements specified. Architecturally exposed structural steel shall be free of runs and holidays. Make repairs to shop or field coat as directed.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver materials to site at such intervals to ensure uninterrupted progress of work. Minimize the disturbances to site and soil conditions.

B. Deliver anchor bolts and anchorage devices, which are to be embedded in cast-in-place concrete, in ample time not to delay work.

C. Store materials to permit easy access for inspection and identification. Keep steel members in a safe, dry, off ground location, using pallets, platforms, or other supports. Protect steel members and packaged materials from corrosion and deterioration, discoloration or staining.

D. Do not store materials on structure in a manner that might cause distortion or damage to members of supporting structures. Repair or replace damaged materials or structures as directed.

1.9 PROJECT CONDITIONS

A. The structural steel contractor shall coordinate the structural steel work with the work of other Contracts. Verify all dimensions and details of this Contract and those of other Contracts that affect the work before proceeding. Any discrepancies shall be immediately reported to the architect.

B. Be fully responsible for the accurate installation of the work. Any discrepancy which arises from his failure to execute the work in conformity to the drawings and specifications shall be properly remedied at the contractor's own expense and in a manner acceptable to the architect.

C. Locate dimensionally on setting plans all anchor bolts, inserts, bearing and base plates, etc., and prepare and deliver all required templates and fully dimensioned setting plans in time for the proper execution of the work. Anchor bolts shall be set by another subcontractor. The structural steel contractor shall check all such settings for correctness after they have been cast in place, and before proceeding with erection work.

D. Report to the architect and certify compliance with the above checking requirements in writing and indicate any inaccuracies found in the location of anchor bolts or inserts, and corrections which must be made to their installation. Any inaccuracies not included in the report and found during or after steel erection shall be the responsibility of the structural steel contractor and the cost of corrective measures shall be borne by the structural steel contractor.

E. Use base lines, bench marks, or other standards for survey work that have been provided or verified by others. If permanent building bench marks have been established, these will be used for field checking.

F. Coordinate with all other trades to ensure that work of this section does not cause undue conflict. Ensure that location of erection devices such as cranes, derricks, booms or hoists, does not cause over-stresses to steel frame to work previously placed by other trades or to existing structures. When required, retain the services of a licensed professional engineer to ascertain that erection devices do not create unsafe conditions or cause overstresses.

G. Ensure full co-ordination with other related trades and professions.

1.10 SUBSTITUTION

A. Architect reserves the right to require substitute shapes of other sizes than those indicated on the drawings when it is apparent that the shapes specified cannot be furnished within the time required for the progress of construction. Make said substitutions without additional cost to the owner.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel shapes, including structural steel wide flange and structural tee rolled shapes, channels, angles, plates, pipe, and hollow structural sections: As noted on structural drawings.

B. High Strength Bolts: As noted on Structural Drawings.

C. Anchor Rods: As noted on structural drawings

D. Filler metal for welding electrodes. As noted on structural drawings.

E. Structural steel primer paint: rust inhibitive primer conforms to the following criteria

1. Demonstrate a minimum of adhesion as classified by 4B of ASTM D 3359 method A
2. Demonstrate a minimum opacity as determined by ASTM D 2805
3. Demonstrate corrosion resistance per standards ASTM B 117 & ASTM D 5894
4. “Slip Critical” compatible rating where applicable
5. The product shall not contain any of the prohibited compounds as listed in Green Seal *Standard for Paintings and Coatings*, GS-11, latest edition and in Master Painters Institute (MPI) *Green Performance Standard*, GPS-1-08.
6. The product shall meet the VOC limits as set forth in the MPI Green Performance Standard, GPS-1-08, with a maximum allowable VOC of 340 g/L for rust preventative coatings. Limits are expressed in THINNED state. Preference shall be given to products with the least crystalline silica content.
7. The product shall meet all the requirements of MPI Standards: 23, 26, 76, 79, 95, 107, 135, 173, 275. Products not listed with MPI are acceptable if and only if they meet the same environmental criteria for the same product category.

    a. Exterior exposed steel, normal conditions: Use alkyd or polyamide solvent based paints (MPI #’s 76, 79 & 101)
    b. Interior exposed steel: Use water based paint (MPI # 107)
    c. Special Applications, highly corrosive environments: Use zinc rich paints (MPI #’s 20 & 200)

PART 3 - EXECUTION

3.1 FABRICATION

A. All shop connections shall be high strength bolted unless specifically shown otherwise. Fabricate work in shop in as large assemblies as practicable. Use welded connections ONLY where shown on drawings. If a bolted connection is not possible, obtain written approval from the Engineer of Record for the welded connection.

B. Mill column ends and bearing stiffeners to give full bearing over the cross section. Plane contact surfaces of bearing plates when required by the AISC Specifications. It is not necessary to plane bottom surfaces of plates on grout beds.

C. Drill or punch holes at right angles to the surface of the metal, not more than 1/16" larger than the connector diameter. Do not make or enlarge holes by burning. Drill material having a thickness in excess of the connector diameter and material thicker than 7/8". Holes shall be clean-cut without torn or ragged edges. Remove outside burrs resulting from drilling operations.

D. Provide holes in members to permit connection of the work of other trades. Use suitable templates for proper location of these holes. Steel requiring adjustment or accurate alignment shall be provided with slotted holes or full bearing shims as shown.

E. Provide holes, slots and openings required by other trades together with necessary reinforcing required. Use suitable templates for proper location of these openings. All such openings shall be shown on the shop drawings. No change in size or location will be permitted without prior approval.

F. Manual flame cutting shall be done only with a mechanically guided torch. An unguided torch may be used provided the cut is within 1/8" of the required line.

3.2 SHOP CONNECTIONS

A. Provide connections as shown on the drawing exactly as detailed. Where connections are not detailed, the minimum connections shall comply with appropriate tables headed, "Framed Beam Connections" shown in the AISC "Manual of Steel Construction" unless otherwise noted on the drawings. Use high strength bolts unless otherwise shown.

B. Do not use welded connections unless shown on details. Field welding is not allowed without written instruction from the Engineer of Record.

C. Proportion and detail all connections on shop drawings to resist forces shown on design drawings.

D. Bolting

1. Bolts shall be of a length that will extend not less than 1/4" beyond the nuts. Enter bolts into holes without damaging the thread.
2. Joint Type: As noted on the Structural Drawings.
3. Make high-strength bolted joints without the use of erection bolts. Bolt heads and nuts shall rest squarely against the metal. Where structural members have sloping surface, bolted connections shall be provided with beveled washers to afford square seating or framing for bolt heads or nuts.
4. All joints are to be compacted to the snug-tight condition in accordance with Section 8 of the RCSC “Specification for Structural Joints Using High-Strength Bolts.” Protect bolt heads and threads from damage during installation.
5. Pretensioned and slip-crtical joints are to be installed by one of the methods prescribed in Section 8.2 of the RCSC “Specification for Structural Joints Using High-Strength Bolts,” unless written approval is obtained from the Engineer of Record.
6. Bolts that have been completely tightened shall be marked for identification.

E. Welding

1. The following environmentally preferable welding processes shall be used as described for the related application without exception:

    a. Submerged Arc Welding (SAW): Plate girders, fillet and butt joints in pipes, cylinders, columns and beams, and welds where 'downhand' or horizontal positions are possible.
    b. Gas Metal Arc Welding (GMAW) shall be used where SAW is not applicable (such as for angled connections and anything irregular or short).
    c. Field welding shall be allowed only in special circumstances; in such cases Flux Core Arc welding (FCAW) shall be specified

2. Do not begin structural welding until joint elements are inspected for surface preparation, fit-up, and cleanliness of surface to be welded and are then bolted or tacked in intimate contact and adjusted to dimensions shown on drawings, or both, with allowance for any weld shrinkage that is expected. No members are to be spliced without prior approval by the Engineer of Record.

    a. Containment surface preparation debris must meet SSPC-Guide 6 guidelines.

3. Pre-heat and interpass temperature shall be in accordance with Table 4.2 (including footnotes) of the AWS Code for Welding in Building Construction. The temperature shall be measured from the side opposite to that which the pre-heat is applied, where possible.
4. All groove welds shall be continuous and full penetration welds unless otherwise shown on the design drawings. Welds made without the aid of a back-up bar shall have their roots chipped, ground or roughened out to sound metal from the second side, before welding is done from the second side.
5. All welds shall be sound throughout. There shall be no crack in any weld or weld pass. Weld may be considered sound if it contains only slight porosity or fusion defects which are well dispersed.
6. The heat, input, length of weld and sequence of weld shall be controlled to prevent distortions. The surfaces to be welded and the filler metals to be used shall be subject to inspection before any welding is performed.

3.3 SHOP PAINTING AND CLEANING

A. Finishing, coating, plating

1. Shop painting and factory finishing shall be preferred to field painting whenever possible. Where applicable, finishes and surface preparations based on a physical process such as abrasive blasting, grinding, buffing and polishing are preferred to coatings and solvent based cleaning. Where coatings are necessary powder-coated fabrication is preferred to painting and plating. Avoid plated metals especially those using cadmium and chromium as plate material or cyanide or copper/formaldehyde based electroless copper as the plating solution.

B. Remove all rust, scale, grease and other detrimental foreign matter in accordance with SSPC-SP 3, Power Tool Cleaning, unless conditions/opportunities listed below apply.

1. Use surface preparation classification recommended by paint manufacturer, SSPC or Master Painters Institute (MPI) for paint product used.

    a. SSPC-Guide 6, Guide for Containing Debris Generated During Paint Removal Operations, must be followed for all applicable surface preparation techniques.

C. Immediately after surface preparation, apply structural steel primer paint where specified, in accordance with manufacturer's instructions and at a rate to provide dry film thickness of not less than 2.0 mils. Use painting methods which result in full coverage of joints, corners, edges and exposed surfaces. Use type of primer paint as specified in "Materials" article above. Apply two coats to surfaces that will be inaccessible after erection

D. Paint all structural steel in accordance with the foregoing specification, except as follows:

1. Steel which is to receive spray-on fireproofing.
2. Within 2" of field welds or welds made after paint is applied.
3. Faying surfaces in bolted connections shall be prepared per Section 3.2 of the RCSC “Specification for Structural Joints Using High-Strength Bolts.”
4. Machined surfaces and threaded parts required for adjustment of the structure. Protect these with suitable rust inhibiting coating which may be removed after final installation of the work so that proper finished coatings may be applied.

3.4 SOURCE QUALITY CONTROL

A. Refer to testing and inspection requirements specified above.

3.5 EXAMINATION

A. Verify field measurements prior to start of erection. Check the alignment and elevation of all column supports and location of all anchor bolts with transit and level instruments before starting erection. Notify architect of any errors. Obtain Architect's approval of methods proposed for correcting errors prior to proceeding with corrections and erection.

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

3.6 PREPARATION

A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.

3.7 ERECTION

A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.

B. Maintain erection tolerances of structural steel within AISC's "Code of Standard Practice for Steel Buildings and Bridges."

C. Column billets and bearing plates shall be supported and aligned on steel wedges, shims, or leveling nuts. After the supported members have been plumbed and properly positioned by instrument and anchor nuts tightened, the entire bearing area under the plate shall be packed solidly with grout specified in another Section. Wedges and shims shall be set back a minimum of 3/4" from the edges of plates and shall be left in place. Leveling plates are not permitted.

D. Plumbing, Leveling and Bracing

1. Structural steel shall be erected true and level, and temporary bracing shall be introduced wherever necessary to provide for all loads to which the structure may be subjected, including equipment and the operation thereof. Such bracing shall be left in place as long as may be required for safety. No welding shall be done or bolts drawn up tight until structural steel has been properly aligned. Obtain approval for guy locations to assure lack of interference with operations of other trades.

E. Drifting

1. Light drifting necessary to draw holes together will be permitted, but drifting of unfair holes will not be

permitted. Twist drills shall be used to enlarge holes as necessary to the next larger size; use next larger size bolts as required. Reaming that weakens the members, or make it impossible to fill the holes properly or to adjust accurately after reaming, will not be allowed.

3.8 FIELD CONNECTIONS

A. In addition to the requirements for shop connections comply with the following:

1. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using High-Strength Bolts" for type of bolt and type of joint specified.
2. Joint Type: As noted on structural drawings.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
2. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.

3.9 REPAIRS AND PROTECTION

A. Touchup Painting: Immediately after erection, clean exposed areas where primer is damaged or missing and paint with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

1. Clean and prepare surfaces by SSPC-SP 3, Power Tool Cleaning.

B. After erection, all damaged areas in shop coat, exposed surfaces of bolt heads, nuts and washers, and all field welds and unpainted areas adjacent to field welds and high strength bolts shall be painted with a "touch-up" application of same paint used in the shop coat and then painted with same paint used for shop coat tinted another color. Retouch in field, any scraped, abraded, and unpainted surfaces. Painting shall be as specified for shop coats.

C. Structural steel which is to support mechanical equipment and will be left exposed to the weather in the finished project shall be field painted with one coat of anti-corrosive paint as described in Part 2 for Paint Materials.

3.10 WASTE MANAGEMENT

A. Separate for recycling and place in designated containers the following metal waste in accordance with the Waste Management Plans and local recycler standards: Steel, iron, galvanized steel, galvanized sheet steel, stainless steel, aluminum, copper, zinc, lead, brass and bronze.

B. Collect all metal cut-offs and scraps and recycle as above.

C. Fold up metal banding, flatten and place in designated area.

D. Close and seal tightly all partly used paint and finish containers and store protected in a well-ventilated, fire-safe area at moderate temperature.

E. Designated un-used paint for:

1. Immediate re-use

2. Long term maintenance needs
3. Recycling by an appropriate facility.
4. Donation

F. Place empty containers of solvent-based paints in areas designated for hazardous materials.

G. Do not dispose of paints or solvents by pouring on the ground. Place amounts too small to re-use in designated containers for proper disposal

H. Place materials defined as hazardous or toxic waste in designated containers.

END OF SECTION

SECTION 061000 - ROUGH CARPENTRY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Wood products.
2. Fire-retardant-treated lumber.
3. Miscellaneous lumber.
4. Plywood backing panels.

1.2 DEFINITIONS

A. Boards or Strips: Lumber of less than 2 inches nominal **(**38 mm actual**)** size in least dimension.

B. Dimension Lumber: Lumber of 2 inches nominal **(**38 mm actual**)** size or greater but less than 5 inches nominal **(**114 mm actual**)** size in least dimension.

C. Exposed Framing: Framing not concealed by other construction.

D. Lumber grading agencies, and abbreviations used to reference them, include the following:
1. NeLMA: Northeastern Lumber Manufacturers' Association.
2. NLGA: National Lumber Grades Authority.
3. SPIB: The Southern Pine Inspection Bureau.
4. WCLIB: West Coast Lumber Inspection Bureau.
5. WWPA: Western Wood Products Association.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
1. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
2. For fire-retardant treatments, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency in accordance with ASTM D5664.

1.4 QUALITY ASSURANCE

A. Provide the following upon request:
1. Material Certificates:
a. For dimension lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by the ALSC Board of Review.
b. For preservative-treated wood products. Indicate type of preservative used and net amount of preservative retained.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Stack wood products flat with spacers beneath and between each bundle to provide air circulation. Protect wood products from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS

A. Lumber: Comply with DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, comply with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Grade lumber by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
1. Factory mark each piece of lumber with grade stamp of grading agency.
2. For exposed lumber indicated to receive a stained or natural finish, mark grade stamp on end or back of each piece.

3. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry wood products.
4. Dress lumber, S4S, unless otherwise indicated.

B. Maximum Moisture Content:
1. Boards: 19 percent.
2. Dimension Lumber: 19 percent unless otherwise indicated.

2.2 FIRE-RETARDANT-TREATED LUMBER

A. General: Where fire-retardant-treated materials are indicated, materials are to comply with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.

B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested in accordance with ASTM E84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet **(**3.2 m**)** beyond the centerline of the burners at any time during the test.
1. Treatment is not to promote corrosion of metal fasteners.
2. Interior Type A: Treated materials are to have a moisture content of 28 percent or less when tested in accordance with ASTM D3201/D3201M at 92 percent relative humidity. Use where exterior type is not indicated.
3. Design Value Adjustment Factors: Treated lumber is to be tested according to ASTM D5664 and design value adjustment factors are to be calculated according to ASTM D6841.

C. Kiln-dry lumber after treatment to maximum moisture content of 19 percent. Kiln-dry plywood after treatment to maximum moisture content of 15 percent.

D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency and other information required by authorities having jurisdiction.
1. For exposed lumber indicated to receive a stained or natural finish, mark end or back of each piece.

E. For exposed items indicated to receive a stained or natural finish, chemical formulations are not to bleed through, contain colorants, or otherwise adversely affect finishes.

2.3 MISCELLANEOUS LUMBER

A. Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
1. Blocking.
2. Nailers.
3. Cants.
4. Furring.

B. Dimension Lumber Items: Construction or No. 2 grade lumber of
1. Spruce-pine-fir (south); NeLMA, WCLIB, or WWPA.

C. Concealed Boards: 19 percent maximum moisture content and any of the following species and grades:
1. Spruce-pine-fir (south) or spruce-pine-fir; Construction or No. 2 Common grade; NeLMA, NLGA, WCLIB, or WWPA.

D. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.

E. For furring strips for installing plywood or hardboard paneling, select boards with no knots capable of producing bent-over nails and damage to paneling.

2.4 PLYWOOD BACKING PANELS

A. Equipment Backing Panels: Plywood, DOC PS 1, Exposure 1, C-D Plugged, fire-retardant treated, in thickness indicated or, if not indicated, not less than 3/4-inch **(**19-mm**)** nominal thickness.

2.5 FASTENERS

A. General: Fasteners are to be of size and type indicated and comply with requirements specified in this article for material and manufacture. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches **(**38 mm**)** into wood substrate.

1. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M or ASTM F2329 of Type 304 stainless steel.
2. For redwood, use brass/bronze stainless steel hot-dip galvanized-steel fasteners.

B. Nails, Brads, and Staples: ASTM F1667.

C. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

D. Post-Installed Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on as appropriate for the substrate.

2.6 MISCELLANEOUS MATERIALS

A. Adhesives for Gluing Furring and Sleepers to Concrete or Masonry: Formulation complying with ASTM D3498 that is approved for use indicated by adhesive manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Framing Standard: Comply with AF&PA's WCD 1, "Details for Conventional Wood Frame Construction," unless otherwise indicated.

B. Set work to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry accurately to other construction. Locate furring, nailers, blocking, and similar supports to comply with requirements for attaching other construction.

C. Install plywood backing panels by fastening to studs; coordinate locations with utilities requiring backing panels. Install fire-retardant-treated plywood backing panels with classification marking of testing agency exposed to view.

D. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.
1. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16 inches **(**406 mm**)** o.c.

E. Provide fire blocking in furred spaces, stud spaces, and other concealed cavities as indicated and as follows:
1. Fire block furred spaces of walls, at each floor level, at ceiling, and at not more than 96 inches **(**2438 mm**)** o.c. with solid wood blocking or noncombustible materials accurately fitted to close furred spaces.
2. Fire block concealed spaces of wood-framed walls and partitions at each floor level, at ceiling line of top story, and at not more than 96 inches **(**2438 mm**)** o.c. Where fire blocking is not inherent in framing system used, provide closely fitted solid wood blocks of same width as framing members and 2-inch nominal **(**38-mm actual**)** thickness.
3. Fire block concealed spaces between floor sleepers with same material as sleepers to limit concealed spaces to not more than 100 sq. ft. **(**9.3 sq. m**)** and to solidly fill space below partitions.
4. Fire block concealed spaces behind combustible cornices and exterior trim at not more than 20 feet **(**6 m**)** o.c.

F. Sort and select lumber so that natural characteristics do not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.

G. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.
1. Use inorganic boron for items that are continuously protected from liquid water.
2. Use copper naphthenate for items not continuously protected from liquid water.

H. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.

I. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
1. Table 2304.10.1, "Fastening Schedule," in ICC's International Building Code (IBC).

2. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings.
3. ICC-ES evaluation report for fastener.

J. Securely attach roofing nailers to substrates by anchoring and fastening to withstand bending, shear, or other stresses imparted by Project wind loads and fastener-resistance loads as designed in accordance with ASCE/SEI 7.

K. Use steel common nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood. Drive nails snug but do not countersink nail heads unless otherwise indicated.

3.2 INSTALLATION OF WOOD BLOCKING AND NAILERS

A. Install where indicated and where required for attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.

B. Attach wood blocking to substrates to support applied loading. Recess bolts and nuts flush with surfaces unless otherwise indicated.

C. Attach wood roofing nailers securely to substrate to resist the designed outward and upward wind loads indicated on Drawings and in accordance with ANSI/SPRI ED-1, Tables A6 and A7.

D. Provide permanent grounds of dressed, pressure-preservative-treated, key-beveled lumber not less than 1-1/2 inches **(**38 mm**)** wide and of thickness required to bring face of ground to exact thickness of finish material. Remove temporary grounds when no longer required.

3.3 INSTALLATION OF WOOD FURRING

A. Install level and plumb with closure strips at edges and openings. Shim with wood as required for tolerance of finish work.

B. Furring to Receive Plywood or Hardboard Paneling: Install 1-by-3-inch nominal- **(**19-by-63-mm actual-**)** size furring horizontally at 24 inches **(**610 mm**)** o.c.

C. Furring to Receive Gypsum Board or Plaster Lath: Install 1-by-2-inch nominal- **(**19-by-38-mm actual-**)** size furring vertically at 16 inches **(**406 mm**)** o.c.

END OF SECTION

SECTION 070150 - CUTTING, PATCHING AND REPAIRING OF EXISTING ROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Partial roof membrane tear-off for installation of new roof mounted equipment, patch and repair.
   2. Replacement of base flashings.

B. Related Requirements:
   1. Section 017300 "Execution" for general requirements regarding cutting and patching
   2. Section 076200 "Sheet Metal Flashing and Trim" for additional roofing requirements for performance of this Section.

1.2 MATERIALS OWNERSHIP

A. Except for items or materials indicated to be reused, reinstalled, or otherwise indicated to remain Owner's property, demolished materials shall become Contractor's property and shall be removed from Project site.

1.3 DEFINITIONS

A. Roofing Terminology: Refer to ASTM D 1079 and glossary in NRCA's "The NRCA Roofing and Waterproofing Manual" for definition of terms related to roofing work in this Section.

B. Existing Membrane Roofing System: SBS-modified bituminous roofing membrane, roof insulation, surfacing, and components and accessories between deck and roofing membrane.

C. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and reinstalled.

D. Existing to Remain: Existing items of construction that are not indicated to be removed.

1.4 ACTION SUBMITTALS

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

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Installer of new membrane roofing system.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning membrane roofing removal. Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Provide the following upon request:
   1. Qualification Data: For Installer.
   2. Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including exterior and interior finish surfaces, that might be misconstrued as having been damaged by reroofing operations. Submit before Work begins.
   3. Landfill Records: Indicate receipt and acceptance of hazardous wastes, such as asbestos-containing material, by a landfill facility licensed to accept hazardous wastes.

1.6 PROJECT CONDITIONS

A. Owner will occupy portions of building immediately below reroofing area. Conduct reroofing so Owner's operations will not be disrupted. Provide Owner with not less than 72 hours' notice of activities that may affect Owner's operations.
   1. Coordinate work activities daily with Owner so Owner can place protective dust or water leakage covers over sensitive equipment or furnishings, shut down HVAC and fire-alarm or -detection equipment if needed, and evacuate occupants from below the work area.
   2. Before working over structurally impaired areas of deck, notify Owner to evacuate occupants from below the affected area. Verify that occupants below the work area have been evacuated before proceeding with work over the impaired deck area.

B. Protect building to be reroofed, adjacent buildings, walkways, site improvements, exterior plantings, and landscaping from damage or soiling from reroofing operations.

C. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities.

D. Conditions existing at time of inspection for bidding will be maintained by Owner as far as practical.

E. Limit construction loads on roof to rooftop equipment wheel loads and for uniformly distributed loads.

F. Weather Limitations: Proceed with reroofing preparation only when existing and forecasted weather conditions permit Work to proceed without water entering existing roofing system or building.

G. Hazardous Materials: It is not expected that hazardous materials such as asbestos-containing materials will be encountered in the Work.
1. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.

1.7 EXISTING WARRANTIES

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during reroofing, by methods and with materials so as not to void existing roofing system warranty. Notify warrantor before proceeding.

B. Notify warrantor of existing roofing system on completion of reroofing, and obtain documentation verifying that existing roofing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

PART 2 - PRODUCTS

2.1 ROOFING AND PATCHING MATERIALS

A. Roof Materials: Use infill and replacement materials matching existing membrane roofing system materials unless otherwise indicated. Use installation materials and methods to match existing assemblies.

B. Due to proximity to air intake vents on roof and possible infiltration of noxious fumes into the hospital spaces, do not use products that require hot asphalt for installation. Provide compatible modified bituminous roof membrane as patching materials.
1. SBS-Modified Bituminous Membrane Roofing:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Siplast, Inc.
      2) Soprema.
2. Roofing Membrane Sheet: ASTM D 6163, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers); smooth surfaced; suitable for application method specified.
3. Smooth-Surfaced Roofing Membrane Cap Sheet: ASTM D 6163, Grade S, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers); smooth surfaced; suitable for application method specified.
4. Granule-Surface Roofing Membrane Cap Sheet: ASTM D 6163, Grade G, Type I or II, SBS-modified asphalt sheet (reinforced with glass fibers); granular surfaced; suitable for application method specified, and as follows:
   a. Granule Color: Match existing.

C.

2.2 AUXILIARY REROOFING MATERIALS

A. General: Auxiliary reroofing preparation materials recommended by roofing system manufacturer for intended use and compatible with components of new membrane roofing system.

B. Base Sheet Fasteners: Capped head, factory-coated steel fasteners, listed in FM Approval's "Approval Guide."

C. Metal Flashing Sheet: Metal flashing sheet is specified in Section 076200 "Sheet Metal Flashing and Trim."

D. Liquid Flashing and Membrane: Polymethyl Methacrylate Flashing (PMMA)
1. Basis-of-Design Manufacturers: Subject to compliance with requirements, provide listed products by the following manufacturer:
   a. Soprema, or comparable by one of the following:
      1) Johns Manville
      2) Siplast
2. Basis-of-Design Products:

a. Soprema ALSAN RS 230 FLASH: Rapid curing, polymethyl methacrylate (PMMA) liquid resin with an embedded polyester reinforcement fabric used for monolithic waterproofing flashing membranes.
b. Soprema ALSAN RS DETAILER: Micro-fiber enhanced, rapid curing, polymethyl methacrylate (PMMA) paste resin used for flashing difficult penetrations where a resin/fleece/resin application is not practical.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine existing roofing system in the presence of the roofer and the technical field representative of the roofing system manufacturer to determine existing roofing assembly, including, but not limited to, quantity of plies, coverboards, insulation, base flashings, and attachment methods. Make test cuts as required. Final determination of roof patching assembly requirements will be based on preconstruction examination of the existing conditions. Patch areas where test cuts are performed until patches can be permanently repaired.

3.2 PREPARATION

A. Coordinate with Owner to shut down air-intake equipment in the vicinity of the Work. Cover air-intake louvers before proceeding with reroofing work that could affect indoor air quality or activate smoke detectors in the ductwork.

B. During removal operations, have sufficient and suitable materials on-site to facilitate rapid installation of temporary protection in the event of unexpected rain.

C. Maintain roof drains in functioning condition to ensure roof drainage at end of each workday. Prevent debris from entering or blocking roof drains and conductors. Use roof-drain plugs specifically designed for this purpose. Remove roof-drain plugs at end of each workday, when no work is taking place, or when rain is forecast.
1. If roof drains are temporarily blocked or unserviceable due to roofing system removal or partial installation of new membrane roofing system, provide alternative drainage method to remove water and eliminate ponding. Do not permit water to enter into or under existing membrane roofing system components that are to remain.

D. Verify that rooftop utilities and service piping have been shut off before beginning the Work.

3.3 DECK PREPARATION

A. If deck surface is not suitable for receiving new roofing or if structural integrity of deck is suspect, immediately notify Architect. Do not proceed with installation until directed by Architect.

3.4 ROOF PATCH INSTALLATION

A. Fill in the tear-off areas to match existing membrane roofing system construction.
1. Install infill materials in accordance with manufacturer's instructions.
2. Install new roofing membrane patch over roof infill area.

3.5 EXISTING BASE FLASHINGS

A. Remove existing base flashings that cannot be reused around parapets, curbs, walls, and penetrations.
1. Clean substrates of contaminants such as asphalt, sheet materials, dirt, and debris.

B. Do not damage metal counterflashings that are to remain. Replace metal counterflashings damaged during removal with counterflashings of same metal, weight or thickness, and finish as specified in Section 076200 "Sheet Metal Flashing and Trim."

C. Inspect parapet sheathing for deterioration and damage. If parapet sheathing has deteriorated, immediately notify Architect.

3.6 LIQUID FLASHING MEMBRANE INSTALLATION

A. General: Apply reinforced liquid flashing at non-round penetrations and where indicated.in accordance with manufacturer's written instructions.
1. Refer to manufacturer's detail drawings, product data sheets and published general requirements for application rates and specific installation instructions.

B. Primer: Apply the appropriate specified primer to dry, compatible substrates as required to enhance adhesion of new specified waterproofing materials in accordance with manufacturer's instructions.

1. Allow primer to fully cure before membrane application.

C. Flashing:
1. Refer to manufacturer's detail drawings, product data sheets and published general requirements for application rates and specific installation instructions.
2. Provide a minimum vertical height of 8 inches for all flashing terminations wherever possible. Flashing height shall be at least as high as the potential water level that could be reached as a result of a deluging rain and/or poor slope.
3. Flashing shall be terminated as required by the manufacturer.
4. Install all flashing membranes before installing field membranes.

3.7 DISPOSAL

A. Collect demolished materials and place in containers. Promptly dispose of demolished materials. Do not allow demolished materials to accumulate on-site.
1. Storage or sale of demolished items or materials on-site is not permitted.

B. Transport and legally dispose of demolished materials off Owner's property.

END OF SECTION

SECTION 076200 - SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Custom flashing and trim fabrications, made from the following:
   1. Sheet metal materials.
   2. Underlayment.
   3. Miscellaneous materials.

B. Related Requirements:
   1. Section 061000 "Rough Carpentry" for wood nailers, curbs, and blocking.
   2. Section 070150 "Cutting, Patching and Repairing of Existing Roofing".

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review construction schedule. Verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
   2. Review special roof details, roof drainage, roof-penetration flashing, equipment curbs, and condition of other construction that affect sheet metal flashing and trim.
   3. Review requirements for insurance and certificates if applicable.
   4. Review sheet metal flashing observation and repair procedures after flashing installation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For sheet metal flashing and trim.
   1. Plans, elevations, sections, and attachment details.
   2. Fabrication and installation layouts, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled Work.
   3. Identification of material, thickness, weight, and finish for each item and location in Project.
   4. Details for forming, including profiles, shapes, seams, and dimensions.
   5. Details for joining, supporting, and securing, including layout and spacing of fasteners, cleats, clips, and other attachments. Include pattern of seams.
   6. Details of termination points and assemblies.
   7. Details of expansion joints and expansion-joint covers, including showing direction of expansion and contraction from fixed points.
   8. Details of roof-penetration flashing.
   9. Details of edge conditions, including eaves, ridges, valleys, rakes, crickets, flashings, and counterflashings.
   10. Details of special conditions.
   11. Details of connections to adjoining work.
   12. Formed flashing and trim at scale of not less than 1-1/2 inches per 12 inches (1:10).

C. Samples for Verification: Actual sample of finished products for each type of exposed finish for sheet metal and other metal accessories.
   1. Sheet Metal Flashing and Trim: Manufacturers' standard size. Include finished seam with required profile. Include fasteners, cleats, clips, closures, and other attachments.
   2. Anodized Aluminum Samples: Samples to show full range to be expected for each color required.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For sheet metal flashing and trim, and its accessories.

1.5 QUALITY ASSURANCE

A. Fabricator Qualifications: Entity that employs skilled workers who custom fabricate sheet metal flashing and trim similar to that required for this Project and whose products have a record of successful in-service performance.

B. Installer Qualifications: Entity that employs a supervisor who is an NRCA ProCertified Roofing Foreman or installers who are NRCA ProCertified Architectural Metal Flashings and Accessories Installers.

C. Provide the following upon request:
   1. Product Test Reports: For each product, for tests performed by a qualified testing agency.

2. Qualification Statements: For fabricator.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage.
   1. Store sheet metal flashing and trim materials away from uncured concrete and masonry.
   2. Protect stored sheet metal flashing and trim from contact with water.

B. Protect strippable protective covering on sheet metal flashing and trim from exposure to sunlight and high humidity, except to extent necessary for period of sheet metal flashing and trim installation.

1.7 COORDINATION

A. Coordinate sheet metal flashing and trim layout and seams with sizes and locations of penetrations to be flashed, and joints and seams in adjacent materials.

B. Coordinate sheet metal flashing and trim installation with adjoining roofing and wall materials, joints, and seams to provide leakproof, secure, and noncorrosive installation.

1.8 WARRANTY

A. Special Warranty on Finishes: Manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.
   1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
      a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
      b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
      c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
   2. Finish Warranty Period: [**20**] [**10**] <**Insert number**> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sheet metal flashing and trim assemblies, including cleats, anchors, and fasteners, are to withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim are not to rattle, leak, or loosen, and are to remain watertight.

B. Sheet Metal Standard for Flashing and Trim: Comply with NRCA's "The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing" requirements for dimensions and profiles shown unless more stringent requirements are indicated.

C. SPRI Wind Design Standard: Manufacture and install roof edge flashings and copings tested in accordance with ANSI/SPRI/FM 4435/ES-1 and capable of resisting the following design pressure:
   1. Design Pressure: As indicated on Drawings.

D. FM Approvals Listing: Manufacture and install roof edge flashings and copings that comply with requirements in FM Approvals 4471 as part of a roofing system and that are listed in FM Approvals' "Approval Guide" and approved for windstorm classification, [**Class 1A-60**] [**Class 1A-75**] [**Class 1A-90**] [**Class 1A-105**] [**Class 1A-120**] <**Insert class**>. Identify materials with name of fabricator and design approved by FM Approvals.

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 SHEET METAL MATERIALS

A. Protect mechanical and other finishes on exposed surfaces from damage by applying strippable, temporary protective film before shipping.

B. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with minimum ASTM A653/A653M, G90 **(**Z275**)** coating designation, or aluminum-zinc alloy-coated steel sheet complying with minimum ASTM A792/A792M, Class AZ50 **(**Class AZM150**)** coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A755/A755M.
   1. Nominal Thickness: 0.022 inch **(**0.56 mm**)** 0.028 inch **(**0.71 mm**)** 0.034 inch **(**0.86 mm**)** 0.040 inch **(**1.02 mm**)** 0.052 inch **(**1.32 mm**)**.
   2. Surface: Smooth, flat.

C. Aluminum Sheet: Coil-coated sheet, ASTM B209/B209M, alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.
   1. Thickness: 0.050 inch **(**1.27 mm**)** 0.063 inch **(**1.60 mm**)**.
   2. Surface: Smooth, flat.
   3. Clear Anodic Finish, Coil Coated: AAMA 611, AA-M12C22A41, Class I, 0.018 mm AA-M12C22A31, Class II, 0.010 mm or thicker.
   4. As-Milled Finish: Mill One-side bright mill Standard one-side bright Standard two-side bright.

D. Stainless Steel Sheet: ASTM A240/A240M, Type 304 Type 316, dead soft, fully annealed.
   1. Nominal Thickness: 0.0313 inch **(**0.795 mm**)** 0.0375 inch **(**0.952 mm**)** 0.0500 inch **(**1.270 mm**)**.
   2. Surface: Smooth, flat.
   3. Exterior Finish: ASTM A480/A480M, No. 2B (bright, cold rolled) ASTM A480/A480M, No. 2D (dull, cold rolled) ASTM A480/A480M No. 4 Insert finish.
      a. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
      b. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
         1) Run grain of directional finishes with long dimension of each piece.
         2) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2.3 UNDERLAYMENT

A. Synthetic Underlayment: Laminated or reinforced, woven polyethylene or polypropylene, synthetic roofing underlayment; bitumen free; slip resistant; suitable for high temperatures over 220 deg F (111 deg C); and complying with physical requirements of ASTM D226/D226M for Type I and Type II felts.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Atlas Molded Products, a division of Atlas Roofing Corporation.
      b. Intertape Polymer Group.
      c. Kirsch Building Products.
      d. SDP Advanced Polymer Products Inc.

B. Self-Adhering, High-Temperature Sheet Underlayment: Provide self-adhering, cold-applied, sheet underlayment, a minimum of 30 mils **(**0.76 mm**)** thick, specifically designed to withstand high metal temperatures beneath metal roofing. Provide primer when recommended by underlayment manufacturer.
   1. Thermal Stability: Stable after testing at 240 deg F (116 deg C); ASTM D1970/D1970M.
   2. Low-Temperature Flexibility: Passes after testing at minus 20 deg F **(**minus 29 deg C**)** or lower; ASTM D1970/D1970M.
   3. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ATAS International, Inc.
      b. Carlisle WIP Products; a brand of Carlisle Construction Materials.
      c. GCP Applied Technologies Inc.
      d. Henry Company; a Carlisle company.
      e. Owens Corning.
      f. Polyglass U.S.A., Inc.
      g. Protecto Wrap Company.
      h. SDP Advanced Polymer Products Inc.

C. Felt: ASTM D226**/**D226M, Type II (No. 30), asphalt-saturated organic felt; nonperforated.

D. Slip Sheet: Rosin-sized building paper, 3 lb/100 sq. ft. (0.16 kg/sq. m) minimum, of type required for application.

2.4 MISCELLANEOUS MATERIALS

A. Provide materials and types of fasteners[**, solder**], protective coatings, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and as recommended by manufacturer of primary sheet metal[**or manufactured item**] unless otherwise indicated.

B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal[**or manufactured item**].
   1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
      a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating. Provide metal-backed EPDM or PVC sealing washers under heads of exposed fasteners bearing on weather side of metal.

b. Blind Fasteners: High-strength aluminum or stainless steel rivets suitable for metal being fastened.
c. Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.

2. Fasteners for Zinc-Coated (Galvanized) or Aluminum-Zinc Alloy-Coated Steel Sheet: Series 300 stainless steel or hot-dip galvanized steel in accordance with ASTM A153/A153M or ASTM F2329/F2329M.
3. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
4. Fasteners for Stainless Steel Sheet: Series 300 stainless steel.
5. Fasteners for Copper, Zinc-Tin Alloy-Coated Copper, or Copper-Clad Stainless Steel Sheet: Copper, hardware bronze or passivated Series 300 stainless steel.
6. Fasteners for Zinc Sheet: Series 300 stainless steel or hot-dip galvanized steel in accordance with ASTM A153/A153M or ASTM F2329/F2329M.

C. Solder:
1. For Zinc-Coated (Galvanized) Steel: ASTM B32, Grade Sn50, 50 percent tin and 50 percent lead or Grade Sn60, 60 percent tin and 40 percent lead with maximum lead content of 0.2 percent.
2. For Stainless Steel: ASTM B32, Grade Sn60, with acid flux of type recommended by stainless steel sheet manufacturer.

D. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch **(**13 mm**)** wide and 1/8 inch **(**3 mm**)** thick.

E. Elastomeric Sealant: ASTM C920, elastomeric polyurethane polysulfide silicone polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

F. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.

G. Epoxy Seam Sealer: Two-part, noncorrosive, aluminum seam-cementing compound, recommended by aluminum manufacturer for exterior nonmoving joints, including riveted joints.

H. Bituminous Coating: Cold-applied asphalt emulsion in accordance with ASTM D1187/D1187M.

I. Asphalt Roofing Cement: ASTM D4586/D4586M, asbestos free, of consistency required for application.

J. Reglets: Units of type, material, and profile required, formed to provide secure interlocking of separate reglet and counterflashing pieces, and compatible with flashing indicated with factory-mitered and -welded corners and junctions with interlocking counterflashing on exterior face, of same metal as reglet.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Cheney Flashing Company.
b. Fry Reglet Corporation.
c. Heckmann Building Products, Inc.
d. Hohmann & Barnard, Inc.
e. Keystone Flashing Company, Inc.
f. Metal-Era, Inc.
g. OMG Roofing Products; a Division of OMG, Inc.
2. Material: Galvanized steel, 0.022 inch **(**0.56 mm**)** thick Aluminum, 0.024 inch **(**0.61 mm**)** thick Stainless steel, 0.0188 inch **(**0.477 mm**)** thick Copper, 16 oz./sq. ft. (0.55 mm thick).
3. Surface-Mounted Type: Provide with slotted holes for fastening to substrate, with neoprene or other suitable weatherproofing washers, and with channel for sealant at top edge.
4. Stucco Type: Provide with upturned fastening flange and extension leg of length to match thickness of applied finish materials.
5. Concrete Type: Provide temporary closure tape to keep reglet free of concrete materials, special fasteners for attaching reglet to concrete forms, and guides to ensure alignment of reglet section ends.
6. Masonry Type: Provide with offset top flange for embedment in masonry mortar joint.
7. Accessories:
a. Flexible-Flashing Retainer: Provide resilient plastic or rubber accessory to secure flexible flashing in reglet where clearance does not permit use of standard metal counterflashing or where Drawings show reglet without metal counterflashing.
b. Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of counterflashing's lower edge.

8. Finish: Mill With manufacturer's standard color coating Insert finish.

2.5 FABRICATION, GENERAL

A. Custom fabricate sheet metal flashing and trim to comply with details indicated and recommendations in cited sheet metal standard that apply to design, dimensions, geometry, metal thickness, and other characteristics of item required.
1. Fabricate sheet metal flashing and trim in shop to greatest extent possible.
2. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
3. Verify shapes and dimensions of surfaces to be covered and obtain field measurements for accurate fit before shop fabrication.
4. Form sheet metal flashing and trim to fit substrates without excessive oil-canning, buckling, and tool marks; true to line, levels, and slopes; and with exposed edges folded back to form hems.
5. Conceal fasteners and expansion provisions where possible. Do not use exposed fasteners on faces exposed to view.

B. Fabrication Tolerances:
1. Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 ft. (6 mm in 6 m) on slope and location lines indicated on Drawings and within 1/8-inch **(**3-mm**)** offset of adjoining faces and of alignment of matching profiles.
2. Fabricate sheet metal flashing and trim that is capable of installation to tolerances specified.

C. Expansion Provisions: Form metal for thermal expansion of exposed flashing and trim.
1. Form expansion joints of intermeshing hooked flanges, not less than 1 inch **(**25 mm**)** deep, filled with butyl sealant concealed within joints.
2. Use lapped expansion joints only where indicated on Drawings.

D. Sealant Joints: Where movable, nonexpansion-type joints are required, form metal in accordance with cited sheet metal standard to provide for proper installation of elastomeric sealant.

E. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

F. Fabricate cleats and attachment devices of sizes as recommended by cited sheet metal standard for application, but not less than thickness of metal being secured.

G. Seams:
1. Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use. Rivet joints where necessary for strength.
2. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints where necessary for strength.

H. Do not use graphite pencils to mark metal surfaces.

I. Cap Flashing/Counterflashing Fabrication - General: Provide two-piece metal cap flashings, consisting of an upper receiver portion and a lower portion extending over the composition flashing, unless otherwise specified or indicated.
1. Cap Flashing/Counterflashing Fabrication - Two Piece
   a. Fabricate the receiver portion with outer edge formed into a double fold turned down one inch **(**25 mm**)**, unless otherwise indicated, and as follows:
      1) At new masonry walls, extend the receiver portion into the wall as indicated, terminated with 1/4 inch **(**6 mm**)** upstand edge, unless indicated to be higher.
      2) At walls faced with metal siding or pre-formed metal panels, extend the receiver portion into the wall as indicated, and terminated with edge folded over support.
      3) At concrete and existing masonry walls, extend the receiver portion into an embedded reglet, sawcut in the profile indicated for a reglet, or form the receiver portion to retain sealant as indicated, using a 3/16 by one inch **(**5 by 25 mm**)** stainless steel clamping bar.
      4) At parapet, extend the receiver portion over wood blocking as indicated.
      5) At parapet, extend the receiver portion as indicated and form the upper edge to engage the double fold of coping

b. Form the upper edge of the lower portion of metal cap flashing to engage in the double fold of receiver portion, bent to provide spring action against the base flashing, fold the lower edge folded back 1/2 inch (13 mm) and lap composition base flashing not less than 4 inches (100 mm).

c. Lap ends of each length of both portions of metal cap flashing not less than 3 inches (75 mm). Weld or solder corner joints. Return ends at roof edge into reglet or wall.

2. Cap Flashing/Counterflashing Fabrication - One Piece: Provide one-piece cap flashing at roof curbs, with top edge formed to retain metal joint sealant and bottom edge folded 1/2 inch (13 mm) to provide drip.

2.6 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

A. Roof-Penetration Flashing: Fabricate from the following materials:
1. Galvanized Steel: 0.028 inch (0.71 mm) thick.
2. Aluminum-Zinc Alloy-Coated Steel: 0.028 inch (0.71 mm) thick.
3. Stainless Steel: 0.0188 inch (0.477 mm) thick.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, substrates, and other conditions affecting performance of the Work.
1. Verify compliance with requirements for installation tolerances of substrates.
2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
3. Verify that air- or water-resistant barriers have been installed over substrate to prevent air infiltration or water penetration.

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

3.2 INSTALLATION OF UNDERLAYMENT

A. Synthetic Underlayment: Install synthetic underlayment, wrinkle free, in accordance with manufacturers' written instructions, and using adhesive where possible to minimize use of mechanical fasteners under sheet metal.
1. Lap horizontal joints not less than 4 inches (100 mm).
2. Lap end joints not less than 12 inches (300 mm).

B. Self-Adhering, High-Temperature Sheet Underlayment:
1. Install self-adhering, high-temperature sheet underlayment; wrinkle free.
2. Prime substrate if recommended by underlayment manufacturer.
3. Comply with temperature restrictions of underlayment manufacturer for installation; use primer for installing underlayment at low temperatures.
4. Apply in shingle fashion to shed water, with end laps of not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses.
5. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps and edges with roller.
6. Roll laps and edges with roller.
7. Cover underlayment within 14 days.

C. Felt Underlayment: Install felt underlayment, wrinkle free, using adhesive to minimize use of mechanical fasteners under sheet metal flashing and trim.
1. Install in shingle fashion to shed water.
2. Lap joints not less than 2 inches (50 mm).

3.3 INSTALLATION OF SHEET METAL FLASHING AND TRIM, GENERAL

A. Install sheet metal flashing and trim to comply with details indicated and recommendations of cited sheet metal standard that apply to installation characteristics required unless otherwise indicated on Drawings.
1. Install fasteners, solder, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
2. Install sheet metal flashing and trim true to line, levels, and slopes. Provide uniform, neat seams with minimum exposure of solder welds sealant.
3. Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement.
4. Install sheet metal flashing and trim to fit substrates and to result in watertight performance.
5. Install continuous cleats with fasteners spaced not more than 12 inches (300 mm) o.c.

6. Space individual cleats not more than 12 inches **(**300 mm**)** apart. Attach each cleat with at least two fasteners. Bend tabs over fasteners.
7. Install exposed sheet metal flashing and trim with limited oil-canning, and free of buckling and tool marks.
8. Do not field cut sheet metal flashing and trim by torch.
9. Do not use graphite pencils to mark metal surfaces.

B. Metal Protection: Where dissimilar metals contact each other, or where metal contacts pressure-treated wood or other corrosive substrates, protect against galvanic action or corrosion by painting contact surfaces with bituminous coating or by other permanent separation as recommended by sheet metal manufacturer or cited sheet metal standard.
1. Coat concealed side of uncoated-aluminum and stainless steel sheet metal flashing and trim with bituminous coating where flashing and trim contact wood, ferrous metal, or cementitious construction.
2. Underlayment: Where installing sheet metal flashing and trim directly on cementitious or wood substrates, install underlayment and cover with slip sheet.

C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim.

D. Fasteners: Use fastener sizes that penetrate substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance.

E. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.

F. Seal joints as required for watertight construction.
1. Use sealant-filled joints unless otherwise indicated.
a. Embed hooked flanges of joint members not less than 1 inch **(**25 mm**)** into sealant.
b. Form joints to completely conceal sealant.
c. When ambient temperature at time of installation is between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement each way.
d. Adjust setting proportionately for installation at higher ambient temperatures.
1) Do not install sealant-type joints at temperatures below 40 deg F (4 deg C).
2. Prepare joints and apply sealants to comply with requirements in Section 079200 "Joint Sealants."

G. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter.
1. Pretin edges of sheets with solder to width of 1-1/2 inches **(**38 mm**)**; however, reduce pretinning where pretinned surface would show in completed Work.
2. Do not solder metallic-coated steel and aluminum sheet.
3. Do not use torches for soldering.
4. Heat surfaces to receive solder, and flow solder into joint.
a. Fill joint completely.
b. Completely remove flux and spatter from exposed surfaces.
5. Stainless Steel Soldering:
a. Tin edges of uncoated sheets, using solder for stainless steel and acid flux.
b. Promptly remove acid-flux residue from metal after tinning and soldering.
c. Comply with solder manufacturer's recommended methods for cleaning and neutralization.

H. Rivets: Rivet joints in [**uncoated aluminum**] [**zinc**] where necessary for strength.

3.4 INSTALLATION TOLERANCES

A. Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 ft. (6 mm in 6 m) on slope and location lines indicated on Drawings and within 1/8-inch **(**3-mm**)** offset of adjoining faces and of alignment of matching profiles.

3.5 CLEANING

A. Clean and neutralize flux materials. Clean off excess solder.

B. Clean off excess sealants.

3.6 PROTECTION

A. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions.

B. On completion of sheet metal flashing and trim installation, remove unused materials and clean finished surfaces as recommended in writing by sheet metal flashing and trim manufacturer.

C. Maintain sheet metal flashing and trim in clean condition during construction.

D. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures, as determined by Architect.

END OF SECTION

SECTION 078413 - PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Penetration firestopping systems.
2. Penetrations in fire-resistance-rated walls.
3. Penetrations in horizontal assemblies.
4. Penetrations in smoke barriers.
5. Exposed penetration firestopping systems.

B. Related Requirements:
1. Section 078443 "Joint Firestopping" for joints in or between fire-resistance-rated construction, at exterior curtain-wall/floor intersections, and in smoke barriers.
2. Section 079200 "Joint Sealants" for non-fire-resistance-rated joint sealants.
3. Section 079219 "Acoustical Joint Sealants" for sealing joints in sound-rated construction.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Unlisted Firestopping Systems: Obtain an Engineering Judgment (EJ) from firestopping manufacturer where no UL, FM Approvals, or other listed assembly is available for particular firestop configuration. Follow International Firestop Council (IFC) recommended guidelines for evaluating firestopping systems in EJs.

C. Product Schedule: For each penetration firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing and inspecting agency.
1. Engineering Judgments: Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular penetration firestopping system, submit illustration, with modifications marked, approved by penetration firestopping system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly developed in accordance with current International Firestop Council (IFC) guidelines. Obtain approval of authorities having jurisdiction prior to submittal.

1.4 CLOSEOUT SUBMITTALS

A. Installer Certificates: From Installer indicating that penetration firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Entity that has been approved by FM Approvals in accordance with FM Approvals 4991 or been evaluated by UL and found to comply with UL's "UL Solutions Qualified Firestop Contractor Program."

B. Installer Qualifications: A firm experienced in installing penetration firestopping similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance. Qualifications include having the necessary experience, staff, and training to install manufacturer's products per specified requirements. Manufacturer's willingness to sell its penetration firestopping products to Contractor or to Installer engaged by Contractor does not in itself confer qualification on buyer.

C. Installation Responsibility: Assign installation of penetration firestopping and fire-resistive joint systems to a single qualified firestop contractor.

D. Manufacturer Qualifications: Entity that has received UL's "Firestop Movement Certification," which demonstrates that manufacturer's firestopping products designated with M-Ratings are based on exposure to cyclic movement and UL 1479 fire test evaluation when tested in accordance with ASTM E3037.

E. Provide the following upon request:
1. Qualification Data: For Installer.

2. Listed System Designs: For each penetration firestopping system, for tests performed by a qualified testing agency.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Do not install penetration firestopping systems when ambient or substrate temperatures are outside limits permitted by penetration firestopping system manufacturers or when substrates are wet because of rain, frost, condensation, or other causes.

B. Install and cure penetration firestopping system materials in accordance with manufacturer's written instructions using natural means of ventilations or, where this is inadequate, forced-air circulation.

1.7 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that penetration firestopping systems can be accessed and installed in accordance with specified firestopping system design.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate penetration firestopping systems.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain penetration firestopping systems for each type of opening indicated from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics:
1. A qualified testing agency, acceptable to authorities having jurisdiction, will perform penetration firestopping system tests.
2. Test in accordance with testing standards referenced in "Penetration Firestopping Systems" Article. Provide rated systems complying with the following requirements:
   a. Penetration firestopping systems installed with products bearing the classification marking of a qualified testing agency.
      1) UL in its online directory "Product iQ."
      2) Intertek Group in its "Directory of Building Products."
      3) FM Approvals in its "Approval Guide."

B. Provide components for each penetration firestopping system that, upon curing, do not re-emulsify, dissolve, leach, break down, or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water, or other forms of moisture characteristic during and after construction.

C. Provide components for each penetration firestopping system that do not contain ethylene glycol.

D. Provide components for each penetration firestopping system that are sufficiently flexible to accommodate movement, such as pipe vibration, water hammer, thermal expansion, and other normal building movement without damage.

E. Provide components for each penetration firestopping system that are appropriately tested for the thickness and type of insulation utilized.

2.3 PENETRATION FIRESTOPPING SYSTEMS

A. Penetration Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems must be compatible with one another, with the substrates forming openings, and with penetrating items if any.
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. 3M Building and Construction.
   b. Balco; a CSW Industrials Company.
   c. Everkem Diversified Products, Inc.
   d. FireShield; Fire Rated Solutions LLC.
   e. Grabber Construction Products, Inc.
   f. Hilti, Inc.
   g. Holdrite; a division of Reliance Worldwide Corporation.
   h. International Fireproof Technology Inc.
   i. NUCO Inc.

j. Passive Fire Protection Partners.
k. Roxtec Inc.
l. Specified Technologies Inc.
m. STC Sound Control.
n. Tremco Incorporated.
o. Unique Fire Stop Products.

B. Penetrations in Fire-Resistance-Rated Walls: Penetration firestopping systems with ratings determined in accordance with ASTM E814 or UL 1479.
1. F-Rating: Not less than the fire-resistance rating of the wall penetrated.
2. Membrane Penetrations: Install recessed fixtures such that the required fire resistance will not be reduced.
3. M-Rating: Provide penetration firestopping systems meeting specified F-Rating after being tested in accordance with ASTM E3037.

C. Penetrations in Horizontal Assemblies: Penetration firestopping systems with ratings determined in accordance with ASTM E814 or UL 1479.
1. F-Rating: At least one hour, but not less than the fire-resistance rating of the floor penetrated.
2. T-Rating: At least one hour, but not less than the fire-resistance rating of the floor. The following floor penetrations do not require a T-rating:
a. Those within the cavity of a wall.
b. Floor, tub, or shower drains within a concealed space.
c. 4-inch **(**200-mm**)** or smaller metal conduit penetrating directly into metal-enclosed electrical switchgear.
3. W-Rating: Provide penetration firestopping systems with a Class 1 W-rating in accordance with UL 1479.
4. M-Rating: Provide penetration firestopping systems meeting specified F-Rating, T-Rating, W-Rating after being tested in accordance with ASTM E3037.

D. Penetrations in Smoke Barriers: Penetration firestopping systems with ratings determined in accordance with UL 1479.
1. L-Rating: Not exceeding 5.0 cfm/sq. ft. **(**0.025 cu. m/s per sq. m**)** of penetration opening and no more than 50-cfm **(**0.024-cu. m/s**)** cumulative total for any 100 sq. ft. **(**9.3 sq. m**)** at both ambient and elevated temperatures.
2. M-Rating: Provide penetration firestopping systems meeting specified L-Rating after being tested in accordance with ASTM E3037.

E. Exposed Penetration Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, when tested in accordance with ASTM E84 or UL 723.

2.4 ACCESSORIES

A. Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping system manufacturer and approved by qualified testing and inspecting agency for conditions indicated, including but not limited to:
1. Permanent forming/damming/backing materials.
2. Substrate primers.
3. Collars.
4. Steel sleeves.

2.5 FILL MATERIALS

A. Cast-in-Place Firestopping Devices: Factory-assembled devices for use in cast-in-place concrete floors and consisting of an outer sleeve lined with an intumescent strip, a flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.

B. Latex Sealants: Single-component latex formulations that do not re-emulsify after cure during exposure to moisture.

C. Firestopping Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.

D. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced intumescent elastomeric sheet bonded to galvanized-steel sheet.

E. Intumescent Putties: Nonhardening, water-resistant, intumescent putties containing no solvents or inorganic fibers.

F. Intumescent Wrap Strips: Single-component intumescent elastomeric strips for use around combustible penetrants.

G. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.

H. Pillows/Bags: Compressible, removable, and reusable intumescent pillows encased in fire-retardant polyester or glass-fiber cloth. Where exposed, and when required by a listed system, cover openings with steel-reinforcing wire mesh to protect pillows/bags from being easily removed or dislodged.

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

J. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants.

K. Thermal and Endothermic Wraps: Flexible, insulating, and fire-resistant protective wraps tested and listed for up to 2-hour fire ratings in accordance with ASTM E814 or UL 1479; for protecting membrane penetrations of utility boxes, critical electrical circuits, communications lines, and fuel lines, and for thermal barrier and circuit integrity protection in accordance with ASTM E1725 or UL 1724.

L. Fire-Rated Cable Sleeve Kits: Complete kits designed for new or existing cable penetrations through walls which accept standard accessories.

M. Fire-Rated Cable Pathways: Single or gangable device modules composed of a steel raceway with integral intumescent material and requiring no additional action in the form of plugs, twisting closure, putty, pillows, sealant, or otherwise to achieve fire and air-leakage ratings.
   1. Fire-rated cable pathway devices are the preferred product for data, video, and communications cable penetrations. Install these devices in locations where frequent cable moves, add-ons, and changes will occur. Such devices must be:
      a. Capable of retrofit around existing cables.
      b. Designed so that two or more devices can be ganged together.
      c. Maintenance-free so no action is required to activate the smoke- and fire-sealing mechanism.
   2. Where fire-rated cable pathway devices are not practical, openings within walls and floors designed to accommodate data, video, and communications cabling must be provided with re-enterable products specifically designed for retrofit, such as retrofit devices for cable bundles, firestopping putty, plugs, or pillows.

N. Retrofit Device for Cable Bundles: Factory-made, intumescent, collar-like device for firestopping existing over-filled cable sleeves and capable of being installed around projecting sleeves and cable bundles.

O. Wall-Opening Protective Materials: Intumescent, non-curing putty pads or self-adhesive inserts for protection of electrical switch and receptacle boxes.

P. Fire-Rated HVAC Retaining Angles: Steel angle system with integral intumescent firestopping gasket for use around rectangular steel HVAC ducts without fire dampers.

Q. Firestopping Plugs: Flexible, re-enterable, intumescent, foam-rubber plug for use in blank round openings and cable sleeves.

R. Fire-Rated Cable Grommet: Molded two-piece grommet made of plenum-grade polymer and foam inner core for sealing small cable penetrations in gypsum walls up to 1/2 inch **(**13 mm**)** in diameter.

S. Closet Flange Gasket: Molded, single-component, flexible, intumescent gasket for use beneath a water closet (toilet) flange in floor applications.

2.6 MIXING

A. Penetration Firestopping Materials: For those products requiring mixing before application, comply with penetration firestopping system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.

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

3.2 PREPARATION

A. Surface Cleaning: Before installing penetration firestopping systems, clean out openings in accordance with manufacturer's written instructions and with the following requirements:
   1. Remove foreign materials from substrate surfaces that could interfere with adhesion of penetration firestopping materials.
   2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with penetration firestopping materials. Remove loose particles remaining from cleaning operation.
   3. Remove laitance and form-release agents from concrete.

B. Prime substrates in accordance with penetration firestopping system manufacturer's written installation instructions, using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

3.3 INSTALLATION

A. General: Install penetration firestopping systems in accordance with manufacturer's written installation instructions and published drawings for products and applications.

B. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
   1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not forming permanent components of firestopping.

C. Install fill materials by proven techniques to produce the following results:
   1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items to achieve required fire-resistance ratings.
   2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
   3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 IDENTIFICATION

A. Wall Identification: Permanently label walls containing penetration firestopping systems with the words "FIRE AND/OR SMOKE BARRIER - PROTECT ALL OPENINGS," using lettering not less than 3 inches **(**76 mm**)** high and with minimum 0.375-inch **(**9.5-mm**)** strokes.
   1. Locate in accessible concealed floor, floor-ceiling, or attic space at 15 ft. **(**4.57 m**)** from end of wall and at intervals not exceeding 30 ft. **(**9.14 m**)**.

B. Penetration Identification: Identify each penetration firestopping system with legible metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches **(**150 mm**)** of penetration firestopping system edge so labels are visible to anyone seeking to remove penetrating items or firestopping systems. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:
   1. The words "Warning - Penetration Firestopping - Do Not Disturb. Notify Building Management of Any Damage."
   2. Contractor's name, address, and phone number.
   3. Designation of applicable testing and inspecting agency.
   4. Date of installation.
   5. Manufacturer's name.
   6. Installer's name.

3.5 FIELD QUALITY CONTROL

A. Owner will engage a qualified inspection agency to conduct and report on inspections in accordance with ASTM E2174.

B. Where deficiencies are found or penetration firestopping system is damaged or removed because of testing, repair or replace penetration firestopping system to comply with requirements.

C. Proceed with enclosing penetration firestopping systems with other construction only after inspection reports are issued and installations comply with requirements.

3.6 CLEANING AND PROTECTION

A. Clean off excess fill materials adjacent to openings as the Work progresses by methods and with cleaning materials that are approved in writing by penetration firestopping system manufacturers and that do not damage materials in which openings occur.

B. Provide final protection and maintain conditions during and after installation that ensure that penetration firestopping systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, immediately cut out and remove damaged or deteriorated penetration firestopping material and install new materials to produce systems complying with specified requirements.

END OF SECTION

SECTION 078443 - JOINT FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Intumescent gypsum wall framing gaskets.
2. Perimeter fire-barrier system.
3. Joints in or between fire-resistance-rated construction.
4. Joints in smoke barriers.

B. Related Requirements:
1. Section 078413 "Penetration Firestopping" for penetrations in fire-resistance-rated walls, horizontal assemblies, and smoke barriers and for wall identification.
2. Section 092216 "Non-Structural Metal Framing" for firestop tracks for metal-framed partition heads.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

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

B. Product Schedule: For each joint firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing agency.
1. Engineering Judgments: Where Project conditions require modification to a qualified testing agency's illustration for a particular joint firestopping system condition, submit illustration, with modifications marked, approved by joint firestopping system manufacturer's fire-protection engineer as an EJ or equivalent fire-resistance-rated assembly developed in accordance with current IFC guidelines. Obtain approval of authorities having jurisdiction prior to submittal.

1.4 CLOSEOUT SUBMITTALS

A. Installer Certificates: From Installer indicating that joint firestopping systems have been installed in compliance with requirements and manufacturer's written installation instructions.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FM Approvals in accordance with FM Approvals 4991 or been evaluated by UL and found to comply with UL's "UL Solutions Qualified Firestop Contractor Program."

B. Installer Qualifications: A firm experienced in installing joint firestopping similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance. Qualifications include having the necessary experience, staff, and training to install manufacturer's products per specified requirements. Manufacturer's willingness to sell its penetration firestopping products to Contractor or to Installer engaged by Contractor does not in itself confer qualification on buyer.

C. Installation Responsibility: Assign installation of penetration firestopping and fire-resistive joint systems to a single qualified firestop contractor.

D. Provide the following upon request:
1. Qualification Data: For Installer.
2. Listed System Designs: For each joint firestopping system, for tests performed by a qualified testing agency.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Do not install joint firestopping systems when ambient or substrate temperatures are outside limits permitted by joint firestopping system manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Install and cure joint firestopping systems in accordance with manufacturer's written installation instructions using natural means of ventilation or, where this is inadequate, forced-air circulation.

1.7 COORDINATION

A. Coordinate construction of joints to ensure that joint firestopping systems can be installed in accordance with specified firestopping system design.

B. Coordinate sizing of joints to accommodate joint firestopping systems.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain joint firestop systems for each type of joint opening indicated from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics:
   1. A qualified testing agency, acceptable to authorities having jurisdiction, will perform joint firestopping system tests.
   2. Test in accordance with testing standards referenced in "Joint Firestopping Systems" Article. Provide rated systems complying with the following requirements:
      a. Joint firestop systems installed with products bearing the classification marking of a qualified product certification agency in accordance with listed system designs published by a qualified testing agency.
         1) UL in its online directory "Product iQ."
         2) Intertek Group in its "Directory of Building Products."

B. Rain/Water Resistance: For perimeter fire-barrier system applications, where inclement weather or greater-than-transient water exposure is expected, use products that dry rapidly and cure in the presence of atmospheric moisture sufficient to pass ASTM D6904 early rain-resistance test (24-hour exposure).

2.3 JOINT FIRESTOPPING SYSTEM TYPES

A. General: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of assemblies in or between which joint firestopping systems are installed. Joint firestopping systems must accommodate building movements without impairing their ability to resist the passage of fire and hot gases.
   1. Joint firestopping systems that are compatible with one another, with the substrates forming openings, and with penetrating items, if any.
   2. Provide products that, upon curing, do not re-emulsify, dissolve, leach, break down, or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture.
   3. Provide firestop products that do not contain ethylene glycol.
   4. Provide additional component systems as may be required by manufacturers to satisfy compatibility requirement.

B. Intumescent Gypsum Wall Framing Gaskets: Applied to steel tracks, runners, and studs prior to framing installation. Provide products with fire, smoke, and acoustical ratings that allow movement of up to 100 percent compression and/or extension when tested in accordance with UL 2079 or ASTM E1966; have an L Rating of less than 1 cfm/ft. **(**0.00115 cu. m/s x m**)** when tested in accordance with UL 2079; and a minimum Sound Transmission Class (STC) rating of 56 when tested in accordance with ASTM E90 or ASTM C919.
   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. CEMCO; California Expanded Metal Products Co.
      b. ClarkDietrich.
      c. International Fireproof Technology Inc.
      d. Specified Technologies, Inc.

C. Perimeter Fire-Barrier System: Provide perimeter fire-barrier system that does not require direct screw attachment to mullions and transoms to support and fasten curtain-wall insulation for aluminum curtain-wall assemblies with one- or two-piece rectangular mullions at least 2-1/2 by 5 inches **(**64 by 127 mm**)**. System will be tested in accordance with ASTM E2307 for up to two-hour fire resistance and with ASTM E1233/E1233M for wind cycling equivalent to 108 mph **(**174 km/h**)** wind for 500 cycles.
   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. CEMCO; California Expanded Metal Products Co.

b. Grabber Construction Products, Inc.
c. Specified Technologies, Inc.

D. Joints in or between Fire-Resistance-Rated Construction: Provide joint firestopping systems with ratings determined in accordance with ASTM E1966 or UL 2079, with published L-Ratings for ambient and elevated temperatures as evidence of the ability of the fire-resistive joint system to restrict the movement of smoke.
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. 3M Building and Construction.
b. Balco; a CSW Industrials Company.
c. CEMCO; California Expanded Metal Products Co.
d. ClarkDietrich.
e. Everkem Diversified Products, Inc.
f. Grabber Construction Products, Inc.
g. Hilti, Inc.
h. International Fireproof Technology Inc.
i. Marino\\WARE.
j. Nelson; Emerson Electric Co., Automation Solutions.
k. NUCO Inc.
l. Owens Corning.
m. Passive Fire Protection Partners.
n. RectorSeal Firestop; a CSW Industrials Company.
o. ROCKWOOL.
p. Specified Technologies, Inc.
q. Tremco Incorporated.
r. Willseal LLC.

E. Joints in Smoke Barriers: Provide joint firestopping systems with ratings determined in accordance with UL 2079 based on testing at a positive pressure differential of 0.30 inch wg **(**74.7 Pa**)**.
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. 3M Building and Construction.
b. Balco; a CSW Industrials Company.
c. CEMCO; California Expanded Metal Products Co.
d. Everkem Diversified Products, Inc.
e. Hilti, Inc.
f. International Fireproof Technology Inc.
g. Marino\\WARE.
h. Nelson; Emerson Electric Co., Automation Solutions.
i. NUCO Inc.
j. Owens Corning.
k. Passive Fire Protection Partners.
l. Polyset.
m. RectorSeal Firestop; a CSW Industrials Company.
n. ROCKWOOL.
o. Specified Technologies, Inc.
p. Tremco Incorporated.
q. Willseal LLC.
2. L-Rating: Not exceeding 5.0 cfm/ft. **(**0.00775 cu. m/s x m**)** of joint at both ambient and elevated temperatures.

F. Exposed Joint Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined in accordance with ASTM E84.

2.4 ACCESSORIES

A. Provide components of joint firestopping systems, including primers and forming materials, that are needed to install elastomeric fill materials and to maintain ratings required. Use only components specified by joint firestopping system manufacturer and approved by the qualified testing agency for conditions indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for joint configurations, substrates, and other conditions affecting performance of the Work.

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

3.2 PREPARATION

A. Surface Cleaning: Before installing joint firestopping systems, clean joints in accordance with fire-resistive joint system manufacturer's written installation instructions and the following requirements:
   1. Remove foreign materials from substrate surfaces that could interfere with adhesion of elastomeric fill materials or compromise fire-resistive rating.
   2. Clean joint substrates to produce clean, sound surfaces capable of developing optimum bond with elastomeric fill materials. Remove loose particles remaining from cleaning operation.
   3. Remove laitance and form-release agents from concrete.

B. Prime substrates in accordance with joint firestopping system manufacturer's written installation instructions, using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Apply a suitable bond breaker to prevent three-sided adhesion in applications where condition occurs.

3.3 INSTALLATION

A. General: Install joint firestopping systems in accordance with manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming materials and other accessories of types required to support elastomeric fill materials during their application and in position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
   1. After installing elastomeric fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of fire-resistive joint system.

C. Install elastomeric fill materials for joint firestopping systems by proven techniques to produce the following results:
   1. Apply elastomeric fill in voids and cavities formed by joints and forming materials as required to achieve fire-resistance ratings indicated.
   2. Apply elastomeric fill materials so they contact and adhere to substrates formed by joints.
   3. For elastomeric fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 IDENTIFICATION

A. Wall Identification: Permanently label walls containing firestopping systems with the words "FIRE AND/OR SMOKE BARRIER - PROTECT ALL OPENINGS," using lettering not less than 3 inches **(**76 mm**)** high and with minimum 0.375-inch **(**9.5-mm**)** strokes.
   1. Locate in accessible concealed floor, floor-ceiling, or attic space at 15 ft. **(**4.57 m**)** from end of wall and at intervals not exceeding 30 ft. **(**9.14 m**)**.

B. Joint Identification: Identify joint firestopping systems with legible metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches **(**150 mm**)** of joint edge, so labels are visible to anyone seeking to remove joint firestopping system. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:
   1. The words "Warning - Joint Firestopping - Do Not Disturb. Notify Building Management of Any Damage."
   2. Contractor's name, address, and phone number.
   3. Designation of applicable testing agency.
   4. Date of installation.
   5. Manufacturer's name.
   6. Installer's name.

3.5 FIELD QUALITY CONTROL

A. Owner will engage a qualified testing agency to perform tests and inspections in accordance with ASTM E2393.

B. Where deficiencies are found or joint firestopping systems are damaged or removed due to testing, repair or replace joint firestopping systems so they comply with requirements.

C. Proceed with enclosing joint firestopping systems with other construction only after inspection reports are issued and installations comply with requirements.

3.6 CLEANING AND PROTECTION

A. Clean off excess elastomeric fill materials adjacent to joints as the Work progresses by methods and with cleaning materials that are approved in writing by joint firestopping system manufacturers and that do not damage materials in which joints occur.

B. Provide final protection and maintain conditions during and after installation that ensure joint firestopping systems are without damage or deterioration at time of Substantial Completion. If damage or deterioration occurs despite such protection, cut out and remove damaged or deteriorated joint firestopping systems immediately and install new materials to produce joint firestopping systems complying with specified requirements.

END OF SECTION

SECTION 079200 - JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Silicone joint sealants.
2. Urethane joint sealants.
3. Latex joint sealants.
4. Mildew-resistant joint sealants.

B. Related Requirements:
1. Section 042000 "Unit Masonry" for masonry control and expansion joint fillers and gaskets.
2. Section 079219 "Acoustical Joint Sealants" for acoustical sealants used in sound rated partitions.
3. Section 078443 "Joint Firestopping" for sealing joints in fire-resistance-rated construction.
4. Section 092900 "Gypsum Board" for sealing perimeter joints and penetrations.
5. Section 093000 "Tiling" for sealing tile joints and penetrations.

1.2 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 013300 "Submittal Procedures".

B. Product Data: For each joint-sealant product indicated.

C. Joint-Sealant Schedule: Include the following information:
1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Source Limitations: Obtain each kind of joint sealant from single source from single manufacturer.

C. Product Testing: Test joint sealants using a qualified testing agency.
1. Testing Agency Qualifications: An independent testing agency qualified in accordance with ASTM C 1021 to conduct the testing indicated.
2. Test in accordance with SWRI's Sealant Validation Program for compliance with requirements specified by reference to ASTM C 920 for adhesion and cohesion under cyclic movement, adhesion-in-peel, and indentation hardness.

D. Provide the following upon request:
1. Qualification Data: For qualified Installer and testing agency.
2. Product Certificates: For each kind of joint sealant and accessory, from manufacturer.
3. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, indicating that sealants comply with requirements.

E. Preinstallation Conference: Conduct conference at Project site.

1.4 PROJECT CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:
1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F **(**5 deg C**)**.
2. When joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.5 WARRANTY

A. Special Installer's Warranty: Manufacturer's standard form in which Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

B. Special Manufacturer's Warranty: Manufacturer's standard form in which joint-sealant manufacturer agrees to furnish joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

C. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:
   1. Movement of the structure caused by structural settlement or errors attributable to design or construction resulting in stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.
   2. Disintegration of joint substrates from natural causes exceeding design specifications.
   3. Mechanical damage caused by individuals, tools, or other outside agents.
   4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

B. VOC Content: Verify sealants and sealant primers comply with the following:
   1. Architectural sealant shall have a VOC content of 250 g/L or less.
   2. Sealants and sealant primers for nonporous substrates have a VOC content of 250 g/L or less.
   3. Sealants and sealant primers for porous substrates have a VOC content of 775 g/L or less.

C. Liquid-Applied Joint Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied joint sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.

D. Stain-Test-Response Characteristics: Where sealants are specified to be nonstaining to porous substrates, provide products that have undergone testing in accordance with ASTM C 1248 and have not stained porous joint substrates indicated for Project.

E. Suitability for Contact with Food: Where sealants are indicated for joints that will come in repeated contact with food, provide products that comply with 21 CFR 177.2600.

F. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

2.2 SILICONE JOINT SEALANTS

Table Notes:
* Indicates substrates with a cement component, such as concrete, that require use of a primer.
** Indicates that other substrates shall be tested for adhesion to determine if a primer will be required.

A. Sealant JS-S2 - Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 100/50, for Use NT.
   1. Products: Subject to compliance with requirements, provide products from the following table that has a validation certificate from the Sealant, Waterproofing and Restoration Institute (SWRI).

Manufacturer	Product	Manufacturer Rated Movement Capability (CLASS)	Substrate Primer Required: Yes/No/Test			
			Mortar*	Uncoated Glass	Alum.	Other**
Dow Inc.	Dowsil 790	+ 100/- 50%	No	Yes	No	Test
Momentive Performance Materials, Inc.	SCS2700 Silpruf LM	+ 100/- 50%	Yes	Test	No	Test

Manufacturer	Product	Manufacturer Rated Movement Capability (CLASS)	Substrate Primer Required: Yes/No/Test			
			Mortar*		Uncoated Glass	Aluminum. Other**
Pecora Corporation	890	+ 100/- 50%	Yes	Test	No	Test
Tremco Incorporated	Spectrem 1	+ 100/- 50%	Yes	Test	No	Test

Table Notes:
* Indicates substrates with a cement component, such as concrete, that require use of a primer.

B. Sealant JS-W1 - Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT; tested and marketed specifically for sealing air barrier and vapor retarder sheets to common building materials, such as aluminum, vinyl, PVC, powder coat, paint and fluoropolymer coatings; UV resistant..
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Dow Corp.; Dowsil 758.

2.3 URETHANE JOINT SEALANTS

A. Sealant JS-U2 - Multicomponent, Nonsag, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Master Builders Solutions; MasterSeal NP 2.
b. Pacific Polymers International, Inc.; Elasto-Thane 227 High Shore Type II or Elasto-Thane 227 Type II.
c. Pecora Corporation; DynaTred.
d. Sika Corporation, Construction Products Division; Sikaflex-2c NS or Sikaflex-2c EZ Mix.
e. Tremco Incorporated; Vulkem 116 + catalyst.

2.4 LATEX JOINT SEALANTS

A. Sealant JS-L1 - Latex Joint Sealant: Acrylic latex or siliconized acrylic latex, ASTM C 834.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Bostik, Inc.; Chem-Calk 600.
b. DAP Products Inc.; Dynaflex 230.
c. Pecora Corporation; AC-20 + Silicone.
d. Schnee-Morehead, Inc.; Acryl-R SM8200.
e. Tremco Incorporated; Tremflex 834.

2.5 MILDEW-RESISTANT JOINT SEALANTS

A. Sealant JS-M1 - Mildew-Resistant, Single-Component, Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Dow Inc.; Dowsil 786 Silicone Sealant.
b. GE Silicones; SCS1700 Sanitary.
c. Pecora Corporation; 898NST.
d. Tremco Incorporated; Tremsil 200.

2.6 JOINT SEALANT BACKING

A. General: Provide sealant backings of material that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.

B. Cylindrical Sealant Backings: ASTM C 1330, Type C (closed-cell material with a surface skin), and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.7 MISCELLANEOUS MATERIALS

A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.

C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

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

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
   1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
   2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
      a. Concrete.
      b. Masonry.
      c. Unglazed surfaces of ceramic tile.
   3. Remove laitance and form-release agents from concrete.
   4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:
      a. Metal.
      b. Glass.
      c. Porcelain enamel.
      d. Glazed surfaces of ceramic tile.

B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Do not extend exterior sealants and primers into building interior (that is, inside the weatherproofing system) unless first verifying compliance with VOC requirements.

D. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
   1. Do not leave gaps between ends of sealant backings.
   2. Do not stretch, twist, puncture, or tear sealant backings.
   3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.

E. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.

F. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
   1. Place sealants so they directly contact and fully wet joint substrates.
   2. Completely fill recesses in each joint configuration.
   3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

G. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants in accordance with requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
   1. Remove excess sealant from surfaces adjacent to joints.
   2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces. Water-based tooling agents are unacceptable.
   3. Provide concave joint profile per Figure 8A in ASTM C 1193, unless otherwise indicated.
   4. Provide flush joint profile where indicated per Figure 8B in ASTM C 1193.
   5. Provide recessed joint configuration of recess depth and at locations indicated per Figure 8C in ASTM C 1193.
      a. Use masking tape to protect surfaces adjacent to recessed tooled joints.

3.4 FIELD QUALITY CONTROL

A. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:
   1. Extent of Testing: Test completed and cured sealant joints as follows:
      a. Perform Two tests for each 100 feet of joint length for each kind of sealant and joint substrate.
   2. Test Method: Test joint sealants in accordance with Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
      a. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
   3. Inspect tested joints and report on the following:
      a. Whether sealants filled joint cavities and are free of voids.
      b. Whether sealant dimensions and configurations comply with specified requirements.
      c. Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if adhesion passes sealant manufacturer's field-adhesion hand-pull test criteria.
   4. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant fill, sealant configuration, and sealant dimensions.
   5. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.

B. Evaluation of Field-Adhesion Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

3.5 CLEANING

A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.6 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION

SECTION 079219 - ACOUSTICAL JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Acoustical joint sealants.

B. Related Requirements:
1. Section 079200 "Joint Sealants" joint sealants for nonacoustical applications.

1.2 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 013300 "Submittal Procedures".

B. Product Data: For each type of product.

C. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants, showing full range of available colors for each product exposed to view.

D. Samples for Verification: For each type and color of acoustical joint sealant required.
1. Size: 1/2-inch- **(**13-mm-**)** wide sealant joints formed between two 6-inch- **(**150-mm-**)** long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

E. Acoustical Joint-Sealant Schedule: Include the following information:
1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.3 INFORMATIONAL SUBMITTALS

A. Test and Evaluation Reports:
1. Product Test Reports: For each type of acoustical joint sealant, for tests performed by manufacturer and witnessed by a qualified testing agency.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained between 40 and 95 deg F **(**4 and 35 deg C**)**.
1. Maintain containers in clean condition, free of foreign materials and residue.
2. Remove rags and waste from storage areas daily.

1.5 FIELD CONDITIONS

A. Apply coatings only when temperature of surfaces to be coated and ambient air temperatures are between 35 and 100 deg F **(**2 and 38 deg C**)**. Warm surfaces to be coated to 70 deg F **(**21 deg C**)** to enhance drying.

1.6 WARRANTY

A. Installer's Special Warranty: Installer agrees to repair or replace acoustical joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
1. Warranty Period: Two years from date of Substantial Completion.

B. Manufacturer's Special Warranty: Manufacturer agrees to furnish acoustical joint sealants to repair or replace those joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
1. Warranty Period: One years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ACOUSTICAL JOINT SEALANTS

A. Acoustical joint-sealant products that effectively reduce airborne sound transmission through perimeter joints and openings in building construction, as demonstrated by testing representative assemblies in accordance with ASTM E90.

B. Acoustical Sealant for Exposed and Concealed Joints: Manufacturer's standard nonsag, paintable, nonstaining latex acoustical sealant complying with ASTM C834.
   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. DAP Products Inc.
      b. Everkem Diversified Products, Inc.
      c. Franklin International.
      d. Grabber Construction Products, Inc.
      e. Hilti, Inc.
      f. OSI Sealants; Henkel Corporation.
      g. Pecora Corporation.
      h. Specified Technologies Inc.
   2. Colors of Exposed Acoustical Joint Sealants: As indicated by manufacturer's designations Match Architect's samples As selected by Architect from manufacturer's full range of colors Insert color.

C. Acoustical Sealant for Concealed Joints: Manufacturer's standard nonsag, nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber acoustical sealant.
   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. OSI Sealants; Henkel Corporation.
      b. Pecora Corporation.
      c. Tremco Incorporated.
      d. USG Corporation.

2.2 MISCELLANEOUS MATERIALS

A. Primer: Material recommended by acoustical joint-sealant manufacturer where required for adhesion of sealant to joint substrates.

B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.

C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive acoustical joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting performance of the Work.

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

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing acoustical joint sealants to comply with joint-sealant manufacturer's written instructions.

B. Joint Priming: Prime joint substrates where recommended by acoustical joint-sealant manufacturer. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF ACOUSTICAL JOINT SEALANTS

A. Comply with acoustical joint-sealant manufacturer's written installation instructions unless more stringent requirements apply.

B. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical joint sealant. Install acoustical joint sealants at both faces of partitions, at perimeters, and through penetrations. Comply with ASTM C919, ASTM C1193, and manufacturer's written instructions for closing off sound-flanking paths around or through assemblies, including sealing partitions to underside of floor slabs above acoustical ceilings.

C. Acoustical Ceiling Areas: Apply acoustical joint sealant at perimeter edge moldings of acoustical ceiling areas in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.

3.4 CLEANING

A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of acoustical joint sealants and of products in which joints occur.

3.5 PROTECTION

A. Protect acoustical joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated acoustical joint sealants immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION

SECTION 081113 - HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Interior standard steel doors and frames.

B. Related Requirements:
   1. Section 087100 "Door Hardware" for door hardware for hollow-metal doors.

1.2 DEFINITIONS

A. Minimum Thickness: Minimum thickness of base metal without coatings in accordance with NAAMM-HMMA 803 or ANSI/SDI A250.8.

1.3 COORDINATION

A. Coordinate anchorage installation for hollow-metal frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.

B. Coordinate requirements for installation of door hardware, electrified door hardware, and access control and security systems.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Product Data:
   1. Interior standard steel doors and frames.

B. Product Data Submittals: For each product.
   1. Include construction details, material descriptions, core descriptions, fire-resistance ratings, temperature-rise ratings, and finishes.

C. Shop Drawings: Include the following:
   1. Elevations of each door type.
   2. Details of doors, including vertical- and horizontal-edge details and metal thicknesses.
   3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
   4. Locations of reinforcement and preparations for hardware.
   5. Details of each different wall opening condition.
   6. Details of electrical raceway and preparation for electrified hardware, access control systems, and security systems.
   7. Details of anchorages, joints, field splices, and connections.
   8. Details of accessories.
   9. Details of moldings, removable stops, and glazing.

D. Samples for Verification:
   1. Finishes: For each type of exposed finish required, prepared on Samples of not less than 3 by 5 inches **(**75 by 127 mm**)**.
   2. Fabrication: Prepare Samples approximately 12 by 12 inches **(**305 by 305 mm**)** to demonstrate compliance with requirements for quality of materials and construction:
      a. Doors: Show vertical-edge, top, and bottom construction; core construction; and hinge and other applied hardware reinforcement. Include separate section showing glazing if applicable.
      b. Frames: Show profile, corner joint, floor and wall anchors, and silencers. Include separate section showing fixed hollow-metal panels and glazing if applicable.

E. Product Schedule: For hollow-metal doors and frames, prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with final door hardware schedule.

1.6 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For each type of fire-rated hollow-metal door and frame assembly for tests performed by a qualified testing agency indicating compliance with performance requirements.

1.7 CLOSEOUT SUBMITTALS

A. Record Documents: For fire-rated doors, list of door numbers and applicable room name and number to which door accesses.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver hollow-metal doors and frames palletized, packaged, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.
   1. Provide additional protection to prevent damage to factory-finished units.

B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.

C. Store hollow-metal doors and frames vertically under cover at Project site with head up. Place on minimum 4-inch- **(**102-mm-**)** high wood blocking. Provide minimum 1/4-inch **(**6-mm**)** space between each stacked door to permit air circulation.

PART 2 - PRODUCTS

2.1 HOLLOW METAL DOORS AND FRAMES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ceco Door; AADG, Inc.; ASSA ABLOY.
   2. Curries, AADG, Inc.; ASSA ABLOY Group .
   3. Pioneer Industries; AADG, Inc.; ASSA ABLOY.
   4. Republic Doors and Frames; a Allegion brand.
   5. Steelcraft; Allegion plc.

2.2 PERFORMANCE REQUIREMENTS

A. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings and temperature-rise limits indicated on Drawings, based on testing at positive pressure in accordance with NFPA 252 or UL 10C.
   1. Smoke- and Draft-Control Door Assemblies: Listed and labeled for smoke and draft control by a qualified testing agency acceptable to authorities having jurisdiction, based on testing in accordance with UL 1784 and installed in compliance with NFPA 105.

2.3 INTERIOR STANDARD STEEL DOORS AND FRAMES

A. Construct hollow-metal doors and frames to comply with standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Heavy-Duty Doors and Frames: ANSI/SDI A250.8, Level 2; ANSI/SDI A250.4, Level B. .
   1. Doors:
      a. Type: As indicated in the Door and Frame Schedule on Drawings.
      b. Thickness: 1-3/4 inches **(**44.5 mm**)**.
      c. Face: Uncoated steel sheet, minimum thickness of 0.042 inch **(**1.0 mm**)**.
      d. Edge Construction: Model 1, Full Flush .
      e. Edge Bevel: Provide manufacturer's standard beveled or square edges.
      f. Core: Manufacturer's standard .
      g. Fire-Rated Core: Manufacturer's standard laminated mineral board core for fire-rated and temperature-rise-rated doors.
   2. Frames:
      a. Materials: Uncoated steel sheet, minimum thickness of 0.053 inch **(**1.3 mm**)**.
      b. Sidelite and Transom Frames: Fabricated from same thickness material as adjacent door frame.
      c. Construction: Face welded .
   3. Exposed Finish: Prime .

2.4 FRAME ANCHORS

A. Jamb Anchors:
   1. Type: Anchors of minimum size and type required by applicable door and frame standard, and suitable for performance level indicated.

2. Quantity: Minimum of three anchors per jamb, with one additional anchor for frames with no floor anchor. Provide one additional anchor for each 24 inches (610 mm) of frame height above 7 feet (2.1 m).
3. Postinstalled Expansion Anchor: Minimum 3/8-inch- (9.5-mm-) diameter bolts with expansion shields or inserts, with manufacturer's standard pipe spacer.

B. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor.

C. Floor Anchors for Concrete Slabs with Underlayment: Adjustable-type anchors with extension clips, allowing not less than 2-inch (51-mm) height adjustment. Terminate bottom of frames at top of underlayment.

D. Material: ASTM A879/A879M, Commercial Steel (CS), 04Z (12G) coating designation; mill phosphatized.
1. For anchors built into exterior walls, steel sheet complying with ASTM A1008/A1008M or ASTM A1011/A1011M; hot-dip galvanized in accordance with ASTM A153/A153M, Class B.

2.5 MATERIALS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

C. Inserts, Bolts, and Fasteners: Hot-dip galvanized in accordance with ASTM A153/A153M.

D. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hollow-metal frames of type indicated.

E. Mineral-Fiber Insulation: ASTM C665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E136 for combustion characteristics.

2.6 FABRICATION

A. Door Astragals: Provide overlapping astragal on one leaf of pairs of doors where required by NFPA 80 for fire-performance rating or where indicated. Extend minimum 3/4 inch (19 mm) beyond edge of door on which astragal is mounted or as required to comply with published listing of qualified testing agency.

B. Hollow-Metal Frames: Fabricate in one piece except where handling and shipping limitations require multiple sections. Where frames are fabricated in sections, provide alignment plates or angles at each joint, fabricated of metal of same or greater thickness as frames.
1. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
2. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers as follows. Keep holes clear during construction.
   a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
   b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.

C. Hardware Preparation: Factory prepare hollow-metal doors and frames to receive templated mortised hardware, and electrical wiring; include cutouts, reinforcement, mortising, drilling, and tapping in accordance with ANSI/SDI A250.6, the Door Hardware Schedule on Drawings, and templates.
1. Reinforce doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.
2. Comply with BHMA A156.115 for preparing hollow-metal doors and frames for hardware.

2.7 STEEL FINISHES

A. Prime Finish: Clean, pretreat, and apply manufacturer's standard primer.
1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

PART 3 - EXECUTION

3.1 PREPARATION

A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces. Touch up factory-applied finishes where spreaders are removed.

B. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.

3.2 INSTALLATION

A. Install hollow-metal doors and frames plumb, rigid, properly aligned, and securely fastened in place. Comply with approved Shop Drawings and with manufacturer's written instructions.

B. Hollow-Metal Frames: Comply with ANSI/SDI A250.11.
1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces without damage to completed Work.
   a. Where frames are fabricated in sections, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces. Touch-up finishes.
   b. Install frames with removable stops located on secure side of opening.
2. Fire-Rated Openings: Install frames in accordance with NFPA 80.
3. Floor Anchors: Secure with postinstalled expansion anchors.
   a. Floor anchors may be set with power-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.
4. Solidly pack mineral-fiber insulation inside frames.
5. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout or mortar.
6. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
7. Installation Tolerances: Adjust hollow-metal frames to the following tolerances:
   a. Squareness: Plus or minus 1/16 inch **(**1.6 mm**)**, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
   b. Alignment: Plus or minus 1/16 inch **(**1.6 mm**)**, measured at jambs on a horizontal line parallel to plane of wall.
   c. Twist: Plus or minus 1/16 inch **(**1.6 mm**)**, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
   d. Plumbness: Plus or minus 1/16 inch **(**1.6 mm**)**, measured at jambs at floor.

C. Hollow-Metal Doors: Fit and adjust hollow-metal doors accurately in frames, within clearances specified below.
1. Non-Fire-Rated Steel Doors: Comply with ANSI/SDI A250.8.
2. Fire-Rated Doors: Install doors with clearances in accordance with NFPA 80.
3. Smoke-Control Doors: Install doors in accordance with NFPA 105.
4. Clearances:
   a. Provide 1/8 inch **(**3.2 mm**)** at heads, jambs, and between pairs of doors.
   b. Floor clearance for fire-rated swinging doors shall not exceed 3/4 inch **(**19 mm**)**. Floor clearance shall be provided for the functional operation of all swinging doors and shall not be less than 1/8 inch **(**3.2 mm**)**.

D. Glazing: Comply with installation requirements in Section 088000 "Glazing" and with hollow-metal manufacturer's written instructions.

3.3 FIELD QUALITY CONTROL

A. Inspections:
1. Fire-Rated Door Inspections: Inspect each fire-rated door in accordance with NFPA 80, Section 5.2.

B. Repair or remove and replace installations where inspections indicate that they do not comply with specified requirements.

C. Reinspect repaired or replaced installations to determine if replaced or repaired door assembly installations comply with specified requirements.

D. Prepare and submit separate inspection report for each fire-rated door assembly indicating compliance with each item listed in NFPA 80.

3.4 REPAIR

A. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.

B. Touchup Painting: Cleaning and touchup painting of abraded areas of paint are specified in painting Sections.

END OF SECTION

SECTION 087100 - DOOR HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Mechanical door hardware for the following:
      a. Swinging doors.

B. Related Requirements:
   1. Section 081113 "Hollow Metal Doors and Frames" for astragals provided as part of labeled fire-rated assemblies and for door silencers provided as part of hollow-metal frames.

1.2 COORDINATION

A. Installation Templates: Distribute for doors, frames, and other work specified to be factory prepared. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.

B. Security: Coordinate installation of door hardware, keying, and access control with Owner's security consultant.

C. Electrical System Roughing-In: Coordinate layout and installation of electrified door hardware with connections to power supplies and building safety and security systems.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Conference participants shall include Installer's Architectural Hardware Consultant.

B. Keying Conference: Conduct conference at Project site.
   1. Conference participants shall include Installer's Architectural Hardware Consultant.
   2. Incorporate conference decisions into keying schedule after reviewing door hardware keying system including, but not limited to, the following:
      a. Flow of traffic and degree of security required.
      b. Preliminary key system schematic diagram.
      c. Requirements for key control system.
      d. Requirements for access control.
      e. Address for delivery of keys.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

B. Shop Drawings: For electrified door hardware.
   1. Include diagrams for power, signal, and control wiring.
   2. Include details of interface of electrified door hardware and building safety and security systems.

C. Samples: For each exposed product in each finish specified, in manufacturer's standard size.
   1. Tag Samples with full product description to coordinate Samples with door hardware schedule.

D. Samples for Verification: For each type of exposed product, in each finish specified.
   1. Sample Size: Full-size units or minimum 2-by-4-inch **(**51-by-102-mm**)** Samples for sheet and 4-inch **(**102-mm**)** long Samples for other products.
      a. Full-size Samples will be returned to Contractor. Units that are acceptable and remain undamaged through submittal, review, and field comparison process may, after final check of operation, be incorporated into the Work, within limitations of keying requirements.
   2. Tag Samples with full product description to coordinate Samples with door hardware schedule.

E. Door Hardware Schedule: Prepared by or under the supervision of Installer's Architectural Hardware Consultant. Coordinate door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.
   1. Submittal Sequence: Submit door hardware schedule concurrent with submissions of Product Data, Samples, and Shop Drawings. Coordinate submission of door hardware schedule with scheduling requirements of other work to facilitate the fabrication of other work that is critical in Project construction schedule.

2. Format: Use same scheduling sequence and format and use same door numbers as in door hardware schedule in the Contract Documents.
3. Content: Include the following information:
   a. Identification number, location, hand, fire rating, size, and material of each door and frame.
   b. Locations of each door hardware set, cross-referenced to Drawings on floor plans and to door and frame schedule.
   c. Complete designations, including name and manufacturer, type, style, function, size, quantity, function, and finish of each door hardware product.
   d. Description of electrified door hardware sequences of operation and interfaces with other building control systems.
   e. Fastenings and other installation information.
   f. Explanation of abbreviations, symbols, and designations contained in door hardware schedule.
   g. Mounting locations for door hardware.
   h. List of related door devices specified in other Sections for each door and frame.

F. Keying Schedule: Prepared by or under the supervision of Installer's Architectural Hardware Consultant, detailing Owner's final keying instructions for locks. Include schematic keying diagram and index each key set to unique door designations that are coordinated with the Contract Documents.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each type of door hardware to include in maintenance manuals.

B. Schedules: Final [**door hardware**][**and**][**keying**] schedule.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Supplier of products and an employer of workers trained and approved by product manufacturers and of an Architectural Hardware Consultant who is available during the course of the Work to consult Contractor, Architect, and Owner about door hardware and keying.
1. Warehousing Facilities: In Project's vicinity.
2. Scheduling Responsibility: Preparation of door hardware and keying schedule.
3. Engineering Responsibility: Preparation of data for electrified door hardware, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Architectural Hardware Consultant Qualifications: A person who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project and who is currently certified by DHI as an Architectural Hardware Consultant (AHC).

C. Provide the following upon request:
1. Qualification Data: For Architectural Hardware Consultant.
2. Product Certificates: For each type of electrified door hardware.
   a. Certify that door hardware for use on each type and size of labeled fire-rated doors complies with listed fire-rated door assemblies.
3. Product Test Reports: For compliance with accessibility requirements, for tests performed by manufacturer and witnessed by a qualified testing agency, for door hardware on doors located in accessible routes.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Inventory door hardware on receipt and provide secure lock-up for door hardware delivered to Project site.

B. Tag each item or package separately with identification coordinated with the final door hardware schedule, and include installation instructions, templates, and necessary fasteners with each item or package.

C. Deliver keys to manufacturer of key control system for subsequent delivery to Owner.

D. Deliver keys and permanent cores to Owner by registered mail or overnight package service.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
   a. Structural failures including excessive deflection, cracking, or breakage.
   b. Faulty operation of doors and door hardware.

c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

2. Warranty Period: Three years from date of Substantial Completion unless otherwise indicated below:
   a. Exit Devices: 55 years from date of Substantial Completion.
   b. Manual Closers: 2525 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of door hardware from single manufacturer.
   1. Provide electrified door hardware from same manufacturer as mechanical door hardware unless otherwise indicated. Manufacturers that perform electrical modifications and that are listed by a testing and inspecting agency acceptable to authorities having jurisdiction are acceptable.

2.2 PERFORMANCE REQUIREMENTS

A. Fire-Rated Door Assemblies: Where fire-rated doors are indicated, provide door hardware complying with NFPA 80 that is listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure in accordance with NFPA 252 or UL 10C.

B. Smoke- and Draft-Control Door Assemblies: Where smoke- and draft-control door assemblies are required, provide door hardware that complies with requirements of assemblies tested in accordance with UL 1784 and installed in compliance with NFPA 105.
   1. Air Leakage Rate: Maximum air leakage of 0.3 cfm/sq. ft. (3 cu. m per minute/sq. m) at the tested pressure differential of 0.3-inch wg **(**75 Pa**)** of water.

C. Electrified Door Hardware: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Means of Egress Doors: Latches do not require more than 15 lbf **(**67 N**)** to release the latch. Locks do not require use of a key, tool, or special knowledge for operation.

E. Accessibility Requirements: For door hardware on doors in an accessible route, comply with the USDOJ's "2010 ADA Standards for Accessible Design".
   1. Provide operating devices that do not require tight grasping, pinching, or twisting of the wrist and that operate with a force of not more than 5 lbf **(**22.2 N**)**.
   2. Comply with the following maximum opening-force requirements:
      a. Interior, Non-Fire-Rated Hinged Doors: 5 lbf **(**22.2 N**)** applied perpendicular to door.
      b. Sliding or Folding Doors: 5 lbf **(**22.2 N**)** applied parallel to door at latch.
      c. Fire Doors: Minimum opening force allowable by authorities having jurisdiction.
   3. Bevel raised thresholds with a slope of not more than 1:2. Provide thresholds not more than 1/2 inch **(**13 mm**)** high.
   4. Adjust door closer sweep periods so that, from an open position of 90 degrees, the door will take at least 5 seconds to move to a position of 12 degrees from the latch.
   5. Adjust spring hinges so that, from an open position of 70 degrees, the door will take at least 1.5 seconds to move to the closed position.

2.3 HINGES

A. Hinges: BHMA A156.1. Provide template-produced hinges for hinges installed on hollow-metal doors and hollow-metal frames.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allegion plc.
      b. Hager Companies.
      c. McKinney Products Company; an ASSA ABLOY Group company.
      d. Stanley Commercial Hardware; a division of Stanley Security Solutions.

2.4 ELECTROMECHANICAL LOCKS

A. Electromechanical Locks: BHMA A156.25; Grade 1Grade 2; motor or solenoid driven; with strike that suits frame.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Corbin Russwin ML20900 Series; ASSA ABLOY
   2. Type: BoredMortise latchboltMortise deadboltMortise deadlocking latchbolt.

2.5 AUTOMATIC AND SELF-LATCHING FLUSH BOLTS

A. Automatic Flush Bolts: BHMA A156.3, Type 25; minimum 3/4-inch (19-mm) throw; with dust-proof strikes; designed for mortising into door edge. Include wear plates.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allegion plc.
      b. Rockwood.
      c. Trimco.

B. Self-Latching Flush Bolts: BHMA A156.3, Type 27; minimum 3/4-inch (19-mm) throw; with dust-proof strikes; designed for mortising into door edge.

2.6 EXIT DEVICES AND AUXILIARY ITEMS

A. Exit Devices and Auxiliary Items: BHMA A156.3.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Corbin Russwin, Inc.; an ASSA ABLOY Group company.

2.7 LOCK CYLINDERS

A. Lock Cylinders: Match existing facility standard.

B. Standard Lock Cylinders: BHMA A156.5; Grade 1Grade 1AGrade 2 permanent cores; face finished to match lockset.
   1. Core Type: Match exisitng facility standard.

C. High-Security Lock Cylinders: BHMA A156.30; permanent cores that are removable; face finished to match lockset.
   1. Type: .

2.8 KEYING

A. Keying System: Match existing facility key system. Incorporate decisions made in keying conference.
   1. Existing System:
      a. Master key or grand master key locks to Owner's existing system.

B. Keys: Nickel silver or Brass.
   1. Stamping: Permanently inscribe each key with a visual key control number and include the following notation:
      a. Notation: "DO NOT DUPLICATE."Information to be furnished by Owner.

2.9 SURFACE CLOSERS

A. Surface Closers: BHMA A156.4; rack-and-pinion hydraulic type with adjustable sweep and latch speeds controlled by key-operated valves and forged-steel main arm. Comply with manufacturer's written instructions for size of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide factory-sized closers, adjustable to meet field conditions and requirements for opening force.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allegion plc.
      b. Corbin Russwin, Inc.; an ASSA ABLOY Group company.
      c. Norton Door Controls; an ASSA ABLOY Group company.
      d. SARGENT Manufacturing Company; ASSA ABLOY.
      e. Stanley Commercial Hardware; a division of Stanley Security Solutions.

2.10 DOOR GASKETING

A. Door Gasketing: BHMA A156.22; with resilient or flexible seal strips that are easily replaceable and readily available from stocks maintained by manufacturer.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. National Guard Products, Inc.
      b. Pemko; an ASSA ABLOY Group Company.
      c. Reese Enterprises, Inc.
      d. Zero International; an Allegion brand.

B. Maximum Air Leakage: When tested in accordance with ASTM E283 with tested pressure differential of 0.3-inch wg (75 Pa), as follows:
   1. Smoke-Rated Gasketing: 0.3 cfm/sq. ft. (3 cu. m per minute/sq. m) of door opening.
   2. Gasketing on Single Doors: 0.3 cfm/sq. ft. (3 cu. m per minute/sq. m) of door opening.
   3. Gasketing on Double Doors: 0.50 cfm per ft. (0.000774 cu.) m/s per m) of door opening.

2.11 FABRICATION

A. Base Metals: Produce door hardware units of base metal indicated, fabricated by forming method indicated, using manufacturer's standard metal alloy, composition, temper, and hardness. Furnish metals of a quality equal to or greater than that of specified door hardware units and BHMA A156.18.

B. Fasteners: Provide door hardware manufactured to comply with published templates prepared for machine, wood, and sheet metal screws. Provide screws that comply with commercially recognized industry standards for application intended, except aluminum fasteners are not permitted. Provide Phillips flat-head screws with finished heads to match surface of door hardware unless otherwise indicated.
   1. Concealed Fasteners: For door hardware units that are exposed when door is closed, except for units already specified with concealed fasteners. Do not use through bolts for installation where bolt head or nut on opposite face is exposed unless it is the only means of securely attaching the door hardware. Where through bolts are used on hollow door and frame construction, provide sleeves for each through bolt.
   2. Fire-Rated Applications:
      a. Wood or Machine Screws: For the following:
         1) Hinges mortised to doors or frames.
         2) Strike plates to frames.
         3) Closers to doors and frames.
   3. Spacers or Sex Bolts: For through bolting of hollow-metal doors.
   4. Gasketing Fasteners: Provide noncorrosive fasteners for exterior applications and elsewhere as indicated.

2.12 FINISHES

A. Provide finishes complying with BHMA A156.18 as indicated in door hardware schedule.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine doors and frames, with Installer present, for compliance with requirements for installation tolerances, labeled fire-rated door assembly construction, wall and floor construction, and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical power systems to verify actual locations of wiring connections before electrified door hardware installation.

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

3.2 PREPARATION

A. Steel Doors and Frames: For surface-applied door hardware, drill and tap doors and frames in accordance with ANSI/SDI A250.6.

3.3 INSTALLATION

A. Mounting Heights: Mount door hardware units at heights to comply with the following unless otherwise indicated or required to comply with governing regulations.
   1. Standard Steel Doors and Frames: ANSI/SDI A250.8.

B. Install each door hardware item to comply with manufacturer's written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work. Do not install surface-mounted items until finishes have been completed on substrates involved.
   1. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.
   2. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors in accordance with industry standards.

C. Hinges: Install types and in quantities indicated in door hardware schedule, but not fewer than the number recommended by manufacturer for application indicated or one hinge for every 30 inches (750 mm) of door height, whichever is more stringent, unless other equivalent means of support for door, such as spring hinges or pivots, are provided.

D. Boxed Power Supplies: Locate power supplies as indicated or, if not indicated, above accessible ceilingsin equipment room. Verify location with Architect.
   1. Configuration: Provide least number of power supplies required to adequately serve doors with electrified door hardware.

E. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.
   1. Do not notch perimeter gasketing to install other surface-applied hardware.

F. Meeting Stile Gasketing: Fasten to meeting stiles, forming seal when doors are closed.

G. Door Bottoms: Apply to bottom of door, forming seal with threshold when door is closed.

3.4 FIELD QUALITY CONTROL

A. Independent Architectural Hardware Consultant: Engage a qualified independent Architectural Hardware Consultant to perform inspections and to prepare inspection reports.
   1. Independent Architectural Hardware Consultant will inspect door hardware and state in each report whether installed work complies with or deviates from requirements, including whether door hardware is properly installed and adjusted.

3.5 ADJUSTING

A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.
   1. Door Closers: Adjust sweep period to comply with accessibility requirements and requirements of authorities having jurisdiction.

B. Occupancy Adjustment: Approximately six months after date of Substantial Completion, Installer's Architectural Hardware Consultant shall examine and readjust each item of door hardware, including adjusting operating forces, as necessary to ensure function of doors, door hardware, and electrified door hardware.

3.6 CLEANING AND PROTECTION

A. Clean adjacent surfaces soiled by door hardware installation.

B. Clean operating items as necessary to restore proper function and finish.

C. Provide final protection and maintain conditions that ensure that door hardware is without damage or deterioration at time of Substantial Completion.

3.7 MAINTENANCE SERVICE

A. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions for Owner's continued adjustment, maintenance, and removal and replacement of door hardware.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain door hardware.

3.9 DOOR HARDWARE SCHEDULE

Set 01
Doors: P1-01

2	Hinges	T4A3786 4-1/2” x 4-1/2”	US26D	MK
1	Hinges	T4A3786 4-1/2” x 4-1/2” x QC8	US26D	MK
1	Electrified Mortise Lockset	ED5200A N9905 M92	US26D	CR
1	Rim Cylinder/Core	MATCH EXISTING FACILITY KEY SYSTEM		
1	Closer	4040XP SCUSH	689	LC
1	Gasketing	S88BL		PE
1	Wiring Harness	QC-C x LENGTH REQ’D		MK
1	Wiring Harness	QC-C1500P		MK
1	Power Supply	AQD SERIES		SU
1	Card Reader	BY SECURITY CONTRACTOR		
1	Door Contact	BY SECURITY CONTRACTOR		
1	Wiring Diagram	ELEVATION & POINT-TO-POINT		

Operational Description: Door is normally closed, latched, and latched; active leaf is electronically locked. Presenting a valid card to the card reader will momentarily unlock outside lever of exit device trim allowing entry. Entry also by key in cylinder. Manual egress at all times by pressing rail of exit device and exiting. Pressing rail of exit device will shunt door contacts (RX) for authorized egress.
Door contact monitors the position of the door and reports this status to the security system.

Set 02
Doors: C-01, JM-01, IND-01

2	Hinges	T4A3786 4-1/2” x 4-1/2”	US26D	MK
1	Hinges	T4A3786 4-1/2” x 4-1/2” x QC8	US26D	MK
1	Electrified Mortise Lockset	ML20906 M92 NSA LESS CYL/CORE	US26D	CR
1	Mortise Cylinder/Core	MATCH EXISTING FACILITY KEY SYSTEM		
1	Closer	4040XP EDA	689	LC
1	Wall Stop	409	US32D	RO
1	Wiring Harness	QC-C x LENGTH REQ’D		MK
1	Wiring Harness	QC-C1500P		MK
1	Power Supply	AQD SERIES		SU
1	Card Reader	BY SECURITY CONTRACTOR		
1	Door Contact	BY SECURITY CONTRACTOR		
1	Wiring Diagram	ELEVATION & POINT-TO-POINT		

Operational Description: Door is normally closed, latched, and locked. Presenting a valid card to the card reader will momentarily unlock outside lever of lockset allowing entry. Entry also by key in cylinder. Manual egress at all times by operating inside lever and exiting. Operating inside lever will shunt door contact (RX) for authorized egress.
Door contact monitors the position of the door and reports this status to the security system.

CR – Corbin Russwin
LC – LCN
MK – McKinney
PE - Pemko
RO - Rockwood
SU - Securitron

END OF SECTION

SECTION 089116 - OPERABLE WALL LOUVERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Operable, extruded-aluminum louvers.

1.2 DEFINITIONS

A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.

B. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.
   1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.
   1. Show weep paths, gaskets, flashings, sealants, and other means of preventing water intrusion.
   2. Show mullion profiles and locations.
   3. Wiring Diagrams: For power, signal, and control wiring for motorized operable louvers.

C. Samples: For each type of metal finish required.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
   1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

B. Provide the following upon request:
   1. Product Test Reports: Based on evaluation of comprehensive tests performed in accordance with AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.

1.5 FIELD CONDITIONS

A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.6 WARRANTY

A. Special Finish Warranty, Anodized Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of anodized finishes within specified warranty period.
   1. Deterioration includes, but is not limited to, the following:
      a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
      b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
      c. Cracking, peeling, or chipping.
   2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain operable louvers from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Structural Performance: Louvers withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver-blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures to the face of the building are considered to act normal.
   1. Wind Loads:
      a. Determine loads based on pressures as indicated on Drawings.
      b. Determine loads based on a uniform pressure of 25 lbf/sq. ft., acting inward or outward.

B. Seismic Performance:
1. As indicated on Drawings.

C. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width in accordance with AMCA 500-L.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
1. Temperature Change (Range): 120 deg F **(**67 deg C**)**, ambient; 180 deg F **(**100 deg C**)**, material surfaces.

E. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

F. UL and NEMA Compliance: Provide motors and related components for motor-operated louvers that are listed and labeled by UL and comply with applicable NEMA standards.

2.3 OPERABLE EXTRUDED-ALUMINUM LOUVERS

A. Louver Construction and Operation: Provide operable louvers with extruded-aluminum frames and blades of not less than 0.080-inch **(**2.03-mm**)** nominal thickness, and with operating mechanisms to suit louver sizes.
1. Motor operation with two-position, spring-return application (with power on, motor opens louver; with power off, spring closes louver); 24-VDC, motor and limit switch; equipped with frame-mounted switch.

B. Operable, Extruded-Aluminum, Single-Blade Louver <Insert drawing designation>:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Air Balance; a division of MESTEK, Inc.
b. Airline Louvers; a division of Mestek, Inc.
c. Greenheck Fan Corporation.
2. Louver Depth: 6 inches **(**150 mm**)**.
3. Blade Type: Drainable.
4. Accessories: Equip louvers as follows:
a. Vinyl blade-edge gaskets for each louver blade.
b. Stainless steel jamb seals.
5. Louver Performance Ratings:
a. Free Area: Not less than 8.73 sq. ft. for 48-inch- **(**1220-mm-**)** wide by 48-inch- **(**1220-mm-**)** high louver.
b. Point of Beginning Water Penetration: Not less than 1107 fpm.
c. Air Performance: Not more than 0.115 inch wg static pressure drop at 1000 fpm free-area intake velocity.
d. Air Leakage: Not more than 3.5 cfm/sq. ft. **(**17.8 L/s per sq. m**)** of louver gross area at a differential static pressure of 0.15-inch wg **(**37 Pa**)** with operable louver blades closed.
6. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.4 MATERIALS

A. Aluminum Extrusions: ASTM B221 **(**ASTM B221M**)**, Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet: ASTM B209 **(**ASTM B209M**)**, Alloy 3003 or 5005, with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Fasteners: Use types and sizes to suit unit installation conditions.

D. Recycled Content of Aluminum Components: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

2.5 FABRICATION

A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Include supports, anchorages, and accessories required for complete assembly.

2.6 ALUMINUM FINISHES

A. Finish louvers after assembly.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.

B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.

C. Form closely fitted joints with exposed connections accurately located and secured.

D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Section 079200 "Joint Sealants" for sealants applied during louver installation.

3.4 ADJUSTING AND CLEANING

A. Test operable louvers and adjust as needed to produce fully functioning units that comply with requirements.

B. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.

C. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.

D. Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.

END OF SECTION

SECTION 090190.52 - MAINTENANCE REPAINTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes maintenance repainting as follows:
   1. Removing existing paint.
   2. Patching substrates.
   3. Repainting.

B. Related Requirements:
   1. Section 013516 "Alteration Project Procedures" for general remodeling, renovation, repair, and maintenance requirements.
   2. Section 099113 "Exterior Painting," Section 099123 "Interior Painting," Section 099300 "Staining and Transparent Finishing,".

1.2 DEFINITIONS

A. Gloss Level 1: Not more than 5 units at 60 degrees and 10 units at 85 degrees, according to ASTM D 523.

B. Gloss Level 2: Not more than 10 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.

C. Gloss Level 3: 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D 523.

D. Gloss Level 4: 20 to 35 units at 60 degrees and not less than 35 units at 85 degrees, according to ASTM D 523.

E. Gloss Level 5: 35 to 70 units at 60 degrees, according to ASTM D 523.

F. Gloss Level 6: 70 to 85 units at 60 degrees, according to ASTM D 523.

G. Low-Pressure Spray: 100 to 400 psi **(**690 to 2750 kPa**)**; 4 to 6 gpm **(**0.25 to 0.4 L/s**)**.

H. Medium-Pressure Spray: 400 to 800 psi **(**2750 to 5510 kPa**)**; 4 to 6 gpm **(**0.25 to 0.4 L/s**)**.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 SEQUENCING AND SCHEDULING

A. Perform maintenance repainting in the following sequence, which includes work specified in this and other Sections:
   1. Dismantle existing surface-mounted objects and hardware except items indicated to remain in place. Tag items with location identification and protect.
   2. Verify that temporary protections have been installed.
   3. Examine condition of surfaces to be painted.
   4. Remove existing paint to the degree required for each substrate and surface condition of existing paint.
   5. Apply paint system.
   6. Reinstall dismantled surface-mounted objects and hardware unless otherwise indicated.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include recommendations for product application and use.
   2. Include test data substantiating that products comply with requirements.

B. Samples: For each type of paint system and each pattern, color, and gloss; minimum 6 inches **(**150 mm**)** long in least dimension, but not less than whole pattern.
   1. Include stepped Samples defining each separate coat, including fillers and primers. Resubmit until each required sheen, color, and texture is achieved.
   2. For each painted color being matched to a standardized color-coding system, include the color chips from the color-coding-system company with Samples.
   3. Include a list of materials for each coat of each Sample.
   4. Label each Sample for location and application.

C. Product List: For each paint product indicated, include the following:

1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
2. Printout of current "MPI Approved Products List" for each MPI-product category specified in paint systems, with the proposed product highlighted.
3. VOC content.

1.6 INFORMATIONAL SUBMITTALS

A. Color Matching Certificate: For computer-matched colors.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra paint materials, from the same production run, that match products applied and that are packaged with protective covering for storage and identified with labels describing contents, including material, finish, source, and location on building.
1. Quantity: Furnish Owner with an additional [**3**] [**5**] [**7**] <**Insert number**> percent, but not less than 1 gal. **(**3.8 L**)** or one case, as appropriate, of each material and color applied.

1.8 QUALITY ASSURANCE

A. Color Matching: Custom computer-match paint colors to colors indicated on Drawings.

B. Provide the following upon request:
1. Preconstruction Test Reports: For cleaning materials, paint removers and paint coatings and systems.

C. Mockups: Prepare mockups of maintenance repainting processes for each type of coating system and substrate indicated and each color and finish required to demonstrate aesthetic effects and to set quality standards for materials and execution. Duplicate appearance of approved Sample submittals.
1. Locate mockups on existing surfaces where directed by Architect.
2. Surface-Preparation Mockups: On existing surfaces using applicable specified methods of cleaning and other surface preparation, provide mockup sample of at least 100 sq. ft. **(**9 sq. m**)**.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing of cleaning materials, paint removers and compatibility of paint coatings and systems for each[**indicated**] type of painted surface.
1. Use test areas as indicated and representative of proposed materials and existing construction.
2. Propose changes to materials and methods to suit Project.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F **(**7 deg C**)**.
1. Maintain containers in clean condition, free of foreign materials and residue.
2. Remove rags and waste daily.

1.11 FIELD CONDITIONS

A. Weather Limitations: Proceed with maintenance repainting only when existing and forecasted weather conditions are within the environmental limits set by each manufacturer's written instructions and specified requirements.

B. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F **(**10 and 35 deg C**)**.

C. Do not apply paint in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F **(**3 deg C**)** above the dew point; or to damp or wet surfaces.
1. Painting may continue during inclement weather if surfaces and areas to be painted are enclosed and heated within temperature limits specified by manufacturer for surface preparation and during paint application and drying periods.

PART 2 - PRODUCTS

2.1 PREPARATORY CLEANING MATERIALS

A. Water: Potable.

B. Hot Water: Water heated to a temperature of 140 to 160 deg F (60 to 71 deg C).

C. Detergent Solution: Solution prepared by mixing 2 cups (0.5 L) of tetrasodium pyrophosphate (TSPP), 1/2 cup (125 mL) of laundry detergent that contains no ammonia, 5 quarts (5 L) of 5 percent sodium hypochlorite bleach, and 15 quarts (15 L) of warm water for every 5 gal. (20 L) of solution required.

D. Abrasives for Ferrous Metal Cleaning: Aluminum oxide paper, emery paper, fine steel wool, steel scrapers, and steel-wire brushes of various sizes.

2.2 PAINT REMOVERS

A. Solvent-Type Paste Paint Remover: Manufacturer's standard water-rinsable, solvent-type paste or gel formulation for removing paint from masonry, stone, wood, plaster, or metal as required to suit Project.

B. Low-Odor, Solvent-Type Paste Paint Remover: Manufacturer's standard low-odor, water-rinsable, solvent-type paste, gel, or foamed emulsion formulation for removing paint from masonry, stone, wood, plaster, or metal as required to suit Project; and containing no methanol or methylene chloride.
1. Products: Subject to compliance with requirements, provide one of the following:
    a. ABR Products, Inc.; ABR Citrus Paint Removers .
    b. Cathedral Stone Products, Inc.; S-301 .
    c. Dumond Chemicals, Inc.; Peel Away 7 without paper covering .
    d. EaCo Chem, Inc.; InStrip.
    e. PROSOCO, Inc.; Enviro Klean SafStrip .

2.3 PAINT, GENERAL

A. Material Compatibility:
1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

B. Colors: As selected by Architect from full range of industry colors.

2.4 PAINT MATERIALS, GENERAL

A. MPI Standards: Provide products that comply with MPI standards indicated and that are listed in its "MPI Approved Products List."

B. VOC Content: For field applications[that are inside the weatherproofing system], paints and coatings shall comply with VOC content limits of authorities having jurisdiction and the following VOC content limits:
1. Flat Paints and Coatings: 50 g/L.
2. Nonflat Paints and Coatings: 50 g/L.
3. Dry-Fog Coatings: 150 g/L.
4. Primers, Sealers, and Undercoaters: 100 g/L.
5. Zinc-Rich Industrial Maintenance Primers: 100 g/L.
6. Floor Coatings: 50 g/L.
7. Stains: 100 g/L.

C. Low-Emitting Materials: For field applications that are inside the weatherproofing system, 90 percent of paints and coatings shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. Transition Coat: Paint manufacturer's recommended coating for use where a residual existing coating is incompatible with the paint system.

2.5 PAINT MATERIAL MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide products indicated in "Paint Materials" Article or comparable product by one of the following:
   1. <**Insert, in separate subparagraphs, manufacturer's name**>.

2.6 PAINT MATERIALS

A. Primers and Sealers:
   1. Primer Sealer, Latex, Interior: MPI #50.
   2. Primer, Stain Blocking, Water Based: MPI #137.

B. Metal Primers:
   1. Primer, Rust-Inhibitive, Water Based: MPI #107.

C. Wood Primers:
   1. Primer, Latex for Exterior Wood: MPI #6.

D. Water-Based Paints:
   1. Latex, Interior, Institutional Low Odor/VOC, Flat (Gloss Level 1): MPI #143.
   2. Latex, Interior, Institutional Low Odor/VOC (Gloss Level 2): MPI #144.
   3. Latex, Interior, Institutional Low Odor/VOC (Gloss Level 3): MPI #145.
   4. Latex, Interior, Institutional Low Odor/VOC (Gloss Level 4): MPI #146.
   5. Latex, Interior, Institutional Low Odor/VOC, Semigloss (Gloss Level 5): MPI #147.

2.7 PATCHING MATERIALS

A. Wood-Patching Compound: Two-part, epoxy-resin, wood-patching compound; knife-grade formulation as recommended in writing by manufacturer for type of wood repair indicated, tooling time required for the detail of work, and site conditions. Compound shall be designed for filling voids in damaged wood materials that have deteriorated from weathering and decay. Compound shall be capable of filling deep holes and spreading to feather edge.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Abatron, Inc.; LiquidWood with WoodEpox.
      b. Advanced Repair Technology, Inc.; Primatrate with Flex-Tec HV.
      c. ConServ Epoxy LLC; Flexible Epoxy Consolidant 100 with Flexible Epoxy Patch 200.
      d. Gougeon Brothers, Inc.; West System (thickened with filler).
      e. Polymeric Systems, Inc.; QuickWood.
      f. Protective Coating Company; PC-Woody.
      g. System Three Resins, Inc.; Sculpwood.

B. Metal-Patching Compound: Two-part, polyester-resin, metal-patching compound; knife-grade formulation as recommended in writing by manufacturer for type of metal repair indicated, tooling time required for the detail of work, and site conditions. Compound shall be produced for filling metal that has deteriorated from corrosion. Filler shall be capable of filling deep holes and spreading to feather edge.

C. Cementitious Patching Compounds: Cementitious patching compounds and repair materials specifically manufactured for filling cementitious substrates and for sanding or tooling prior to repainting; formulation as recommended in writing by manufacturer for type of cementitious substrate indicated, exposure to weather and traffic, the detail of work, and site conditions.

D. Gypsum-Plaster Patching Compound: Finish coat plaster and bonding compound according to ASTM C 842 and manufacturer's written instructions.

PART 3 - EXECUTION

3.1 PROTECTION

A. Comply with each manufacturer's written instructions for protecting building and other surfaces against damage from exposure to its products. Prevent chemical solutions from coming into contact with people, motor vehicles, landscaping, buildings, and other surfaces that could be harmed by such contact.
   1. Cover adjacent surfaces with materials that are proven to resist chemical solutions being used unless the solutions will not damage adjacent surfaces. Use protective materials that are UV resistant and waterproof. Apply masking agents to comply with manufacturer's written instructions. Do not apply liquid masking agent to painted or porous surfaces. When no longer needed, promptly remove masking to prevent adhesive staining.
   2. Do not apply chemical solutions during winds of sufficient force to spread them to unprotected surfaces.

3. Neutralize and collect alkaline and acid wastes before disposal.
4. Dispose of runoff from operations by legal means and in a manner that prevents soil erosion, undermining of paving and foundations, damage to landscaping, and water penetration into building interiors.

3.2 MAINTENANCE REPAINTING, GENERAL

A. Maintenance Repainting Appearance Standard: Completed work is to have a uniform appearance as viewed by Architect from building interior at 5 feet (1.5 m) away from painted surface and from building exterior at 20 feet (6 m) away from painted surface.

B. Execution of the Work: In repainting surfaces, disturb them as minimally as possible and as follows:
1. Remove failed coatings and corrosion and repaint.
2. Verify that substrate surface conditions are suitable for repainting.
3. Allow other trades to repair items in place before repainting.

C. Mechanical Abrasion: Where mechanical abrasion is needed for the work, use gentle methods, such as scraping and lightly hand sanding, that will not abrade softer substrates, reducing clarity of detail.

D. Heat Processes: Do not use torches, heat guns, or heat plates.

3.3 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of painting work. Comply with paint manufacturer's written instructions for inspection.

B. Maximum Moisture Content of Substrates: Do not begin application of coatings unless moisture content of exposed surface is below the maximum value recommended in writing by paint manufacturer and not greater than the following maximum values when measured with an electronic moisture meter appropriate to the substrate material:
1. Concrete: 12 percent.
2. Gypsum Board: 12 percent.
3. Masonry (Clay and CMU): 12 percent.
4. Wood: 15 percent.

C. Alkalinity: Do not begin application of coatings unless surface alkalinity is within range recommended in writing by paint manufacturer. Conduct alkali testing with litmus paper on exposed plaster, cementitious, and masonry surfaces.

D. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.
1. If existing surfaces cannot be prepared to an acceptable condition for proper finishing by using specified surface-preparation methods, notify Architect in writing.

E. Begin coating application only after unsatisfactory conditions have been corrected and surfaces are dry.
1. Beginning coating application constitutes Contractor's acceptance of substrates and conditions.

3.4 PREPARATORY CLEANING

A. General: Use the gentlest, appropriate method necessary to clean surfaces in preparation for painting. Clean all surfaces, corners, contours, and interstices.

B. Detergent Cleaning: Wash surfaces by hand using clean rags, sponges, and bristle brushes. Scrub surface with detergent solution and bristle brush until soil is thoroughly dislodged and can be removed by rinsing. Use small brushes to remove soil from joints and crevices. Dip brush in solution often to ensure that adequate fresh detergent is used and that surface remains wet. Rinse with water applied by clean rags or sponges.

C. Mechanical Rust Removal:
1. Remove rust with specified abrasives for ferrous-metal cleaning. Clean to bright metal.
2. Wipe off residue with mineral spirits and either steel wool or soft rags.
3. Dry immediately with clean, soft cloths. Follow direction of grain in metal.
4. Prime immediately to prevent rust. Do not touch cleaned metal surface until primed.

3.5 PAINT REMOVAL

A. General: Remove paint where indicated. Where cleaning methods have been attempted and further removal of the paint is required because of incompatible or unsatisfactory surfaces for repainting, remove paint to extent required by conditions.

1. Application: Apply paint removers according to paint-remover manufacturer's written instructions. Do not allow paint removers to remain on surface for periods longer than those indicated or recommended in writing by manufacturer.
    a. Apply materials to all surfaces, corners, contours, and interstices, to provide a uniform final appearance without streaks.
    b. After work is complete, remove protection no longer required. Remove tape and adhesive marks.
2. Brushes: Use brushes that are resistant to chemicals being used.
    a. Metal Substrates: If using wire brushes on metal, use brushes of same metal composition as metal being treated.
    b. Wood Substrates: Do not use wire brushes.
3. Spray Equipment: Use spray equipment that provides controlled application at volume and pressure indicated, measured at nozzle. Adjust pressure and volume to ensure that spray methods do not damage surfaces.
    a. Equip units with pressure gages.
    b. Unless otherwise indicated, hold spray nozzle at least 6 inches **(**150 mm**)** from surface and apply material in horizontal, back-and-forth sweeping motion, overlapping previous strokes to produce uniform coverage.
    c. For chemical spray application, use low-pressure tank or chemical pump suitable for chemical indicated, equipped with nozzle having a cone-shaped spray.
    d. For water-spray application, use fan-shaped spray tip that disperses water at an angle of 25 to 50 degrees.
    e. For heated water-spray application, use equipment capable of maintaining temperature between 140 and 160 deg F **(**60 and 71 deg C**)** at flow rates indicated.

B. Paint Removal with Hand Tools: Remove paint manually using hand-held scrapers, wire brushes, sandpaper, and metallic wool as appropriate for the substrate material.

C. Paint Removal with Solvent-Type Paste Paint Remover:
1. Remove loose and peeling paint using water, scrapers, stiff brushes, or a combination of these. Let surface dry thoroughly.
2. Apply thick coating of paint remover to dry, painted surface with natural-fiber cleaning brush, deep-nap roller, or large paintbrush. Apply in one or two coats according to manufacturer's written instructions.
3. Allow paint remover to remain on surface for period recommended in writing by manufacturer or as determined by preconstruction testing.
4. Rinse with water applied by medium-pressure spray to remove chemicals and paint residue.
5. Use mechanical methods recommended in writing by manufacturer to remove chemicals and paint residue.
6. Repeat process if necessary to remove all paint.

3.6 SUBSTRATE REPAIR

A. General: Repair substrate surface defects that are inconsistent with the surface appearance of adjacent materials and finishes.

B. Wood Substrate:

C. Cementitious Material Substrate:

D. Gypsum-Plaster and Gypsum-Board Substrates:

E. Metal Substrate:

3.7 PAINT APPLICATION, GENERAL

A. Comply with manufacturers' written instructions for application methods unless otherwise indicated in this Section.

B. Prepare surfaces to be painted according to the Surface-Preparation Schedule and with manufacturer's written instructions for each substrate condition.

C. Apply a transition coat over incompatible existing coatings.

D. Metal Substrate: Stripe paint corners, crevices, bolts, welds, and sharp edges before applying full coat. Apply two coats to surfaces that are inaccessible after completion of the Work. Tint stripe coat different than the main coating and apply with brush.

E. Blending Painted Surfaces: When painting new substrates patched into existing surfaces or touching up missing or damaged finishes, apply coating system specified for the specific substrate. Apply final finish coat over entire surface from edge to edge and corner to corner.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage paint-remover manufacturer's factory-authorized service representative for consultation and Project-site inspection and to provide on-site assistance when requested by Architect.

B. Paint Material Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for composition and dry film thickness.
   1. Paint Composition: The following procedure may be performed at any time and as often as Owner deems necessary during the period when paints are being applied:
      a. Testing agency will sample paint materials being used. Samples of material delivered to Project site will be taken, identified, sealed, and certified in presence of Contractor.
      b. Testing agency will perform tests for compliance of paint materials with product requirements.
      c. If test results show materials being used do not comply with product requirements, Contractor shall remove noncomplying-paint materials from Project site, pay for testing, and repaint surfaces painted with rejected materials. Remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.
   2. Dry Film Thickness:
      a. Contractor shall touch up and restore painted surfaces damaged by testing.
      b. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written instructions, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written instructions.

3.9 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

END OF SECTION

SECTION 090561.13 - MOISTURE VAPOR EMISSION CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes fluid-applied, resin-based, membrane-forming systems that control the moisture-vapor-emission rate of high-moisture, interior concrete to prepare it for floor covering installation.

B. Contractor's Responsibility: Suitability of concrete slab to meet vapor emission limits as required by scheduled floor finish materials is the responsibility of the Contractor. Where concrete slab vapor emission exceeds limits, apply topical vapor retarders specified in this section.

C. Related Requirements:
1. Section 096513 "Resilient Base and Accessories."
2. Section 096519 "Resilient Tile Flooring."
3. Section 096813 "Tile Carpeting."

1.2 DEFINITIONS

A. MVE: Moisture vapor emission.

B. MVER: Moisture vapor emission rate.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Certifications: Furnish written certification that the manufacturer has verified the compatibility between the vapor retarder provided and the flooring product scheduled to be applied, including adhesives and floor leveling materials.

B. Flooring Manufacturer Acceptance of Vapor Retarder Application: Furnish a signed written statement obtained from flooring manufacturer, stating that the water vapor emission levels, after application of vapor retarders, are acceptable and suitable for their flooring application.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Employs factory-trained personnel who are available for consultation and Project-site inspection.

B. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

C. Provide the following upon request:
1. Qualification Data: For installer and manufacturer.
2. Product Test Reports: For each MVE-control system, for tests performed by manufacturer and witnessed by a qualified testing agency.
3. Preinstallation testing reports.
4. Field quality-control reports.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in original packages and containers, with seals unbroken, bearing manufacturer's labels indicating directions for storage and mixing with other components.

1.7 FIELD CONDITIONS

A. Environmental Limitations: Comply with MVE-control system manufacturer's written instructions for substrate and ambient temperatures, humidity, ventilation, and other conditions affecting system installation.
1. Store system components in a temperature-controlled environment and protected from weather and at ambient temperature of not less than 65 deg F **(**18 deg C**)** and not more than 85 deg F **(**29.4 deg C**)** at least 48 hours before use.
2. Maintain ambient temperature and relative humidity in installation areas within range recommended in writing by MVE-control system manufacturer, but not less than 65 deg F **(**18 deg C**)** or more than 85 deg F **(**29.4 deg C**)** and not less than 40 or more than 60 percent relative humidity, for 48 hours before installation, during installation, and for 48 hours after installation unless longer period is recommended in writing by manufacturer.

3. Install MVE-control systems where concrete surface temperatures will remain a minimum of 5 deg F (3 deg C) higher than the dew point for ambient temperature and relative humidity conditions in installation areas for 48 hours before installation, during installation, and for 48 hours after installation unless longer period is recommended in writing by manufacturer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. MVE-Control System Capabilities: Capable of suppressing MVE without failure where installed on concrete that exhibits the following conditions:
1. MVER: Maximum 25 lb of water/1000 sq. ft. (11.34 kg of water/92.9 sq. m) when tested according to ASTM F1869.
2. Relative Humidity: Maximum 100 percent when tested according to ASTM F2170 using in situ probes.

B. Water-Vapor Transmission: Through MVE-control system, maximum 0.10 perm (5.75 ng/Pa x s x sq. m) when tested according to ASTM E96/E96M.

C. Tensile Bond Strength: For MVE-control system, greater than 200 psi (1.38 MPa) with failure in the concrete according to ASTM D7234.

2.2 MVE-CONTROL SYSTEM

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advanced Moisture Control, Inc.
2. ARDEX Americas.
3. Dependable, LLC.
4. Floor Seal Technology, Inc.
5. ISE Logik Industries
6. KOSTER American Corporation.
7. LATICRETE SUPERCAP, LLC.
8. MAPEI Corporation.
9. Schonox, HPS North America, Inc.
10. USG Corporation.

B. MVE-Control System: ASTM F3010-qualified, fluid-applied, two-component, epoxy-resin, membrane-forming system; formulated for application on concrete substrates to reduce MVER to level required for installation of floor coverings indicated and acceptable to manufacturers of floor covering products indicated, including adhesives.
1. Substrate Primer: Provide MVE-control system manufacturer's concrete-substrate primer if required for system indicated by substrate conditions.
2. Cementitious Underlayment Primer: If required for subsequent installation of cementitious underlayment products, provide MVE-control system manufacturer's primer to ensure adhesion of products to MVE-control system.
3. VOC Content: Provide coating with VOC content of 200 g/L or less.
4. Low-Emitting Materials: Coating shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
5. VOC Content: Provide coating with VOC content of 100 g/L or less.
6. Low-Emitting Materials: Coating shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
7. Material Emissions and Pollutant Control: Coating shall comply with either of the following:
   a. Low-Emitting Materials: VOC emissions shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
   b. VOC Content: Provide coating with VOC content of 100 g/L or less.
8. Emissions Requirements: Coating shall comply with either of the following:
   a. Low-Emitting Materials: VOC emissions shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
   b. VOC Content: Provide coating with VOC content of 100 g/L or less.

2.3 ACCESSORIES

A. Patching and Leveling Material: Moisture-, mildew-, and alkali-resistant product recommended in writing by MVE-control system manufacturer and with minimum of 3000-psi **(**20.68-MPa**)** compressive strength after 28 days when tested according to ASTM C109/C109M.

B. Crack-Filling Material: Resin-based material recommended in writing by MVE-control system manufacturer for sealing concrete substrate crack repair.

C. Cementitious Underlayment: If required to maintain manufacturer's warranty, provide MVE-control system manufacturer's hydraulic cement-based underlayment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for maximum moisture content, installation tolerances, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
1. Installation of system indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Preinstallation Testing:
1. Testing Agency: Engage a qualified testing agency to perform tests.
2. Alkalinity Testing: Perform pH testing according to ASTM F710. Install MVE-control system in areas where pH readings are less than 7.0 and in areas where pH readings are greater than 8.5.
3. Moisture Testing: Perform tests so that each test area does not exceed [200 sq. ft. **(**18.6 sq. m**)**] [1000 sq. ft. **(**304.8 sq. m**)**] <**Insert dimension**>, and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
   a. Anhydrous Calcium Chloride Test: ASTM F1869. Install MVE-control system in locations where concrete substrate MVER exceeds 3 lb of water/1000 sq. ft. **(**1.36 kg of water/92.9 sq. m**)** in 24 hours.
   b. Internal Relative Humidity Test: Using in situ probes, ASTM F2170. Install MVE-control system in locations where concrete substrates exhibit relative humidity level greater than 75 percent.
4. Tensile-Bond-Strength Testing: For typical locations indicated to receive installation of MVE-control system, install minimum 100-sq. ft. **(**9.29-sq. m**)** area of MVE-control system to prepared concrete substrate and test according to ASTM D7234.
   a. Proceed with installation only where tensile bond strength is greater than 200 psi **(**1.38 MPa**)** with failure in the concrete.

B. Concrete Substrates: Prepare and clean substrates according to MVE-control system manufacturer's written instructions to ensure adhesion of system to concrete.
1. Remove coatings and other substances that are incompatible with MVE-control system and that contain soap, wax, oil, or silicone, using mechanical methods recommended in writing by MVE-control system manufacturer. Do not use solvents.
2. Provide concrete surface profile complying with ICRI 310.2R CSP 3 by shot blasting using apparatus that abrades the concrete surface with shot, contains the dispensed shot within the apparatus, and recirculates the shot by vacuum pickup.
3. After shot blasting, repair damaged and deteriorated concrete according to MVE-control system manufacturer's written instructions.
4. Protect substrate voids and joints to prevent resins from flowing into or leaking through them.
5. Fill surface depressions and irregularities with patching and leveling material.
6. Fill surface cracks, grooves, control joints, and other nonmoving joints with crack-filling material.
7. Allow concrete to dry, undisturbed, for period recommended in writing by MVE-control system manufacturer after surface preparation, but not less than 24 hours.
8. Before installing MVE-control systems, broom sweep and vacuum prepared concrete.

C. Protect walls, floor openings, electrical openings, door frames, and other obstructions during installation.

3.3 INSTALLATION

A. Install MVE-control system according to ASTM F3010 and manufacturer's written instructions to produce a uniform, monolithic surface free of surface deficiencies such as pin holes, fish eyes, and voids.

1. Install primers as required to comply with manufacturer's written instructions.

B. Do not apply MVE-control system across substrate expansion, isolation, and other moving joints.

C. Apply system, including component coats if any, in thickness recommended in writing by MVE-control system manufacturer for MVER indicated by preinstallation testing.

D. Cure MVE-control system components according to manufacturer's written instructions. Prevent contamination or other damage during installation and curing processes.

E. After curing, examine MVE-control system for surface deficiencies. Repair surface deficiencies according to manufacturer's written instructions.

F. Install cementitious underlayment over cured membrane if required to maintain manufacturer's warranty and in thickness required to maintain the warranty.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform installation inspections.

B. Installation Inspections: Inspect substrate preparation and installation of system components to ensure compliance with manufacturer's written instructions and to ensure that a complete MVE-control system is installed without deficiencies.
1. Verify that surface preparation meets requirements.
2. Verify that component coats and complete MVE-control-system film thicknesses comply with manufacturer's written instructions.
3. Verify that MVE-control-system components and installation areas that evidence deficiencies are repaired according to manufacturer's written instructions.

C. MVE-control system will be considered defective if it does not pass inspections.

3.5 PROTECTION

A. Protect MVE-control system from damage, wear, dirt, dust, and other contaminants before floor covering installation. Use protective methods and materials, including temporary coverings, recommended in writing by MVE-control system manufacturer.

B. Do not allow subsequent preinstallation examination and testing for floor covering installation to damage, puncture, or otherwise compromise the MVE-control system membrane.

END OF SECTION

SECTION 092116.23 - GYPSUM BOARD SHAFT WALL ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes gypsum board shaft wall assemblies.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
   1. Review requirements for control joint locations.

1.3 ACTION SUBMITTALS

A. Product Data: For each component of gypsum board shaft wall assembly.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and support them on risers on a flat platform to prevent sagging.

1.5 FIELD CONDITIONS

A. Environmental Limitations: Comply with gypsum-shaftliner-board manufacturer's written instructions.

B. Do not install finish panels until installation areas are enclosed and conditioned. Use moisture- and mold-resistant panels or moisture- and mold-resistant fiberglass-mat faced panels if installation must take place prior to installation area being enclosed and conditioned.

C. Do not install panels that are wet, moisture damaged, or mold damaged.
   1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, and irregular shape.
   2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E119 by an independent testing agency.

B. STC-Rated Assemblies: Provide materials and construction identical to those of assemblies tested according to ASTM E90 and classified according to ASTM E413 by a testing and inspecting agency.

2.2 GYPSUM BOARD SHAFT WALL ASSEMBLIES

A. Fire-Resistance Rating: As indicated on Drawings .

B. STC Rating: As indicated on Drawings .

C. Gypsum Shaftliner Board:
   1. Type X: ASTM C1396/C1396M; manufacturer's proprietary fire-resistive liner panels with paper faces, 1 inch **(**25.4 mm**)** thick, with double beveled long edges.
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) American Gypsum.
         2) CertainTeed Corporation.
         3) Continental Building Products, LLC.
         4) Georgia-Pacific Gypsum LLC.
         5) National Gypsum Company.
         6) PABCO Gypsum.
         7) USG Corporation.

D. Non-Load-Bearing Steel Framing, General: Complying with ASTM C645 requirements for metal unless otherwise indicated and complying with requirements for fire-resistance-rated assembly indicated.

1. Protective Coating: Coating with equivalent corrosion resistance of ASTM A653/A653M, G40 (Z120) ASTM A653/A653M, G40 (Z120), hot-dip galvanized ASTM A653/A653M, G60 (Z180), hot-dip galvanized unless otherwise indicated.

E. Studs: Manufacturer's standard profile for repetitive, corner, and end members as follows:
1. Depth: As indicated .
2. Minimum Base-Metal Thickness: As indicated .

F. Runner Tracks: Manufacturer's standard J-profile track with manufacturer's standard long-leg length, but at least 2 inches (51 mm) Insert dimension long and matching studs in depth.
1. Minimum Base-Metal Thickness: As indicated .

G. Firestop Tracks: Top runner manufactured to allow partition heads to expand and contract with movement of the structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CEMCO; California Expanded Metal Products Co.
   b. ClarkDietrich.
   c. Fire Trak Corp.
   d. MarinoWARE.
   e. Metal-Lite.
   f. SCAFCO Steel Stud Company.
   g. Steel Construction Systems.
   h. The Steel Network, Inc.

H. Elevator-Hoistway-Entrance Struts: Manufacturer's standard J-profile jamb strut with long-leg length of 3 inches (76 mm), matching studs in depth, and not less than 0.033 inch (0.84 mm) thick.

I. Finish Panels: As indicated. .

2.3 AUXILIARY MATERIALS

A. Provide auxiliary materials that comply with shaft wall manufacturer's written instructions.

B. Trim Accessories: Cornerbead, edge trim, and control joints of material and shapes as specified in Section 092900 "Gypsum Board" that comply with gypsum board shaft wall assembly manufacturer's written instructions for application indicated.

C. Steel Drill Screws: ASTM C1002 unless otherwise indicated.

D. Track Fasteners: Power-driven fasteners of size and material required to withstand loading conditions imposed on shaft wall assemblies without exceeding allowable design stress of track, fasteners, or structural substrates in which anchors are embedded.
1. Expansion Anchors: Fabricated from corrosion-resistant materials, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing per ASTM E488/E488M conducted by a qualified testing agency.
2. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with allowable load capacities calculated according to ICC-ES AC70, greater than or equal to the design load, as determined by testing per ASTM E1190 conducted by a qualified testing agency.

E. Reinforcing: Galvanized-steel reinforcing strips with 0.033-inch (0.84-mm) minimum thickness of base metal (uncoated).

F. Acoustical Sealant: Section 079219 "Acoustical Joint Sealants."

G. Gypsum Board Cants:
1. Gypsum Board Panels: As specified in Section 092900 "Gypsum Board," Type X, 1/2- or 5/8-inch (13- or 16-mm) panels.
2. Adhesive: Laminating adhesive as specified in Section 092900 "Gypsum Board."
3. Non-Load-Bearing Steel Framing: As specified in Section 092216 "Non-Structural Metal Framing."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine panels before installation. Reject panels that are wet, moisture damaged, or mold damaged.

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

3.2 PREPARATION

A. Sprayed Fire-Resistive Materials: Coordinate with gypsum board shaft wall assemblies so both elements of Work remain complete and undamaged. Patch or replace sprayed fire-resistive materials removed or damaged during installation of shaft wall assemblies to comply with requirements specified in Section 078100 "Applied Fire Protection."

B. After sprayed fire-resistive materials are applied, remove only to extent necessary for installation of gypsum board shaft wall assemblies and without reducing the fire-resistive material thickness below that which is required to obtain fire-resistance rating indicated. Protect remaining fire-resistive materials from damage.

3.3 INSTALLATION

A. General: Install gypsum board shaft wall assemblies to comply with requirements of fire-resistance-rated assemblies indicated and manufacturer's written installation instructions.

B. Do not bridge building expansion joints with shaft wall assemblies; frame both sides of expansion joints with furring and other support.

C. Install supplementary framing in gypsum board shaft wall assemblies around openings and as required for blocking, bracing, and support of gravity and pullout loads of fixtures, equipment, services, heavy trim, furnishings, wall-mounted door stops, and similar items that cannot be supported directly by shaft wall assembly framing.
   1. Elevator Hoistway: At elevator hoistway-entrance door frames, provide jamb struts on each side of door frame.
   2. Reinforcing: Provide where items attach directly to shaft wall assembly as indicated on Drawings; accurately position and secure behind at least one layer of face panel.

D. Penetrations: At penetrations in shaft wall, maintain fire-resistance rating of shaft wall assembly by installing supplementary steel framing around perimeter of penetration and fire protection behind boxes containing wiring devices, elevator call buttons and floor indicators, and similar items.

E. Isolate perimeter of gypsum panels from building structure to prevent cracking of panels while maintaining continuity of fire-rated construction.

F. Firestop Tracks: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.

G. Control Joints: Install control joints according to ASTM C840, including compliance with ASTM 20.3.1 - 20.4 for control joint spacing, whether or not such joints are indicated on Drawings, in specific locations approved by Architect and as follows, while maintaining fire-resistance rating of gypsum board shaft wall assemblies.
   1. Install at changes in backup material.
   2. Framed Openings (Both Sides of Partition):
      a. Doors: Install above both jambs unless indicated or directed otherwise.
      b. Glazed Openings: Install above and below both jambs unless indicated or directed otherwise.

H. Install at other locations indicated on Drawings.

I. Sound-Rated Shaft Wall Assemblies: Seal gypsum board shaft walls with acoustical sealant at perimeter of each assembly where it abuts other work and at joints and penetrations within each assembly.

J. Gypsum Board Cants: At projections into shaft exceeding 4 inches **(**102 mm**)**, install gypsum board cants covering tops of projections.

1. Slope cant panels at least 75 degrees from horizontal. Set base edge of panels in adhesive and secure top edges to shaft walls at 24 inches **(**610 mm**)** o.c. with screws fastened to shaft wall framing.
2. Where non-load-bearing steel framing is required to support gypsum board cants, install framing at 24 inches **(**610 mm**)** o.c. and extend studs from the projection to shaft wall framing.

K. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch **(**3 mm**)** from the plane formed by faces of adjacent framing.

3.4 PROTECTION

A. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

B. Remove and replace panels that are wet, moisture damaged, or mold damaged.
1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, and irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION

SECTION 092216 - NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Framing systems.
2. Suspension systems.
3. Grid suspension systems.

1.2 ACTION SUBMITTALS

A. Product Data:
1. Framing systems.
2. Suspension systems.
3. Grid suspension systems.

1.3 QUALITY ASSURANCE

A. Code-Compliance Certification of Studs and Tracks: Provide documentation that framing members are certified according to the product-certification program of the Certified Steel Stud Association the Steel Framing Industry Association the Steel Stud Manufacturers Association the Supreme Steel Framing System Association.

B. Provide the following upon request:
1. Product Certificates: For each type of code-compliance certification for studs and tracks.
2. Evaluation Reports: For firestop tracks post-installed anchors and power-actuated fasteners, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Notify manufacturer of damaged materials received prior to installation.

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

C. Protect cold-formed metal framing from corrosion, deformation, and other damage during delivery, storage, and handling as required by AISI S202, "Code of Standard Practice for Cold-Formed Steel Structural Framing."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For fire-resistance-rated assemblies that incorporate non-load-bearing steel framing, provide materials and construction identical to those tested in assembly indicated, in accordance with ASTM E119 by an independent testing agency.

B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated on Drawings, in accordance with ASTM E90 and classified in accordance with ASTM E413 by an independent testing agency.

2.2 FRAMING SYSTEMS

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Framing Members, General: Comply with AISI S220 and ASTM C645, Section 10 for conditions indicated.
1. Steel Sheet Components: Comply with AISI S220 and ASTM C645, Section 10 requirements for metal unless otherwise indicated
2. Protective Coating: Comply with AISI S220; ASTM A653/A653M, G60 **(**Z180**)**; or coating with equivalent corrosion resistance. Galvannealed products are unacceptable.
a. Coating demonstrates equivalent corrosion resistance with an evaluation report acceptable to authorities having jurisdiction.

C. Studs and Track: AISI S220 and ASTM C645, Section 10 .
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. CEMCO; California Expanded Metal Products Co.

b. ClarkDietrich.
c. Custom Stud.
d. Jaimes Industries.
e. MarinoWARE.
f. MBA Building Supplies.
g. MRI Steel Framing, LLC.
h. Phillips Manufacturing Co.
i. SCAFCO Steel Stud Company.
j. Steel Construction Systems.
k. Steel Network, Inc. (The).
l. Telling Industries.

2. Minimum Base-Steel Thickness: As indicated on Drawings .
3. Depth: As indicated on Drawings .

D. Slip-Type Head Joints: Where indicated, provide[**one of**] the following:
1. Clip System: Clips designed for use in head-of-wall deflection conditions that provide a positive attachment of studs to tracks while allowing 1-1/2-inch **(**38-mm**)** 2-inch **(**51-mm**)** 2-1/2-inch **(**64-mm**)** 3-inch **(**76-mm**)** Insert dimension minimum vertical movement.
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) CEMCO; California Expanded Metal Products Co.
2) ClarkDietrich.
3) Fire Trak Corp.
4) MarinoWARE.
5) SCAFCO Steel Stud Company.
6) Steel Construction Systems.
7) Steel Network, Inc. (The).
8) Super Stud Building Products Inc.
2. Single Long-Leg Track System: Top track with 2-inch- **(**51-mm-**)** deep flanges in thickness not less than indicated for studs, installed with studs friction fit into top track and with continuous bridging located within 12 inches **(**305 mm**)** of the top of studs to provide lateral bracing.
3. Double-Track System: Top outer tracks, inside track with 2-inch- **(**51-mm-**)** deep flanges in thickness not less than indicated for studs and fastened to studs, and outer track sized to friction-fit over inner track.
4. Deflection Track: Steel sheet top track manufactured to prevent cracking of finishes applied to interior partition framing resulting from deflection of structure above; in thickness not less than indicated for studs and in width to accommodate depth of studs.
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) CEMCO; California Expanded Metal Products Co.
2) ClarkDietrich.
3) MarinoWARE.
4) MBA Building Supplies.
5) Metal-Lite.
6) SCAFCO Steel Stud Company.
7) Steel Construction Systems.
8) Steel Network, Inc. (The).
9) Telling Industries.

E. Firestop Tracks: Top track manufactured to allow partition heads to expand and contract with movement of structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ClarkDietrich.
b. Fire Trak Corp.
c. MarinoWARE.
d. Metal-Lite.

F. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ClarkDietrich.
b. MarinoWARE.
c. MBA Building Supplies.

d. MRI Steel Framing, LLC.
e. SCAFCO Steel Stud Company.
f. Steel Construction Systems.
g. Steel Network, Inc. (The).

2. Minimum Base-Steel Thickness: As indicated on Drawings .

G. Cold-Rolled Channel Bridging: Steel, 0.0538-inch (1.367-mm) minimum base-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ClarkDietrich.
b. MarinoWARE.
c. MBA Building Supplies.
d. MRI Steel Framing, LLC.
e. SCAFCO Steel Stud Company.
f. Steel Construction Systems.
2. Depth: As indicated on Drawings .
3. Clip Angle: Not less than 1-1/2 by 1-1/2 inches (38 by 38 mm), 0.068-inch- (1.72-mm-) thick, galvanized steel.

H. Hat-Shaped, Rigid Furring Channels:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ClarkDietrich.
b. Jaimes Industries.
c. MarinoWARE.
d. MBA Building Supplies.
e. MRI Steel Framing, LLC.
f. SCAFCO Steel Stud Company.
g. Steel Construction Systems.
2. Minimum Base-Steel Thickness: As indicated on Drawings .
3. Depth: As indicated on Drawings 7/8 inch (22.2 mm) 1-1/2 inches (38 mm).

I. Resilient Furring Channels: 1/2-inch- (13-mm-) deep, steel sheet members designed to reduce sound transmission.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ClarkDietrich.
b. MarinoWARE.
c. MBA Building Supplies.
d. MRI Steel Framing, LLC.
e. SCAFCO Steel Stud Company.
f. Steel Construction Systems.
2. Configuration: hat shaped.

J. Cold-Rolled Furring Channels: 0.053-inch (1.34-mm) uncoated-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges.
1. Depth: As indicated on Drawings .
2. Furring Brackets: Adjustable, corrugated-edge-type steel sheet with minimum uncoated-steel thickness of 0.0329 inch (0.8 mm).
3. Tie Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.59-mm-) diameter wire, or double strand of 0.048-inch- (1.21-mm-) diameter wire.

K. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches (32 mm), wall attachment flange of 3/4 inch (19 mm), minimum uncoated-steel thickness of 0.0179 inch (0.455 mm), and depth required to fit insulation thickness indicated.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ClarkDietrich.
b. MarinoWARE.
c. MBA Building Supplies.
d. MRI Steel Framing, LLC.
e. SCAFCO Steel Stud Company.
f. Steel Construction Systems.
g. Steel Network, Inc. (The).

2.3 SUSPENSION SYSTEMS

A. Tie Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.59-mm-) diameter wire, or double strand of 0.048-inch- (1.21-mm-) diameter wire.

B. Hanger Attachments to Concrete:
1. Post-Installed Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC01, AC193, AC58, or AC308 as appropriate for the substrate.
   a. Uses: Securing hangers to structure.
   b. Type: Torque-controlled, expansion anchor .
   c. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B633 or ASTM F1941 (ASTM F1941M), Class Fe/Zn 5, unless otherwise indicated.
   d. Material for Exterior or Interior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) Group 2 (A4) stainless steel bolts, ASTM F593 (ASTM F738M), and nuts, ASTM F594 (ASTM F836M).
2. Power-Actuated Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

C. Wire Hangers: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.16 inch (4.12 mm) in diameter.

D. Wire Hangers: ASTM A641/A641M, Class 1 zinc coating, soft temper of the following sizes:
1. 0.15 inch (3.80 mm) in diameter when spacing is 3'-0" by 4'-0".
2. 0.16 inch (4.12 mm) in diameter when spacing is 4'-0" by 4'-0".

E. Flat Hangers: Steel sheet, in size indicated on Drawings .

F. Carrying Channels (Main Runners): Cold-rolled, commercial-steel sheet with a base-steel thickness of 0.0538 inch (1.367 mm) and minimum 1/2-inch- (13-mm-) wide flanges.
1. Depth: As indicated on Drawings .

G. Carrying Channels: 1-1/2 inch hot-rolled channels weighing 1.12 pounds per foot.

H. Furring Channels (Furring Members):
1. Cold-Rolled Channels: 0.0538-inch (1.367-mm) uncoated-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges, 3/4 inch (19 mm) deep.
2. Steel Studs and Tracks:
   a. Minimum Base-Steel Thickness: As indicated on Drawings .
   b. Depth: As indicated on Drawings .
3. Hat-Shaped, Rigid Furring Channels: 7/8 inch (22 mm) deep.
   a. Minimum Base-Steel Thickness: As indicated on Drawings .
4. Resilient Furring Channels: 1/2-inch- (13-mm-) deep members designed to reduce sound transmission.
   a. Configuration: hat shaped.

2.4 GRID SUSPENSION SYSTEMS

A. Grid Suspension Systems for Gypsum Board Ceilings: ASTM C635, direct-hung system composed of main beams and cross-furring members that interlock.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong Ceiling & Wall Solutions.
   b. Certainteed; SAINT-GOBAIN.
   c. Rockfon; ROCKWOOL International.
   d. USG Corporation.

2.5 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards.
1. Fasteners for Steel Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

B. Isolation Strip at Exterior Walls: Provide[**one of**] the following:
1. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch (3.2 mm) thick, in width to suit steel stud size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance of the Work.

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

3.2 PREPARATION

A. Suspended Assemblies: Coordinate installation of suspension systems with installation of overhead structure to ensure that inserts and other provisions for anchorages to building structure have been installed to receive hangers at spacing required to support the Work and that hangers will develop their full strength.
   1. Furnish concrete inserts and other devices indicated to other trades for installation in advance of time needed for coordination and construction.

B. Coordination with Sprayed Fire-Resistive Materials:
   1. Before sprayed fire-resistive materials are applied, attach offset anchor plates or ceiling tracks to surfaces indicated to receive sprayed fire-resistive materials. Where offset anchor plates are required, provide continuous plates fastened to building structure not more than 24 inches **(**610 mm**)** o.c.
   2. After sprayed fire-resistive materials are applied, remove them only to extent necessary for installation of non-load-bearing steel framing. Do not reduce thickness of fire-resistive materials below that are required for fire-resistance ratings indicated. Protect adjacent fire-resistive materials from damage.

3.3 INSTALLATION, GENERAL

A. Installation Standard: ASTM C754.
   1. Gypsum Plaster Assemblies: Also comply with requirements in ASTM C841 that apply to framing installation.
   2. Portland Cement Plaster Assemblies: Also comply with requirements in ASTM C1063 that apply to framing installation.
   3. Gypsum Veneer Plaster Assemblies: Also comply with requirements in ASTM C844 that apply to framing installation.
   4. Gypsum Board Assemblies: Also comply with requirements in ASTM C840 that apply to framing installation.

B. Install framing and accessories plumb, square, and true to line, with connections securely fastened.

C. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.

D. Install bracing at terminations in assemblies.

E. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

3.4 INSTALLATION OF FRAMING SYSTEMS

A. Install framing system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.
   1. Single-Layer Application: As required by horizontal deflection performance requirements unless otherwise indicated.
   2. Multilayer Application: As required by horizontal deflection performance requirements unless otherwise indicated.
   3. Tile Backing Panels: As required by horizontal deflection performance requirements unless otherwise indicated.

B. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.

C. Install studs so flanges within framing system point in same direction.

D. Install tracks at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings except where partitions are indicated to terminate at suspended ceilings. Continue framing around ducts that penetrate partitions above ceiling.
   1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
   2. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install track section (for cripple studs) at head and secure to jamb studs.
      a. Install two studs at each jamb unless otherwise indicated.
      b. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch **(**13-mm**)** clearance from jamb stud to allow for installation of control joint in finished assembly.
      c. Extend jamb studs through suspended ceilings and attach to underside of overhead structure.
   3. Other Framed Openings: Frame openings other than door openings the same as required for door openings unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.
   4. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.
      a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.
   5. Sound-Rated Partitions: Install framing to comply with sound-rated assembly indicated.
   6. Curved Partitions:
      a. Bend track to uniform curve and locate straight lengths so they are tangent to arcs.
      b. Begin and end each arc with a stud, and space intermediate studs equally along arcs. On straight lengths of no fewer than two studs at ends of arcs, place studs 6 inches **(**150 mm**)** o.c.

E. Direct Furring:
   1. Screw to wood framing.
   2. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches **(**610 mm**)** o.c.

F. Z-Shaped Furring Members:
   1. Erect insulation, specified in Section 072100 "Thermal Insulation," vertically and hold in place with Z-shaped furring members spaced [24 inches **(**610 mm**)**] <**Insert dimension**> o.c.
   2. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches **(**610 mm**)** o.c.
   3. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches **(**305 mm**)** from corner and cut insulation to fit.

G. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch **(**3 mm**)** from the plane formed by faces of adjacent framing.

3.5 INSTALLATION OF SUSPENSION SYSTEMS

A. Install suspension system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

B. Install in accordance with DSA IR 25-3.
   1. Hangers: 48 inches **(**1219 mm**)** o.c.
   2. Carrying Channels (Main Runners): 48 inches **(**1219 mm**)** o.c.
   3. Furring Channels (Furring Members): 16 inches **(**406 mm**)** o.c.

C. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

D. Suspend hangers from building structure as follows:
   1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or suspension system.
      a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.

2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with locations of hangers required to support standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.
   a. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced installation standards.
3. Wire Hangers: Secure by looping and wire tying, either directly to structures or to inserts, eye screws, or other devices and fasteners that are secure and appropriate for substrate, and in a manner that will not cause hangers to deteriorate or otherwise fail.
4. Flat Hangers: Secure to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices and fasteners that are secure and appropriate for structure and hanger, and in a manner that will not cause hangers to deteriorate or otherwise fail.
5. Do not attach hangers to steel roof deck.
6. Do not attach hangers to permanent metal forms. Furnish cast-in-place hanger inserts that extend through forms.
7. Do not attach hangers to rolled-in hanger tabs of composite steel floor deck.
8. Do not connect or suspend steel framing from ducts, pipes, or conduit.

E. Fire-Resistance-Rated Assemblies: Wire tie furring channels to supports.

F. Seismic Bracing: Sway-brace suspension systems with hangers used for support.

3.6 INSTALLATION OF GRID SUSPENSION SYSTEMS

A. Grid Suspension Systems: Attach perimeter wall track or angle where grid suspension systems meet vertical surfaces. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.

3.7 FIELD QUALITY CONTROL

A. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet **(**3 mm in 3.6 m**)** measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION

SECTION 092900 - GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Interior gypsum board.
2. Exterior gypsum board for ceilings and soffits.
3. Backing panels.

B. Related Requirements:
1. Section 061600 "Sheathing" for gypsum sheathing for exterior walls.
2. Section 079219 "Acoustical Joint Sealants" for acoustical joint sealants installed in gypsum board assemblies.
3. Section 092116.23 "Gypsum Board Shaft Wall Assemblies" for metal shaft-wall framing, gypsum shaft liners, and other components of shaft-wall assemblies.
4. Section 092216 "Non-Structural Metal Framing" for non-structural steel framing and suspension systems that support gypsum board panels.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
1. Review requirements for control joint locations.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show locations and installation of control and expansion joints, including plans, elevations, sections, details of components, and attachments to other work.

1.4 MOCKUPS

A. Build mockups of at least 100 sq. ft. **(**9 sq. m**)** in surface area to demonstrate aesthetic effects and to set quality standards for materials and execution.
1. Build mockups for the following:
a. Each level of gypsum board finish indicated for use in exposed locations.
b. Each texture finish indicated.
2. Apply or install final decoration indicated, including painting and wallcoverings, on exposed surfaces for review of mockups.
3. Simulate finished lighting conditions for review of mockups.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE AND HANDLING

A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and supported on risers on a flat platform to prevent sagging.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Comply with ASTM C840 requirements or gypsum board manufacturer's written instructions, whichever are more stringent.

B. Do not install paper-faced gypsum panels until installation areas are enclosed and conditioned. Use mold-resistant gypsum board or glass-mat interior gypsum board if installation must take place prior to installation areas being enclosed and conditioned.

C. Do not install panels that are wet, moisture damaged, and mold damaged.
1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of gypsum panel and joint finishing material from single source with resources to provide products of consistent quality in appearance and physical properties.

2.2 PERFORMANCE REQUIREMENTS

A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E119 by an independent testing agency.

B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E90 and classified according to ASTM E413 by an independent testing agency.

2.3 GYPSUM BOARD, GENERAL

A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

B. Size: Provide maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

2.4 INTERIOR GYPSUM BOARD

A. Gypsum Board, Type X: ASTM C1396/C1396M.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Gypsum.
      b. Certainteed; SAINT-GOBAIN.
      c. Continental Building Products, LLC.
      d. Georgia-Pacific Gypsum LLC.
      e. National Gypsum Company.
      f. PABCO Gypsum.
      g. Panel Rey.
      h. USG Corporation; EcoSmart Panels Firecode X (Basis-of-Design).
   2. Thickness: 5/8 inch **(**15.9 mm**)**.
   3. Long Edges: Tapered .

2.5 BACKING PANELS

A. Glass-Mat, Water-Resistant Backing Board: ASTM C1178/C1178M, with manufacturer's standard edges.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Certainteed; SAINT-GOBAIN.
      b. Georgia-Pacific Gypsum LLC.
      c. National Gypsum Company.
      d. USG Corporation.
   2. Core: As indicated on Drawings .
   3. Mold Resistance: ASTM D3273, score of 10 as rated according to ASTM D3274.

B. Cementitious Backer Units: ANSI A118.9 and ASTM C1288 or ASTM C1325, with manufacturer's standard edges.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Certainteed; SAINT-GOBAIN.
      b. National Gypsum Company.
      c. USG Corporation.
   2. Thickness: As indicated on Drawings.
   3. Mold Resistance: ASTM D3273, score of 10 as rated according to ASTM D3274.

2.6 TRIM ACCESSORIES

A. Interior Trim: ASTM C1047.
   1. Material: Galvanized or aluminum-coated steel sheet, rolled zinc, plastic, or paper-faced galvanized-steel sheet Paper-faced galvanized-steel sheet.
   2. Shapes:
      a. Cornerbead.
      b. LC-Bead: J-shaped; exposed long flange receives joint compound.

c. L-Bead: L-shaped; exposed long flange receives joint compound.
d. U-Bead: J-shaped; exposed short flange does not receive joint compound.
e. Expansion (control) joint.
f. Curved-Edge Cornerbead: With notched or flexible flanges.
g. Base-of-Wall Galvanized Moisture Barrier Trim: Galvanized-steel sheet, 2 inches **(**50 mm**)** high.
1) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a) Telling Industries; VersaDry Drywall Track System.

B. Acoustical Mullion Trim Covers.
1. General: Provide sound barrier mullion trim caps of design, basic profile, materials, and operation indicated. Provide units with capability to accommodate variations in adjacent surfaces.
a. Furnish units in lengths of sufficient additional length to allow for field trimming to required length to match variations in construction tolerances of adjacent systems.
2. Partition Closures:
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Mull-It-Over Products; Mullion trim cap
b. Profile: 55 Classic Mullion Trim Cap.
1) Performance requirements:
a) Single sided installations: STC 50 or higher.
b) Double-sided installations: [**STC 55**] [**STC 60**] or higher.
2) Thermal movements: Allow for thermal movements from ambient and surface temperature changes.
a) Mullion trim cap to be sized to accomodate thermal movement.
3) Finish and Color: Match adjacent aluminum mullion.
c. Components:
1) Aluminum Extrusions:
a) Thickness: 0.125 inches.
b) Profile: As selected and approved by Architect to allow solid attachment and fastening to the partition wall framing.
2) Sound Absorbing Composite:
a) Resistant to smoke, flame, and microbial growth.
b) Fire Rating: ASTM E 84 Class 1.
c) Fungi Resistance: Zero rating per ASTM G 21.
3) Intumescent Layer: Manufacturer's standard at rated closure locations.
4) Compressible Foam Gasket: Between edge of extrusion and interior face of curtain wall glass.
a) Thickness: [Standard, 1/2 inch **(**12.7 mm**)**], [3/4 inch **(**19.1 mm**)**], [1 inch **(**25.4 mm**)**] or [1-1/2 inch **(**38.1 mm**)**] as required to accommodate mullion deflection.
b) Color: As selected by Architect.
5) Fasteners:
a) Self Tapping or appropriate threaded fastener.
b) Compatible with all materials fasteners will contact with and not causing galvanic corrosion.
6) Snap Cover: Snap-on fastener cover.
a) Acoustical Sound Sealant: Acrylic latex based.
3. Isolation Strip at Window Mullions:
a. Foam Gasket: Adhesive-backed, closed-cell neoprene foam strips, 1/4 inch **(**3.2 mm**)** thick, in width to suit mullion size.
b. Solid Rubber Gasket: Neoprene rubber strip with offset pressure-sensitive adhesive; 1/8 inch thick by 1-1/2 inch wide.
1) Product: STC Sound Control; Mullion Seal, or equal.
4. Partition Closures:
a. Products: Gordon, Inc.; Mullion Mate [**Series 30**][**Series 40 Plus**].
1) Profile [**Mullion Mate 3**][**Mullion Mate 4**][**Mullion Mate 5**][**Mullion Mate 7**][**Mullion Mate 9**].
2) Finish: Match aluminum window wall mullion.
3) Sound Transmission: [**STC 35**][**STC 38**]

4) End Caps:
[**MMEC-375**][**MMEC-487**][**MMEC-600**][**MMEC-725**][**MMECBF-518**][**MMECBF-514**][**MMECBF-512**][**MMECBF-618**][**MMECBF-812**].

C. Exterior Trim: ASTM C1047.
1. Material: [**Hot-dip galvanized-steel sheet, plastic, or rolled zinc**] <**Insert material**>.
2. Shapes:
a. Cornerbead.
b. LC-Bead: J-shaped; exposed long flange receives joint compound.
c. Expansion (Control) Joint: One-piece, rolled zinc with V-shaped slot and removable strip covering slot opening.

D. Aluminum Trim: Extruded accessories of profiles and dimensions indicated.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Flannery, Inc.
b. Fry Reglet Corporation.
c. Gordon, Inc.
d. Pittcon Industries.
e. Tamlyn.
2. Aluminum: Alloy and temper with not less than the strength and durability properties of ASTM B221 **(**ASTM B221M**)**, Alloy 6063-T5.
3. Finish: Corrosion-resistant primer compatible with joint compound and finish materials specified.

2.7 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C475/C475M.

B. Joint Tape:
1. Interior Gypsum Board: Paper.
2. Exterior Gypsum Soffit Board: Paper.
3. Glass-Mat Gypsum Sheathing Board: 10-by-10 glass mesh.
4. Backing Panels: As recommended by panel manufacturer.

C. Joint Compound for Interior Gypsum Board: For each coat, use formulation that is compatible with other compounds applied on previous or for successive coats.
1. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping compound.
a. Use setting-type compound for installing paper-faced metal trim accessories.
2. Fill Coat: For second coat, use drying-type, all-purpose compound.
3. Finish Coat: For third coat, use drying-type, all-purpose compound.
4. Skim Coat: For final coat of Level 5 finish, use drying-type, all-purpose compound .

D. Joint Compound for Backing Panels:
1. Glass-Mat, Water-Resistant Backing Panel: As recommended by backing panel manufacturer.
2. Cementitious Backer Units: As recommended by backer unit manufacturer.

2.8 AUXILIARY MATERIALS

A. Provide auxiliary materials that comply with referenced installation standards and manufacturer's written instructions.

B. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.

C. Steel Drill Screws: ASTM C1002 unless otherwise indicated.
1. Use screws complying with ASTM C954 for fastening panels to steel members from 0.033 to 0.112 inch **(**0.84 to 2.84 mm**)** thick.
2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.

D. Sound-Attenuation Blankets: ASTM C665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.
1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.

E. Sound-Attenuation Boards: ASTM C612, Types IA, IB, unfaced, 3 pcf semi-rigid board produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.
1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.
2. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.

F. Acoustical Sealant: As specified in Section 079219 "Acoustical Joint Sealants."

G. Thermal Insulation: As specified in Section 072100 "Thermal Insulation."

H. Firestop Putty Pads for Electrical Boxes: Listed intumescent moldable firestop putty pads.
   1. Product: Subject to compliance with requirements, provide one of the following:
      a. Hilti Corporation; CP 617 6" x 7" Putty Pad or CP 617L 7" x 7" Putty Pad.
      b. Kinetics Noise Control; IsoBacker.
      c. RectorSeal Firestop Solutions; Metacaulk Box Guard.
      d. Specified Technologies Inc. (STI); SpecSeal Series SSP Putty Pad.

I. Acoustic Putty Pads for Electrical Boxes: Asbestos-free, putty pads composed of polybutene-butyl and inert fillers.
   1. Product: Subject to compliance with requirements, provide one of the following:
      a. Kinetics Noise Control; IsoBacker.
      b. QuietRock; QuietPutty.
      c. Specified Technologies Inc. (STI); SpecSeal Series SSP Putty Pad.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and substrates including welded hollow-metal frames and support framing, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.

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

3.2 INSTALLATION AND FINISHING OF PANELS, GENERAL

A. Comply with ASTM C840.

B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.

C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch **(**1.5 mm**)** of open space between panels. Do not force into place.

D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.

E. Form control and expansion joints with space between edges of adjoining gypsum panels.

F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.
   1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. **(**0.7 sq. m**)** in area.
   2. Fit gypsum panels around ducts, pipes, and conduits.
   3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch- **(**6.4- to 9.5-mm-**)** wide joints to install sealant.

G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments. Provide 1/4- to 1/2-inch- **(**6.4- to 12.7-mm-**)** wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

H. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

I. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C919 and with manufacturer's written instructions for locating edge trim and closing off sound-flanking paths around or through assemblies, including sealing partitions above acoustical ceilings.

J. Install sound attenuation blankets before installing gypsum panels unless blankets are readily installed after panels have been installed on one side.

3.3 INSTALLATION OF INTERIOR GYPSUM BOARD

A. Install interior gypsum board in the following locations:
   1. Type X: As indicated on Drawings .

B. Single-Layer Application:
   1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing unless otherwise indicated.
   2. On partitions/walls, apply gypsum panels horizontally (perpendicular to framing) unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
      a. Stagger abutting end joints not less than one framing member in alternate courses of panels.
      b. At stairwells and other high walls, install panels horizontally unless otherwise indicated or required by fire-resistance-rated assembly.
   3. On Z-shaped furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.
   4. Fastening Methods: Apply gypsum panels to supports with steel drill screws.

C. Multilayer Application:
   1. On ceilings, apply gypsum board indicated for base layers before applying base layers on walls/partitions; apply face layers in same sequence. Apply base layers at right angles to framing members and offset face-layer joints one framing member, 16 inches **(**400 mm**)** minimum, from parallel base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly.
   2. On partitions/walls, apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions.
   3. On Z-shaped furring members, apply base layer vertically (parallel to framing) and face layer either vertically (parallel to framing) or horizontally (perpendicular to framing) with vertical joints offset at least one furring member. Locate edge joints of base layer over furring members.
   4. Fastening Methods: Fasten base layers with screws; fasten face layers with adhesive and supplementary fasteners.

D. Laminating to Substrate: Where gypsum panels are indicated as directly adhered to a substrate (other than studs, joists, furring members, or base layer of gypsum board), comply with gypsum board manufacturer's written instructions and temporarily brace or fasten gypsum panels until fastening adhesive has set.

3.4 INSTALLATION OF BACKING PANELS

A. Glass-Mat, Water-Resistant Backing Panels: Comply with manufacturer's written installation instructions and install at non-wet locations indicated to receive tile or other indicated finish materials. Install with 1/4-inch **(**6.4-mm**)** gap where panels abut other construction or penetrations.

B. Cementitious Backer Units: ANSI A108.11, at wet area locations indicated to receive tile or other indicated finish materials.

C. Where backing panels abut other types of panels in same plane, shim surfaces to produce a uniform plane across panel surfaces.

3.5 INSTALLATION OF TRIM ACCESSORIES

A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.

B. Control Joints: Install control joints according to ASTM C 840, including compliance with ASTM 20.3.1 - 20.4 for control joint spacing, whether or not such joints are indicated on Drawings, in specific locations approved by Architect for visual effect and as follows.

1. Install at changes in backup material.
2. Framed Openings (Both Sides of Partition):
   a. Doors: Install above both jambs unless indicated or directed otherwise.
   b. Glazed Openings: Install above and below both jambs unless indicated or directed otherwise.
3. Install at other locations indicated on Drawings.

C. Interior Trim: Install in the following locations:
1. Cornerbead: Use at outside corners unless otherwise indicated.
2. LC-Bead: Use at exposed panel edges.
3. L-Bead: Use where indicated on Drawings.
4. U-Bead: Use at exposed panel edges.
5. Curved-Edge Cornerbead: Use at curved openings.

D. Aluminum Trim: Install in locations indicated on Drawings.

E. Firestop Putty Pads: Install at power, audio/visual, data, light and similar boxes located in fire-rated partitions. Install in accordance with pad manufacturer's instructions.

F. Acoustic Putty Pads: Install at power, audio/visual, data, light and similar boxes located in acoustic-rated partitions. Install in accordance with pad manufacturer's instructions.

3.6 FINISHING OF GYPSUM BOARD

A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.

B. Prefill open joints[**, rounded or beveled edges,**] and damaged surface areas.

C. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.

D. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C840:
1. Level 1: Ceiling plenum areas, concealed areas, and where indicated.
2. Level 2: Where indicated on Drawings.
3. Level 3: Where indicated on Drawings.
4. Level 4: At panel surfaces that will be exposed to view unless otherwise indicated.
   a. Primer and its application to surfaces are specified in Section 099123 "Interior Painting."
5. Level 5: Where indicated on Drawings.
   a. Primer and its application to surfaces are specified in Section 099123 "Interior Painting."

E. Glass-Mat Faced Panels: Finish according to manufacturer's written instructions.

F. Cementitious Backer Units: Finish according to manufacturer's written instructions.

3.7 PROTECTION

A. Protect adjacent surfaces from drywall compound and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.

B. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

C. Remove and replace panels that are wet, moisture damaged, and mold damaged.
1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION

SECTION 095113 - ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Acoustical panels.
   2. Metal suspension system.
   3. Metal edge moldings and trim.

B. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 013300 "Submittal Procedures".

B. Product Data:
   1. Acoustical panels.
   2. Metal suspension system.
   3. Metal edge moldings and trim.

C. Shop 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-system members.
   2. Structural members to which suspension systems will be attached.
   3. Method of attaching hangers to building structure.
      a. Furnish layouts for cast-in-place anchors, clips, and other ceiling attachment devices whose installation is specified in other Sections.
   4. Carrying channels or other supplemental support for hanger-wire attachment where conditions do not permit installation of hanger wires at required spacing.
   5. Size and location of initial access modules for acoustical panels.
   6. Items penetrating finished ceiling and ceiling-mounted items including the following:
      a. Lighting fixtures.
      b. Diffusers.
      c. Grilles.
      d. Speakers.
      e. Sprinklers.
      f. Access panels.
      g. Perimeter moldings.
   7. Show operation of hinged and sliding components covered by or adjacent to acoustical panels.
   8. Minimum Drawing Scale: 1/4 inch = 1 foot **(**1:48**)**.

D. Samples: For each exposed product and for each color and texture specified, 6 inches **(**150 mm**)** in size.

E. Samples for Initial Selection: For components with factory-applied finishes.

F. Samples for Verification: For each component indicated and for each exposed finish required, prepared on Samples of sizes indicated below:
   1. Acoustical Panels: Set of full-size Samples of each type, color, pattern, and texture.
   2. Exposed Suspension-System Members, Moldings, and Trim: Set of 6-inch- **(**150-mm-**)** long Samples of each type, finish, and color.
   3. Clips: Full-size hold-down impact seismic clips.

G. Delegated-Design Submittal: Refer to Section 013573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.
   1. Provide delegated-design submittals for seismic restraints for ceiling systems.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Acoustical Ceiling Units: Full-size panels equal to 2 percent of quantity installed.
   2. Suspension-System Components: Quantity of each exposed component equal to 2 percent of quantity installed.
   3. Hold-Down Clips: Equal to 2 percent of quantity installed.
   4. Impact Clips: Equal to 2 percent of quantity installed.

1.6 QUALITY ASSURANCE

A. Provide the following upon request:
   1. Qualification Data: For testing agency.
   2. Product Test Reports: For each acoustical panel ceiling, for tests performed by manufacturer and witnessed by a qualified testing agency.
   3. Evaluation Reports: For each acoustical panel ceiling suspension system and anchor and fastener type, from ICC-ES.
   4. Field quality-control reports.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver acoustical panels, suspension-system components, and accessories to Project site and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.

1.8 FIELD CONDITIONS

A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.
   1. Pressurized Plenums: Operate ventilation system for not less than 48 hours before beginning acoustical panel ceiling installation.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Source Limitations for Ceiling System: Obtain each type of acoustical ceiling panel and its supporting suspension system from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a registered design professional, as defined in Section 013573 "Delegated Design Requirements and Procedures" to design seismic restraints for ceiling systems.
   1. Material properties indicated in this Section shall be considered as minimum properties.

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: Class A in accordance with ASTM E1264.
   2. Smoke-Developed Index: 450 or less.

C. Fire-Resistance Ratings: Comply with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Indicate design designations from UL or from the listings of another qualified testing agency.

2.3 ACOUSTICAL PANELS : ACT-01

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Armstrong Ceiling & Wall Solutions.
   2. Rockfon; ROCKWOOL International.
   3. USG Corporation.

B. Basis-of-Design Products: As scheduled; refer to Finish Schedule.

C. Acoustical Panel Standard: Provide manufacturer's standard panels in accordance with ASTM E1264 and designated by type, form, pattern, acoustical rating, and light reflectance unless otherwise indicated.

D. Color: As indicated in a schedule .

E. Light Reflectance (LR): Not less than .

F. Ceiling Attenuation Class (CAC): Not less than 35 .

G. Noise Reduction Coefficient (NRC): Not less than 0.75 .

H. Edge/Joint Detail: Flush reveal sized to fit flange of exposed suspension-system members .

I. Thickness:
1. 3/4 inch **(**19 mm**)** .

J. Modular Size: As indicated in a schedule .

K. Antimicrobial Treatment: Manufacturer's standard broad spectrum, antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested in accordance with ASTM D3273, ASTM D3274, or ASTM G21 and evaluated in accordance with ASTM D3274 or ASTM G21.

2.4 METAL SUSPENSION SYSTEM : ACT-01

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Ceiling & Wall Solutions.
2. Certainteed; SAINT-GOBAIN.
3. Rockfon; ROCKWOOL International.
4. USG Corporation.

B. Metal Suspension-System Standard: Provide manufacturer's standard, direct-hung, metal suspension system and accessories in accordance with ASTM C635/C635M and designated by type, structural classification, and finish indicated.
1. High-Humidity Finish: Where indicated, provide coating tested and classified for "severe environment performance" in accordance with ASTM C635/C635M.

C. Wide-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet; prepainted, electrolytically zinc coated, or hot-dip galvanized, G30 **(**Z90**)** coating designation; with prefinished 15/16-inch- **(**24-mm-**)** wide metal caps on flanges.
1. Fire Rating: As indicated on Drawings.
2. Structural Classification: Heavy-duty system.
3. End Condition of Cross Runners: butt-edge type.
4. Face Design: Flat, flush.
5. Cap Material: aluminum.
6. Cap Finish: Painted in color as selected from manufacturer's full range .

2.5 ACCESSORIES

A. Attachment Devices: Size for five times the design load indicated in ASTM C635/C635M, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.
1. Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing in accordance with ASTM E488/E488M or ASTM E1512 as applicable, conducted by a qualified testing and inspecting agency.
a. Type: Postinstalled expansion anchors.
b. Corrosion Protection, Nickel-Copper Alloy: Components fabricated from nickel-copper-alloy rods complying with ASTM B164 for UNS No. N04400 alloy.
2. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing in accordance with ASTM E1190, conducted by a qualified testing and inspecting agency.

B. Wire Hangers, Braces, and Ties: Provide wires as follows:
1. Zinc-Coated, Carbon-Steel Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper.

2. Size: Wire diameter sufficient for its stress at three times hanger design load (ASTM C635/C635M, Table 1, "Direct Hung") will be less than yield stress of wire, but not less than 0.135-inch- **(**3.5-mm-**)** diameter wire.
3. Size:
   a. Hanger Wire Size: 0.106 inch (No. 12-gauge) (2.68 mm) diameter wire.
   b. Seismic Bracing Wire Size: 0.106 inch (No. 12-gauge) (2.68 mm) diameter wire.
   c. Slack Safety Wire Size: 0.106 inch (No. 12-gauge) (2.68 mm) diameter wire.

C. Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.

D. Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.

E. Angle Hangers: Angles with legs not less than 7/8 inch **(**22 mm**)** wide; formed with 0.04-inch- **(**1-mm-**)** thick, galvanized-steel sheet complying with ASTM A653/A653M, G90 **(**Z275**)** coating designation; with bolted connections and 5/16-inch- **(**8-mm-**)** diameter bolts.

F. Hold-Down Clips: Manufacturer's standard hold-down.

G. Impact Clips: Manufacturer's standard impact-clip system designed to absorb impact forces against acoustical panels.

H. Seismic Clips: Manufacturer's standard seismic clips designed to secure acoustical panels in place during a seismic event.

I. Stabilizer Clips: Manufacturer's standard stabilizer clips designed for use with large format ceiling panels.

2.6 METAL EDGE MOLDINGS AND TRIM : ACT-01

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Ceiling & Wall Solutions.
2. Certainteed; SAINT-GOBAIN.
3. Rockfon; ROCKWOOL International.
4. USG Corporation.

B. Extruded-Aluminum Edge Moldings and Trim: Where indicated, provide manufacturer's extruded-aluminum edge moldings and trim of profile indicated or referenced by manufacturer's designations, including splice plates, corner pieces, and attachment and other clips, complying with seismic design requirements.
1. Baked-Enamel or Powder-Coat Finish: Minimum dry film thickness of 1.5 mils **(**0.04 mm**)**. Comply with ASTM C635/C635M and coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
2. Seismic Requirements: [Provide 2-inch **(**50 mm**)** wide wall angles.][Provide manufacturer's seismic perimeter clips used with standard nominal 7/8-inch **(**22 mm**)** wall angles, with current ICC Evaluation Service Report (ESR) acceptable to authority having jurisdiction.]

2.7 ACOUSTICAL SEALANT

A. Acoustical Sealant: As specified in Section 079219 "Acoustical Joint Sealants."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.

B. Examine acoustical panels before installation. Reject acoustical panels that are wet, moisture damaged, or mold damaged.

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

3.2 PREPARATION

A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders unless otherwise indicated, and comply with layout shown on reflected ceiling plans.

B. Layout openings for penetrations centered on the penetrating items.

3.3 INSTALLATION OF ACOUSTICAL PANEL CEILINGS

A. Install acoustical panel ceilings in accordance with ASTM C636/C636M, seismic design requirements, and manufacturer's written instructions.
   1. Fire-Rated Assembly: Install fire-rated ceiling systems in accordance with tested fire-rated design.
   2. Seismic Design Requirements: Install in accordance with the following:
      a. ASTM E 580/E 580M for Seismic Design Category C.
      b. ASTM E 580/E580M Section 5 as amended by 2010 CBC Section 1615.10.13 1615A.1.16 and DSA IR 25-2.10.

B. Suspend ceiling hangers from building's structural members and as follows:
   1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
   2. Splay hangers only where required and, if permitted with fire-resistance-rated ceilings, to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
   3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension-system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
   4. Secure wire hangers to ceiling-suspension members and to supports above with a minimum of three tight turns. Connect hangers directly to structure or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
   5. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both the structure to which hangers are attached and the type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
   6. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
   7. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
   8. Do not attach hangers to steel deck tabs.
   9. Do not attach hangers to steel roof deck. Attach hangers to structural members.
   10. Space hangers not more than 48 inches **(**1200 mm**)** o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches **(**200 mm**)** from ends of each member.
   11. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards.

C. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.

D. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.
   1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
   2. Screw attach moldings to substrate at intervals not more than 16 inches **(**400 mm**)** o.c. and not more than 3 inches **(**75 mm**)** from ends. Miter corners accurately and connect securely.
   3. Do not use exposed fasteners, including pop rivets, on moldings and trim.

E. Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

F. Install acoustical panels with undamaged edges and fit accurately into suspension-system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide precise fit.
   1. Arrange directionally patterned acoustical panels as follows:
      a. As indicated on reflected ceiling plans.
      b. Install panels with pattern running in one direction parallel to [**long**] [**short**] axis of space.
      c. Install panels in a basket-weave pattern.

2. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension-system runners and moldings.
3. For reveal-edged panels on suspension-system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.
4. For reveal-edged panels on suspension-system members with box-shaped flanges, install panels with reveal surfaces in firm contact with suspension-system surfaces and panel faces flush with bottom face of runners.
5. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces using coating recommended in writing for this purpose by acoustical panel manufacturer.
6. Install hold-down impact seismic clips in areas indicated; space in accordance with panel manufacturer's written instructions unless otherwise indicated.
   a. Hold-Down Clips: Space o.c. on all cross runners.
7. Install stabilizer clips in areas receiving ceiling panels with a dimension of 48 inches or more on one or more sides. Install in accordance with manufacturer's instructions, at ceiling panel mid-points. At ceiling panels with a dimension greater than 48 inches, provide stabilizer clips at 24 inches o.c. maximum.
8. Install clean-room gasket system in areas indicated, sealing each panel and fixture as recommended by panel manufacturer's written instructions.
9. Protect lighting fixtures and air ducts in accordance with requirements indicated for fire-resistance-rated assembly.

3.4 ERECTION TOLERANCES

A. Suspended Ceilings: Install main and cross runners level to a tolerance of 1/8 inch in 12 feet **(**3 mm in 3.6 m**)**, non-cumulative.

B. Moldings and Trim: Install moldings and trim to substrate and level with ceiling suspension system to a tolerance of 1/8 inch in 12 feet **(**3 mm in 3.6 m**)**, non-cumulative.

3.5 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
   1. Periodic inspection during the installation of suspended ceiling grids in accordance with ASCE/SEI 7.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections of completed installations of acoustical panel ceiling hangers and anchors and fasteners in successive stages and when installation of ceiling suspension systems on each floor has reached 20 percent completion, but no panels have been installed. Do not proceed with installations of acoustical panel ceiling hangers for the next area until test results for previously completed installations of acoustical panel ceiling hangers show compliance with requirements.
   1. Within each test area, testing agency will select one of every 10 power-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbf **(**890 N**)** of tension; it will also select one of every two postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbf **(**1957 N**)** of tension.
   2. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 pass consecutively and then will resume initial testing frequency.

D. Acoustical panel ceiling hangers, anchors, and fasteners will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 CLEANING

A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension-system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage.

B. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION

SECTION 096513 - RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Resilient base.

B. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 013300 "Submittal Procedures".

C. Product Data: For each type of product.

D. Samples: For each exposed product and for each color and texture specified, not less than 12 inches (300 mm) long.

E. Samples for Verification: For each type of product indicated and for each color, texture, and pattern required in manufacturer's standard-size Samples, but not less than 12 inches (300 mm) long.

F. Product Schedule: For resilient base and accessory products. Use same designations indicated on Drawings.

1.2 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Furnish not less than 10 linear feet (3 linear m) for every 500 linear feet (150 linear m) or fraction thereof, of each type, color, pattern, and size of resilient product installed.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Store resilient products and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F (10 deg C) or more than 90 deg F (32 deg C).

1.4 FIELD CONDITIONS

A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F (21 deg C) or more than 95 deg F (35 deg C), in spaces to receive resilient products during the following periods:
   1. 48 hours before installation.
   2. During installation.
   3. 48 hours after installation.

B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F (13 deg C) or more than 95 deg F (35 deg C).

C. Install resilient products after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 THERMOPLASTIC-RUBBER BASE (RB1)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Armstrong World Industries, Inc.
   2. Johnsonite; A Tarkett Company (Basis of Design).
   3. Nora Systems, Inc.

B. Basis-of-Design Products: As scheduled; refer to Interior Finish System Schedule.

C. Product Standard: ASTM F 1861, Type TP (rubber, thermoplastic).
   1. Group: I (solid, homogeneous).

D. Thickness: Manufacturer's standard.

E. Height: 4 inches (102 mm).

F. Lengths: Coils in manufacturer's standard length

G. Outside Corners: Job formed.

H. Inside Corners: Job formed.

I. Color and profile: As indicated on Interior Finish System Schedule.

2.2 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland-cement-based or blended hydraulic-cement-based formulation provided or approved by resilient-product manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by resilient-product manufacturer for resilient products and substrate conditions indicated.

C. Floor Polish: Provide protective, liquid floor-polish products recommended by resilient stair-tread manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resilient products.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
1. Installation of resilient products indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.

B. Concrete Substrates for Resilient Stair Accessories: Prepare horizontal surfaces according to ASTM F 710.
1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrate alkalinity falls within range on pH scale recommended by manufacturer in writing, but not less than 5 or more than 9 pH.
4. Moisture Testing: Perform tests so that each test area does not exceed 1000 sq. ft. **(**304.8 sq. m**)**, and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
    a. Anhydrous Calcium Chloride Test: ASTM F 1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. **(**1.36 kg of water/92.9 sq. m**)** in 24 hours.
    b. Relative Humidity Test: Using in-situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.
    c. If water moisture tests exceed stated limits, apply vapor retarder for moisture vapor emission control as specified in Section 090561.13.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install resilient products until materials are the same temperature as space where they are to be installed.
1. At least 48 hours in advance of installation, move resilient products and installation materials into spaces where they will be installed.

E. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient products.

3.3 RESILIENT BASE INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient base.

B. Apply resilient base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required.

C. Install resilient base in lengths as long as practical without gaps at seams and with tops of adjacent pieces aligned.

D. Tightly adhere resilient base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.

E. Do not stretch resilient base during installation.

F. On masonry surfaces or other similar irregular substrates, fill voids along top edge of resilient base with manufacturer's recommended adhesive filler material.

G. Job-Formed Corners:
   1. Outside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 3 inches **(**76 mm**)** in length.
      a. Form without producing discoloration (whitening) at bends.
   2. Inside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 3 inches **(**76 mm**)** in length.
      a. Cope corners to minimize open joints.

3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protecting resilient products.

B. Perform the following operations immediately after completing resilient-product installation:
   1. Remove adhesive and other blemishes from surfaces.

C. Protect resilient products from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.

D. Cover resilient products subject to wear and foot traffic until Substantial Completion.

END OF SECTION

SECTION 096813 - TILE CARPETING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Carpet tile.

B. Related Requirements:
1. Section 024119 "Selective Demolition" for removing existing floor coverings.
2. Section 096513 "Resilient Base and Accessories" for resilient wall base and accessories installed with carpet tile.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.
1. Review methods and procedures related to carpet tile installation including, but not limited to, the following:
   a. Review delivery, storage, and handling procedures.
   b. Review ambient conditions and ventilation procedures.
   c. Review subfloor preparation procedures.

1.3 ACTION SUBMITTALS

A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 013300 "Submittal Procedures.".

B. Product Data: For each type of product.
1. Include manufacturer's written data on physical characteristics, durability, and fade resistance.
2. Include manufacturer's written installation recommendations for each type of substrate.

C. Shop Drawings: For carpet tile installation, showing the following:
1. Columns, doorways, enclosing walls or partitions, built-in cabinets, and locations where cutouts are required in carpet tiles.
2. Carpet tile type, color, and dye lot.
3. Type of subfloor.
4. Type of installation.
5. Pattern of installation.
6. Pattern type, location, and direction.
7. Pile direction.
8. Type, color, and location of insets and borders.
9. Type, color, and location of edge, transition, and other accessory strips.
10. Transition details to other flooring materials.

D. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type of carpet tile.
1. Include Samples of exposed edge, transition, and other accessory stripping involving color or finish selection.

E. Samples for Verification: Actual sample of finished products for each of the following products and for each color and texture required. Label each Sample with manufacturer's name, material description, color, pattern, and designation indicated on Drawings and in schedules.
1. Carpet Tile: Full-size Sample.
2. Exposed Edge, Transition, and Other Accessory Stripping: 12-inch- **(**300-mm-**)** long Samples.

F. Product Schedule: For carpet tile. Use same designations indicated on Drawings.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For carpet tiles. Include the following:
1. Methods for maintaining carpet tile, including cleaning and stain-removal products and procedures and manufacturer's recommended maintenance schedule.
2. Precautions for cleaning materials and methods that could be detrimental to carpet tile.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials, from the same production run, to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Carpet Tile: Full-size units equal to 5 percent of amount installed for each type indicated, but no fewer than 10 full-size units.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is certified by the International Certified Floorcovering Installers Association at the Commercial II certification level.

B. Provide the following upon request:
1. Product Test Reports: For carpet tile, for tests performed by a qualified testing agency.
2. Qualification Statements: For Installer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with CRI 104.

1.8 FIELD CONDITIONS

A. Comply with CRI 104 for temperature, humidity, and ventilation limitations.

B. Environmental Limitations: Do not deliver or install carpet tiles until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at levels planned for building occupants during the remainder of the construction period.

C. Do not install carpet tiles over concrete slabs until slabs have cured and are sufficiently dry to bond with adhesive and concrete slabs have pH range recommended in writing by carpet tile manufacturer.

D. Where demountable partitions or other items are indicated for installation on top of carpet tiles, install carpet tiles before installing these items.

1.9 WARRANTY

A. Special Warranty for Carpet Tiles: Manufacturer agrees to repair or replace components of carpet tile installation that fail in materials or workmanship within specified warranty period.
1. Warranty does not include deterioration or failure of carpet tile due to unusual traffic, failure of substrate, vandalism, or abuse.
2. Failures include, but are not limited to, the following:
a. More than 10 percent loss of face fiber, edge raveling, snags, and runs.
b. Loss of tuft-bind strength.
c. Excess static discharge.
d. Delamination.
e. Dimensional instability.
3. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CARPET TILE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Mannington Commercial; a business unit of Mannington Mills, Inc.
2. Mohawk Carpet, LLC; The Mohawk Group.
3. Shaw Industries Group, Inc.; Berkshire Hathaway Company.

B. Color: Match existing.

C. Pattern: Match existing.

D. Primary Backing/Backcoating: Manufacturer's standard composite materials .

E. Secondary Backing: Manufacturer's standard material .

F. Backing System: Manufacturer's standard material .

G. Size: As indicated on finish scheduleAs indicated on finish schedule.

H. Applied Treatments:
1. Soil-Resistance Treatment: Manufacturer's standard treatment .
2. Antimicrobial Treatment: Manufacturer's standard treatment that protects carpet tiles as follows:

a. Antimicrobial Activity: Not less than 2 mm halo of inhibition for gram-positive bacteria, not less than 1 mm halo of inhibition for gram-negative bacteria, and no fungal growth, in accordance with AATCC 174.

2.2 INSTALLATION ACCESSORIES

A. Trowelable Leveling and Patching Compounds: Latex-modified, hydraulic-cement-based formulation provided or recommended in writing by carpet tile manufacturer.

B. Adhesives: Water-resistant, mildew-resistant, nonstaining, pressure-sensitive types to suit products and subfloor conditions indicated, that comply with flammability requirements for installed carpet tile, and that are recommended in writing by carpet tile manufacturer for releasable installation.

C. Metal Edge/Transition Strips: Extruded aluminum with mill finish of profile and width shown, of height required to protect exposed edge of carpet, and of maximum lengths to minimize running joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet tile performance.

B. Examine carpet tile for type, color, pattern, and potential defects.

C. Concrete Slabs: Verify that finishes comply with requirements specified in Section 033000 "Cast-in-Place Concrete" and that surfaces are free of cracks, ridges, depressions, scale, and foreign deposits.
1. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (20 sq. m) , and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
a. Anhydrous Calcium Chloride Test: ASTM F1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. (1.36 kg of water/100 sq. m) in 24 hours.
b. Relative Humidity Test: Using in situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.
c. Perform additional moisture tests recommended in writing by adhesive and carpet tile manufacturers. Proceed with installation only after substrates pass testing.
d. If water moisture tests exceed stated limits, apply vapor retarder for moisture vapor emission control as specified in Section 090561.13.

D. Wood Subfloors: Verify the following:
1. Underlayment over subfloor complies with requirements specified in Section 061600 "Sheathing."
2. Underlayment surface is free of irregularities and substances that may interfere with adhesive bond or show through surface.

E. Metal Subfloors: Verify the following:
1. Underlayment surface is free of irregularities and substances that may interfere with adhesive bond or show through surface.

F. Painted Subfloors: Perform bond test recommended in writing by adhesive manufacturer. Verify the following:
1. Underlayment surface is flat, smooth, evenly planed, tightly jointed, and free of irregularities, gaps greater than 1/8 inch (3 mm), protrusions more than 1/32 inch (0.8 mm), and substances that may interfere with adhesive bond or show through surface.

G. Access Flooring Systems: Verify the following:
1. Access floor substrate is compatible with carpet tile and adhesive if any.

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

3.2 PREPARATION

A. General: Comply with CRI 104 and with carpet tile manufacturer's written installation instructions for preparing substrates.

B. Use trowelable leveling and patching compounds, in accordance with manufacturer's written instructions, to fill cracks, holes, depressions, and protrusions in substrates. Fill or level cracks, holes and depressions 1/8 inch **(**3 mm**)** wide or wider, and protrusions more than 1/32 inch **(**0.8 mm**)** unless more stringent requirements are required by manufacturer's written instructions.

C. Concrete Substrates: Remove coatings, including curing compounds, and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, without using solvents. Use mechanical methods recommended in writing by adhesive and carpet tile manufacturers.

D. Metal Substrates: Clean grease, oil, soil and rust, and prime if recommended in writing by adhesive manufacturer. Rough sand painted metal surfaces and remove loose paint. Sand aluminum surfaces, to remove metal oxides, immediately before applying adhesive.

E. Broom and vacuum clean substrates to be covered immediately before installing carpet tile.

3.3 INSTALLATION

A. General: Comply with CRI 104, Section 10, "Carpet Tile," and with carpet tile manufacturer's written installation instructions.

B. Installation Method: As recommended in writing by carpet tile manufacturer.

C. Maintain dye-lot integrity. Do not mix dye lots in same area.

D. Maintain pile-direction patterns indicated on Drawings.

E. Extend carpet tile into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on carpet tile as marked on subfloor. Use nonpermanent, nonstaining marking device.

G. Install pattern parallel to walls and borders.

H. Access Flooring: Stagger joints of carpet tiles so carpet tile grid is offset from access flooring panel grid. Do not fill seams of access flooring panels with carpet adhesive; keep seams free of adhesive.

3.4 CLEANING AND PROTECTION

A. Perform the following operations immediately after installing carpet tile:
   1. Remove excess adhesive and other surface blemishes using cleaner recommended in writing by carpet tile manufacturer.
   2. Remove yarns that protrude from carpet tile surface.
   3. Vacuum carpet tile using commercial machine with face-beater element.

B. Protect installed carpet tile to comply with CRI 104, Section 13.7.

C. Protect carpet tile against damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by carpet tile manufacturer.

END OF SECTION

SECTION 099123 - INTERIOR PAINTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes surface preparation and the application of paint systems on the following interior substrates:
   1. Steel and iron.
   2. Gypsum board.

1.2 DEFINITIONS

A. MPI Gloss Level 3 (Eggshell Finish): 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D523.

B. MPI Gloss Level 4 (Satin Finish): 20 to 35 units at 60 degrees and not less than 35 units at 85 degrees, according to ASTM D523.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application instructions.
   1. Include printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.
   2. Indicate VOC content.

B. Samples for Initial Selection: For each type of topcoat product.

C. Samples for Verification: For each type of paint system and in each color and gloss of topcoat.
   1. Submit Samples on rigid backing, 8 inches **(**200 mm**)** square.
   2. Apply coats on Samples in steps to show each coat required for system.
   3. Label each coat of each Sample.
   4. Label each Sample for location and application area.

D. Product List: Use same designations indicated on Drawings and in the Interior Painting Schedule to cross-reference paint systems specified in this Section. Include color designations.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Paint: 5 percent, but not less than 1 gal. **(**3.8 L**)** of each material and color applied.

1.5 QUALITY ASSURANCE

A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Architect will select one surface to represent surfaces and conditions for application of each paint system.
   2. Final approval of color selections will be based on mockups.
      a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.
   3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
   4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F **(**7 deg C**)**.
   1. Maintain containers in clean condition, free of foreign materials and residue.
   2. Remove rags and waste from storage areas daily.

1.7 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F **(**10 and 35 deg C**)**.

B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures of less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Benjamin Moore & Co.
2. Dunn-Edwards Corporation (a Nippon Paint Holdings Co. Ltd. company).
3. PPG Paints.
4. Pratt & Lambert.
5. Sherwin-Williams Company (The).

2.2 PAINT, GENERAL

A. MPI Standards: Products shall comply with MPI standards indicated and shall be listed in its "MPI Approved Products List."
1. Provide products from manufacturer's premium or professional product line.

B. Material Compatibility:
1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.

C. Colors: As indicated in finish schedule.
1. Items Not Included in Finish Schedule: As selected by Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
1. Gypsum Board: 12 percent.

C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

D. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.

E. Proceed with coating application only after unsatisfactory conditions have been corrected.
1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and paint systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

D. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

3.3 INSTALLATION

A. Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."
   1. Use applicators and techniques suited for paint and substrate indicated.
   2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
   3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
   4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
   5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.
   6. Paint latex sealants color as directed by Architect.

B. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

D. Painting Fire-Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
   1. Paint the following work where exposed in occupied spaces:
      a. Equipment, including panelboards.
      b. Uninsulated metal piping.
      c. Uninsulated plastic piping.
      d. Pipe hangers and supports.
      e. Metal conduit.
      f. Plastic conduit.
      g. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
      h. Other items as directed by Architect.
   2. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

3.4 FIRE-RATED AND SMOKE CONTAINMENT ASSEMBLIES

A. Fire walls, fire barriers, fire partitions, smoke barriers and smoke partitions or any other wall required to have protected openings or penetrations shall be effectively and permanently identified with signs or stenciling. Such identification shall:
   1. Be located in accessible concealed floor, floor-ceiling or attic spaces; and
   2. Be located within 15 feet of each end of each wall and repeated at intervals not exceeding 30 feet measured horizontally along both sides of the wall or partition; and
   3. Include lettering not less than 3 inches in height, incorporating the suggested wording: " FIRE AND/OR SMOKE BARRIER-PROTECT ALL OPENINGS" or other wording approved or required by AHJ (Authority Having Jurisdiction).
   4. Apply a minimum one-inch wide bright red horizontal line, both sides of wall, interrupted for approved text, at the required interval.

3.5 FIELD QUALITY CONTROL

A. Dry-Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry-film thickness.
   1. Contractor shall touch up and restore painted surfaces damaged by testing.
   2. If test results show that dry-film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry-film thickness that complies with paint manufacturer's written recommendations.

3.6 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.7 INTERIOR PAINTING SCHEDULE

A. Steel Substrates:
   1. Institutional Low-Odor/VOC Latex System, MPI INT 5.1S:
      a. Prime Coat: Factory applied shop primer.
      b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
      c. Topcoat: Latex, interior, institutional low odor/VOC, satin (MPI Gloss Level 4), MPI #146.

B. Gypsum Board Substrates:
   1. Institutional Low-Odor/VOC Latex System, MPI INT 9.2M:
      a. Prime Coat: Primer sealer, interior, institutional low odor/VOC, MPI #149.
      b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
      c. Topcoat: Latex, interior, institutional low odor/VOC, eggshell (MPI Gloss Level 3), MPI #145.

END OF SECTION

211313 - WET-PIPE AND DRY-PIPE SPRINKLER 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 when provided.
b. Division 9 Specification Sections for painting.
c. Division 27 Specification Sections for electrical connections and power.

1.2 SUMMARY

a. The work includes, but is not limited to, modifying the existing sprinkler system as indicated in the contract documents. This work shall include all components necessary for a complete, code-compliant, operational system, whether such components are listed in the contract documents or not.
b. The work shall comply with the editions of NFPA 13 and the International Building Code adopted by the local Authority Having Jurisdiction (AHJ).

1.3 SECTION INCLUDES:

i. Aboveground pipe.
ii. Fittings.
iii. Valves.
iv. Alarm and supervisory devices.
v. Pressure gauges.
vi. Signs and pipe identifiers.
vii. Hangers, anchors, and supports.
viii. Sprinklers.

1.4 SUBMITTALS

a. General Submittal Requirements:
   i. Shop Drawings shall be prepared by persons with the following qualifications:
      (a) Trained and certified by manufacturer in sprinkler system design.
      (b) One of the following:
         (i) NICET-certified, Water-Based Systems Layout, Level III minimum. Licensed to practice in the project jurisdiction.
         (ii) Registered professional engineer, licensed to practice fire protection engineering in the project jurisdiction.
   ii. Contractor’s Material and Test Certificates: Prepared in accordance with NFPA 13 and AHJ requirements.
   iii. Operations and Maintenance Information: For all provided and modified components.
b. Action Submittals, to be reviewed for general conformance with the contract documents.
   i. Product Data: For each type of product indicated.
      (a) Include construction details, material descriptions, dimensions, profiles, and finishes.
      (b) Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
      (c) Submit as a complete product data package in conjunction with shop drawings. Product data will not be reviewed separately from the shop drawings.
   ii. LEED Submittal: Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content and chemical components.
   iii. Shop Drawings:
      (a) Comply with recommendations and requirements in the “Plans and Calculations” section of NFPA 13, as well as any AHJ requirements.
      (b) Include plans, elevations, sections, details, and attachments to other work.
      (c) Include wiring diagrams for power, signal, and control wiring.
      (d) Indicate points of connection to existing work.
      (e) Indicate all existing pipe and components necessary for a complete hydraulic calculation traced back to the water supply.
      (f) Indicate reflected ceiling plan for coordination of sprinkler locations.
      (g) Detail assembly and support requirements.
   iv. Hydraulic calculations: Prepared according to NFPA 13 and showing the pipe sizes proposed to produce adequate performance. Safety factor required in this specification shall be demonstrated in the hydraulic calculations.

c. Informational submittals, to be made available upon request by Architect/Engineer:
   i. Qualification Data: For qualified Designer and Installer.
   ii. As-Built Sprinkler Piping Drawings: Updated daily on-site reflecting extent and details of installed conditions. Final as-built drawings prepared after AHJ approval of the completed work shall be provided in hard-copy and digital (.dwg) format.
   iii. Acceptance Test Procedures: Prepared by one of the following:
      (a) National Institute for Certification of Engineering Technologies (NICET) certified Level III, Inspection and Testing of Water-Based Systems technician. Licensed to practice in the project jurisdiction.
      (b) Registered professional engineer, licensed to practice fire protection engineering in the project jurisdiction.

1.5 PERFORMANCE REQUIREMENTS
   a. Delegated Design: Design tenant improvement fire suppression systems by a qualified professional engineer, licensed to practice in the Project's jurisdiction, using performance requirements and design criteria indicated.
      i. The design engineer, as the "engineer of record", shall be responsible to ensure that the design complies with all applicable codes and local jurisdictional regulations.
      ii. The design engineer shall ensure that the design complies with best practice industry standards.
   b. Design shall be approved by the AHJ.
   c. Design shall include a minimum margin of safety of 10 psi or 10 percent of the hydraulically calculated demand pressure, whichever is higher, including losses through water-service piping, valves, and backflow preventers.
   d. Sprinkler occupancy hazard classifications shall be in accordance with NFPA 13 and the contract documents.
   e. Margin of Safety:
      i. Margin of Safety for Available Water Flow and Pressure: 10 percent of the minimum required residual pressure or 10 psig, whichever is greater, including losses through water-service piping, valves, and backflow preventers.

1.6 PROJECT CONDITIONS
   a. Interruption of Existing Sprinkler 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 guard or sprinkler service according to requirements indicated:
      i. Notify Owner no fewer than 48 hours in advance of proposed interruption of sprinkler service or as required by Owner's construction requirements.
      ii. Notify AHJ as required by the authority.
      iii. Do not proceed with interruption of sprinkler service without Owner's written permission.
      iv. Provide interim life safety measures as required by the Authority Having Jurisdiction throughout the outage. This shall include, but be limited to, fire watch service when the fire suppression system is rendered inoperable for more than four hours during a 24-hour period. Additional measures may be required by the Authority Having Jurisdiction.

1.7 SEQUENCING AND SCHEDULING
   a. Existing Sprinkler System: Maintain existing system fully operational until new components have been installed and are ready for connection to the existing system.
   b. Ceiling Demolition: If ceilings with pendent sprinklers are demolished and new ceilings are not provided within 48 hours, provide upright sprinklers for protection during construction.
   c. Sprinkler System Demolition:
      i. All sprinklers which are to be relocated shall be demolished and replaced with new sprinklers.
      ii. All components and piping which are not used in the modified system shall be demolished back to the point of connection to active piping. Do not abandon any components in place.

1.8 QUALITY ASSURANCE
   a. Permit Fees: Contractor shall be responsible for filing all documents, paying all fees and securing all permits, inspections and approvals necessary for completing the scope of the work in this section.

1.9 WARRANTY AND EMERGENCY SERVICE
   a. Contractor shall warranty all materials and workmanship for a period of one (1) year beginning with the date of final acceptance of Contractor's completed installation by Owner. Contractor shall be responsible during the design, installation, testing and warranty periods for any damage caused by Contractor (or its subcontractors) work, materials, or equipment.

b. Emergency Service: During the installation and warranty period, Contractor shall provide emergency repair service for the sprinkler and standpipe systems within twenty-four (24) hours of a request by Owner for such service. This service shall be provided on a 24-hour per day, seven days per week basis.

Part 2 - PRODUCTS

2.1 GENERAL

a. All components shall be compatible with the existing system.
b. All components shall be UL listed or FM Approved for use in water-based fire protection systems, unless the component is specifically exempt from listing requirements by NFPA 13.
c. Protect all materials from weather, environmental hazards, and physical damage. Cover the ends of all pipe until ready for installation.
d. All components and chemicals shall be compatible with CPVC piping if CPVC pipe is present anywhere in the existing system. This includes, but is not limited to, joint compound/pipe thread tape, cutting oils, gasket grease, and pipe coatings.
e. All components shall have a minimum working pressure of 175 psi or as required by NFPA 13, whichever is greater. Where exposed to pressures in excess of 175, components shall have a minimum working pressure of 300 psi or as required by NFPA 13, whichever is greater.

2.2 ABOVEGROUND PIPE

a. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    i. Wheatland Tube
    ii. Bull Moose Tube
    iii. State Pipe & Supply, Inc.
    iv. Youngstown Tube
b. Schedule 40 Black Steel: Shall comply with NFPA 13 and ASTM A53 or ASTM A795.
c. Schedule 10 Black Steel: Shall comply with NFPA 13 and ASTM A135 or ASTM A795.
d. All pipe shall have an internal antimicrobial coating.

2.3 FITTINGS

a. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    i. Anvil (ASC Engineered Solutions)
    ii. Flexhead (ASC Engineered Solutions)
    iii. Grinnell (Tyco/Johnson Controls)
    iv. Gruvlok (ASC Engineered Solutions)
    v. Victaulic
b. Fittings shall be ductile iron, malleable iron, cast iron, or steel.
c. Cast Iron: Shall comply with NFPA 13 and ASME B16.4 or B16.1.
d. Malleable Iron: Shall comply with NFPA 13 and ASME B16.3
e. Steel: Shall comply with NFPA 13 and ASME B16.5, B16.9, B16.11, B16.25, or ASTM A234.

2.4 VALVES

a. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    i. Ames Fire & Waterworks (Watts Water Technologies)
    ii. Gruvlok (ASC Engineered Solutions)
    iii. Kennedy Valve
    iv. Milwaukee Valve
    v. Mueller Company (ASC Engineered Solutions)
    vi. NIBCO
    vii. Reliable Automatic Sprinkler Company
    viii. Tyco Fire (Johnson Controls)
    ix. Victaulic
    x. Viking Group
    xi. Watts Water Technologies
    xii. Zurn Industries / ZurnWilkins (Zurn Elkay Water Solutions)
b. Control and isolation valves shall be indicating-type valves.
c. Butterfly valves shall have integral tamper switches.

d. Drum drip valves shall be provided by the manufacturer as a complete assembly. Drum drip valves shall incorporate either a sight glass or an electric water level alarm with audible and visual alarm. Electric water level alarm, if provided, shall be supervised by the building fire alarm system or Building Management System (BMS).

2.5 ALARM AND SUPERVISORY DEVICES

a. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   i. Potter Signal
   ii. Safe Signal
   iii. Manufacturers of valves with integral tamper switches or riser assemblies with integral water flow alarm switches as identified in the Valves paragraph.
b. General
   i. Alarm and supervisory devices shall have two SPDT (Form C) contacts.
   ii. Alarm and supervisory devices shall have integral cover removal tamper switches.
c. Paddle- or vane-type water flow alarm switches shall have an adjustable delay setting.
d. Pressure-type water flow alarm switches shall have an adjustable pressure activation point.
e. Valve supervisory switches shall operate within two revolutions of the valve operating mechanism.
   (a) Switches supervising normally-closed valves shall operate within two revolutions of the valve operating mechanism in the open direction from a fully-closed starting position.
   (b) Plunger-type valve supervisory switches shall be provided for ball valves and similar valves with quarter-turn handle operation.
f. High/Low Air Pressure switches shall Have field-adjustable pressure settings with a range from 5 to 30 psi for low-differential dry valves and 10 to 60 psi for high-differential dry valves or as otherwise recommended by the dry valve manufacturer.

2.6 PRESSURE GAUGES

a. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   i. Ashcroft
   ii. AGF Manufacturing
   iii. Potter Roemer
   iv. Viking Group
   v. Winters Instruments
   vi. Zurn Industries (Zurn Elkay Water Solutions)
b. Pressure gauge shall have a metal case and shall be provided with a shutoff valve and drain.
c. Pressure gauge ranges shall comply with the following:
   i. For system working water pressures up to 175 psi, water gauges shall have a range of 0-200 psi.
   ii. For system working water pressures in excess of 175 psi, water gauges shall have a range of 0-300 psi.
   iii. Air pressure gauges shall have a range of 0-80 psi with a 250 psi retard.

2.7 SIGNS AND PIPE IDENTIFIERS

a. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   i. Brady ID
   ii. Brimar Industries
   iii. Compliance Signs
   iv. FPPI (ASC Engineered Solutions)
   v. Graphic Products
   vi. Seton
b. Signs
   i. Signs shall be a minimum of 6 inches wide by 2 inches high.
   ii. Signs shall have an enamel baked finish on 18-gage steel or 0.024-inch aluminum.
   iii. Signs shall have red letters on a white background or white letters on a red background.
   iv. Hydraulic design data shall have the same baked enamel finish or be engraved into the sign.
c. Pipe Marker
   i. Pipe marker shall be a self-adhesive vinyl label. Marker shall be large enough to completely encircle the pipe.

ii. Pipe marker shall be red with white text. Text shall indicate “Fire Protection” or “Sprinkler”. Text shall be a minimum of ¾ inches in height for pipe sizes up to 2½ inches nominal diameter and 1¼ inches in height for pipe sizes 2½ inches and greater.

d. Painted Pipe Bands
   i. Low-VOC, red enamel; comply with Division 9 paint specifications.

2.8 HANGERS, ANCHORS, AND SUPPORTS
   a. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      i. AFCON (ASC Engineered Solutions)
      ii. Anvil (ASC Engineered Solutions)
      iii. DeWalt
      iv. Eaton B-Line
      v. Eaton Tolco
      vi. Hilti North America
      vii. ITW Buildex
   b. Provide hangers in accordance with NFPA 13 and AHJ requirements.
   c. Hangers shall be designed to support a minimum of five times the weight of water-filled pipe plus 250 lbs, or as otherwise required by code, whichever is greater.
   d. Hanger components shall be ferrous.

2.9 SPRINKLERS
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      i. Reliable Automatic Sprinkler Company
      ii. Tyco Fire & Building Products (Johnson Controls)
      iii. Victaulic
      iv. Viking Group
   b. Sprinklers shall be provided with matching, listed escutcheons and cover plates.
   c. Provide sprinkler types, K-factors, and temperature ratings as required by NFPA 13.
   d. Refer to contract drawings for schedule of required sprinkler finishes based on ceiling type.
   e. Provide sprinkler guards listed for use with the associated sprinkler.

Part 3 - EXECUTION

3.1 GENERAL
   a. All work shall be completed in accordance with NFPA 13, AHJ, and component manufacturer requirements and recommendations.
   b. Do not cut or otherwise damage any structural members during installation.
   c. Protect existing finishes during work. Restore any finishes damaged by the work to match adjacent, intact conditions.
   d. Provide listed firestop assemblies for all penetrations of fire- and smoke-rated walls and floors.

3.2 ABOVEGROUND PIPE, FITTING, AND VALVE INSTALLATION
   a. Locations and Arrangements:
      i. Avoid routing pipe directly over electrical equipment such as transformers and panels. If the installation of pipe over electrical equipment is unavoidable, provided galvanized drip pans under piping to protect electrical equipment.
      ii. Install pipe parallel to and at right angles from walls and structure.
      iii. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect/Engineer before deviating from approved working plans.
      iv. Make all changes in direction with fittings; bending of pipe is not permitted.
      v. Make all changes in pipe size through standard, tapered reducing fittings. Bushings are not permitted.
      vi. Install drops to pendent sprinklers using return-bend arm-overs (“goosenecks”). Connection shall be to the top of branchlines.
      vii. Drains:
         (a) Avoid trapped water; route pipe so that all pipe drains back to the main zone drain valve.
         (b) Where trapped water is unavoidable, provide auxiliary drains in accordance with NFPA 13.
         (c) All drains shall be connected to the main drain risers, which shall discharge to the exterior. Auxiliary drains may discharge to a floor sink or similar drain that complies with NFPA 13 and applicable plumbing codes when approved in advance by the Architect/Engineer.

viii. Access:
(a) Install valves so that they are readily accessible without use of a ladder.
(b) Provide access panels for all valves concealed behind walls and above any ceiling that does not have removable ceiling tiles.
(c) Provide printed, permanently affixed label on access panel – or ceiling grid, for ceilings with removable ceiling tiles – for all concealed valves. Identify valve type, purpose, and zone/area served.

b. Valve Installation:
i. Install valves per NFPA 13, AHJ requirements, and manufacturer requirements and recommendations.
ii. Provide all isolation and control valves with electronically-supervised tamper switches, monitored by the building fire alarm system. Make all required connections.
iii. Provide valves and tamper switches intended for normally-closed operation for all normally-closed valves.
iv. Provide combination test and drain valves for zone control assemblies.
v. Provide permanently-attached, printed tags for all valves indicating valve purpose and zone/area served.

c. Piping Standard and Installation:
i. Comply with requirements for installation of sprinkler piping in NFPA 13, AHJ requirements, and manufacturer requirements and recommendations.
ii. Pipe Schedule:
(a) Pipe 2 inches (NPS) and smaller shall be Schedule 40.
(b) Pipe 2½ inches (NPS) and larger may be Schedule 10 or Schedule 40.
(c) All threaded and cut-grooved pipe shall be Schedule 40.
iii. All pipe shall be black steel, except that modifications to existing systems with galvanized pipe shall utilize galvanized pipe.
iv. Perform all welding in the shop; field welding is not permitted.
v. Utilize PTFE pipe thread tape applied to the male threads for all threaded fittings; other joint compounds are not permitted.
vi. Pipe threads shall be rolled to ASME B1.20.1.
vii. Pipe grooves shall be rolled in accordance with fitting and pipe manufacturers' requirements and recommendations.
viii. Do not cut structural members when installing pipe or other components.

3.3 ALARM AND SUPERVISORY DEVICE INSTALLATION
a. Install in accordance with NFPA 13, AHJ requirements, and manufacturer requirements and recommendations.
b. Provide water flow alarm device for all sprinkler system zones.
c. Provide valve tamper supervisory switch for all control and isolation valves.
d. Coordinate with fire alarm installation to make all connections for supervision of the sprinkler system components by the fire alarm system.

3.4 PRESSURE GAUGE INSTALLATION
a. Install pressure gauges in accordance with NFPA 13, AHJ requirements, and manufacturer requirements and recommendations.
b. Provide shutoff valve and drain valve for all pressure gauges.
c. Install pressure gauges at an accessible location. Install so that the dial is visible without the use of a ladder.
d. Provide access panels for all pressure gauges concealed behind walls and above any ceiling that does not have removable ceiling tiles.
e. Provide printed, permanently affixed label on access panel – or ceiling grid, for ceilings with removable ceiling tiles – for all concealed pressure gauges. Identify gauge and zone/area served.

3.5 SIGN AND PIPE IDENTIFIER INSTALLATION
a. Valves, pressure gauges, and other components:
i. Provide signs for all concealed components as indicated in this specification.
ii. Provide identifying tags for all valves as indicated in this specification. Indicate purpose and zone or area served. Indicate whether valve is normally-open or normally-closed.
iii. Provide hydraulic data plates at riser or other location approved by the AHJ when utilizing a different hydraulic basis than the existing system.

b. Pipe:
    i. All concealed sprinkler pipe and exposed pipe in back-of-house spaces (e.g. – mechanical rooms, electrical rooms, etc.) shall be factory-finished or field-painted red.
    ii. Exposed pipe in finished rooms shall be painted to match adjacent finishes and provided with pipe identifiers as indicated below.
        (a) Provide pipe identifiers consisting of permanently-affixed, printed pipe markers or painted red bands. Apply pipe identifiers to all sprinkler pipe that is not painted red, except that branchlines and other sprinkler pipe with directly attached sprinklers within ten feet do not require such markings.
        (b) Printed pipe markers shall be permanently affixed with adhesive and completely wrap around the pipe. Install so that the label is visible without use of a ladder.
        (c) Red painted bands shall be a minimum of two inches wide and shall completely encircle the pipe.
        (d) Provide pipe identifiers on either side of wall and floor penetrations and a maximum of every 10 feet thereafter. Where multiple identifiers are required along a pipe, space identifiers evenly. Provide pipe identifiers at each control or isolation valve.
    iii. Provide warning labels

3.6 HANGER, ANCHORS, AND SUPPORT INSTALLATION
a. Support all pipe and components in accordance with NFPA 13, AHJ requirements, and manufacturer requirements and recommendations.
b. Fire protection systems shall be supported independently from all other systems, unless shared support structures – designed in accordance with NFPA 13 – are provided.
c. Threaded rod shall not be bent and shall not be subjected to non-axial loads. Provide appropriate hanger components and additional hangers as needed to avoid non-axial loading. At least two full threads shall be showing below the nut at all hanger attachment points. Structural anchor thread engagement shall be in accordance with structural attachment manufacturer requirements and recommendations.
d. Do not install concrete anchors in concrete joists or tees. Install concrete anchors in main slab. Maintain clearance around all beams and columns.
e. Provide trapeze supports where necessary due to pipe location and available structural attachment points.
f. Verify suitability of existing structure for attachment prior to installation. Notify Architect/Engineer of any unsuitable structural conditions.

3.7 SPRINKLER INSTALLATION
a. Provide sprinklers in accordance with NFPA 13, AHJ requirements, and manufacturer requirements and recommendations.
b. Install sprinklers located in acoustic-tile ceilings in the center of the tile.
c. Utilize uniform sprinkler spacing. Align sprinklers with adjacent ceiling elements. Center between lights, diffusers, etc. where possible.
d. Provide quick-response sprinklers throughout the area of work, unless otherwise required by NFPA 13 or as noted herein.
    i. All sprinklers within a given compartment (i.e. – room) shall have the same response, as required by NFPA 13.
    ii. When there are existing standard-response sprinklers and more than 50% of the sprinklers in a given compartment or room are being replaced, provide new quick-response sprinklers throughout and replace all existing standard-response sprinklers to match.
    iii. When there are existing standard-response sprinklers and fewer than 50% of the sprinklers in a given compartment or room are being replaced, provide new standard-response sprinklers to match the existing.
e. Provide sprinklers with uniform K-factors.
    i. Do not use differing K-factors to balance the system.
    ii. Different K-factors are allowed where required by NFPA 13 for different hazards and where permitted by NFPA 13 when using different sprinkler types, such as extended-coverage and standard-coverage sprinklers, in the same area.
f. Provide sprinkler guards on all mechanical and electrical room sprinklers, all exposed sprinklers installed lower than 7 feet, 6 inches above the finished floor, and as indicated in the contract drawings. Concealed sprinklers do not require guards.

g. Provide spare sprinklers in the number required by NFPA 13, but no less than one of each type of sprinkler provided in this scope of work. Place in existing spare sprinkler cabinet or provide new spare sprinkler cabinet if there is no spare capacity. If there is no existing spare sprinkler cabinet, provide a new spare sprinkler cabinet at the main sprinkler system backflow preventer. Provide new sprinkler wrench in spare sprinkler cabinet for each type of provided sprinkler.

3.8 FIELD QUALITY CONTROL

a. Notify Owner at least 48 hours prior to testing.
b. Perform tests and inspections required by NFPA 3, NFPA 13, NFPA 25, and the AHJ. Tests shall include, but not be limited to:
   i. Hydrostatic tests of all new and modified piping.
   ii. Functional test of all new and modified components, such as valves and flow switches.
   iii. Functional test of all new and modified system interfaces, such as fire alarm supervision of valve tamper and sprinkler water flow alarm switches.
c. Conduct tests in accordance with NFPA 3, NFPA 13, NFPA 25, AHJ requirements, and the acceptance test plan prepared by the system designer.
d. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
e. Prepare test and inspection reports, including the Contractor's Material and Test Certificates, in accordance with NFPA 13 and AHJ requirements.
f. Prepare as-built system documentation and Operations and Maintenance Information. Make available on-site during all tests and inspections.

3.9 SPRINKLER SCHEDULE

a. Use sprinkler types in subparagraphs below for the following applications:
   i. Rooms without Ceilings: Upright sprinklers or pendent sprinklers as indicated.
   ii. Rooms with Suspended Ceilings: Recessed sprinklers or concealed sprinklers as indicated.
b. Provide sprinkler types in subparagraphs below with finishes indicated.
   i. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
      (a) Specialty Ceiling Finishes: Provide manufacturers standard or custom color cover plate as selected by the Architect.
   ii. Recessed Sprinklers: White, with white escutcheon.
   iii. Upright. Pendent, and Sidewall Sprinklers: White in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

SECTION 220413 - COMMON SUBMITTAL REQUIREMENTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.2 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract, including but not limited to a Construction Manager.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Informational Submittals: Written and graphic information and physical samples that do not require Architect's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

E. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.

1.3 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Initial Review: Allow 10 business days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required.

2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.
3. Resubmittal Review: Allow 10 business days for review of each resubmittal.
4. Sequential Review: Where sequential review of submittals by Architect's consultants, Owner, or other parties is indicated, allow 15 business days for initial review of each submittal.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

1.4 DELEGATED-DESIGN SERVICES

A. Definitions:
1. Delegated Design: A portion or component of the Work identified by the Contract Documents to be designed by the Contractor, or an entity assigned by the Contractor, to satisfy performance and design criteria specified in the Contract Documents for that portion or component.
2. Registered Design Professional: Design professional, assigned by the Contractor, who is responsible for providing the delegated design work, and for certifying that the work is in compliance with the specified performance requirements and design criteria. Design professional shall be legally qualified to practice in jurisdiction where Project is located and shall be experienced in providing delegated design services of the kind indicated. Delegated design services are defined as those performed for installation of the system, assembly or product that are similar in material, design, and extent to those indicated for this Project.

B. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.

C. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally signed PDF electronic file copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.
1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Combine with Submittal Review Sheet before submitting to Architect .

B. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

C. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

D. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

E. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal.

3.2 ARCHITECT'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.

D. The Final Review Code on the Submittal Review Sheet prevails and governs the action of the overall submittal.

E. Review Code meanings are as follows:
1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
   d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.
2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.
3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.
1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
1. Do not submit Material Safety Data Sheets. They will be returned without review.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
1. Submittal Numbering: See below.
2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).
4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering
1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:
      1) Initial Complete Submittal: 044200-01. First Re-Submittal: 044200-01-R1.
      2) Initial Partial Submittal: 044200-01-P1. Second Partial Submittal: 044200-01-P2.
      3) First Re-submittal of Second Partial Submittal: 044200-R1-P2.

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION

SECTION 220516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Rubber union connector packless expansion joints.
2. Flexible-hose packless expansion joints.
3. Metal-bellows packless expansion joints.
4. Externally pressurized metal-bellows packless expansion joints.
5. Rubber packless expansion joints.
6. Grooved-joint expansion joints.
7. Alignment guides and anchors.
8. Pipe loops and swing connections.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.3 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

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

2.2 PACKLESS EXPANSION JOINTS

A. Rubber Union Connector Expansion Joints RUEJ-01:
1. Manufacturers: Subject to compliance with requirements, provide products by the following
a. Amber/Booth Company, Inc.; a MC Group Company.
b. Flex-Hose Co., Inc.
c. Flexicraft Industries.
d. General Rubber Corporation.
e. Mason Industries, Inc.
f. Proco Products, Inc.
g. Unaflex.
h. Unisource Manufacturing, Inc.
2. Material: Twin reinforced-rubber spheres with external restraining cables.
3. Minimum Pressure Rating: 150 psig at 170 deg F **(**1035 kPa at 77 deg C**)**unless otherwise indicated.
4. End Connections for NPS 2 **(**DN 50**)** and Smaller: Threaded.

B. Flexible-Hose Packless Expansion Joints :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following]:
a. Flex-Hose Co., Inc.

b. Flexicraft Industries.
c. Mason Industries, Inc.
d. Metraflex, Inc.
e. Unisource Manufacturing, Inc.

2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.
   a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
   b. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.
5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F (2890 kPa at 21 deg C) and 315 psig at 450 deg F (2170 kPa at 232 deg C) ratings.
6. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with threaded end connections.
   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 515 psig at 600 deg F (3550 kPa at 315 deg C) ratings.
7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon-steel fittings with flanged end connections.
   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.
8. Expansion Joints for Steel Piping NPS 8 to NPS 12 (DN 200 to DN 300): Carbon-steel fittings with flanged end connections.
   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F (860 kPa at 21 deg C) and 90 psig at 600 deg F (625 kPa at 315 deg C) ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.
9. Expansion Joints for Steel Piping NPS 14 (DN 350) and Larger: Carbon-steel fittings with welded end connections.
   a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.

C. Metal-Bellows Packless Expansion Joints :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Adsco Manufacturing LLC.
   b. American BOA, Inc.
   c. Badger Industries, Inc.
   d. Expansion Joint Systems, Inc.
   e. Flex-Hose Co., Inc.
   f. Flexicraft Industries.
   g. Flex-Weld, Inc.
   h. Hyspan Precision Products, Inc.
   i. Mason Industries, Inc.
   j. Metraflex, Inc.
   k. Tozen Corporation.
   l. Unaflex.
   m. Unisource Manufacturing, Inc.
   n. Universal Metal Hose; a subsidiary of Hyspan Precision Products, Inc.
   o. U.S. Bellows, Inc.
   p. WahlcoMetroflex.

2. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
3. Type: Circular, corrugated bellows with external tie rods.
4. Minimum Pressure Rating: 200 psig (1379 kPa), unless otherwise indicated.
5. Expansion Joints for Copper Tubing: [Single-] [or] [multi-] ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
   a. End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint .
   b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Solder joint.
   c. End Connections for Copper Tubing NPS 5 (DN 125) and Larger: Flanged.
6. Expansion Joints for Steel Piping: [Single-] [or] [multi-] ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.
   a. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
   b. End Connections for Steel Pipe NPS 2-1/2 (DN 65) and Larger: Welded.

D. Externally Pressurized Metal-Bellows Packless Expansion Joints:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Adsco Manufacturing LLC.
   b. Hyspan Precision Products, Inc.
   c. Mason Industries, Inc.
   d. Metraflex, Inc.
   e. U.S. Bellows, Inc.
2. Minimum Pressure Rating: 200 psig (1379 kPa) , unless otherwise indicated.
3. Description:
   a. Totally enclosed, externally pressurized, multi-ply, stainless-steel bellows isolated from fluid flow by an internal pipe sleeve.
   b. Carbon-steel housing.
   c. Drain plugs and lifting lug for NPS 3 (DN 80) and larger.
   d. Bellows shall have operating clearance between the internal pipe sleeves and the external shrouds.
   e. Joints shall be supplied with a built-in scale to confirm the starting position and operating movement.
4. Permanent Locking Bolts: Set locking bolts to maintain joint lengths during installation. Temporary welding tabs that are removed after installation in lieu of locking bolts are not acceptable.
5. End Connection Configuration: Flanged; one raised, fixed and one floating flange.

E. Rubber Packless Expansion Joints :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amber/Booth Company, Inc.; a VMC Group Company.
   b. Flex-Hose Co., Inc.
   c. Flexicraft Industries.
   d. Flex-Weld, Inc.
   e. Garlock Sealing Technologies.
   f. General Rubber Corporation.
   g. Mason Industries, Inc.
   h. Metraflex, Inc.
   i. Proco Products, Inc.
   j. Red Valve Company, Inc.
   k. Tozen Corporation.
   l. Unaflex.
   m. Unisource Manufacturing, Inc.
   n. .
2. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
3. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
4. Arch Type: Single or multiple arches with external control rods.
5. Spherical Type: Single or multiple spheres with external control rods.
6. Minimum Pressure Rating for NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 150 psig (1035 kPa) at 220 deg F (104 deg C) .
7. Minimum Pressure Rating for NPS 5 and NPS 6 (DN 125 and DN 150): 140 psig (966 kPa) at 200 deg F (93 deg C) .
8. Minimum Pressure Rating for NPS 8 to NPS 12 (DN 200 to DN 300): 140 psig (966 kPa) at 180 deg F (82 deg C) .

9. Material for Fluids Containing Acids, Alkalis, or Chemicals: Butyl rubber.
10. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N.
11. Material for Water: Buna-N .
12. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.3 GROOVED-JOINT EXPANSION JOINTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Anvil International, Inc.
2. Shurjoint Piping Products.
3. Victaulic Company.
4. .

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: Galvanized, ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.

E. Couplings: Five, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water, and bolts and nuts.

2.4 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Adsco Manufacturing LLC.
b. Advanced Thermal Systems, Inc.
c. Flex-Hose Co., Inc.
d. Flexicraft Industries.
e. Flex-Weld, Inc.
f. Hyspan Precision Products, Inc.
g. Mason Industries, Inc.
h. Metraflex, Inc.
i. Senior Flexonics Pathway.
j. Unisource Manufacturing, Inc.
k. U.S. Bellows, Inc.
2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:
1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
a. Stud: Threaded, zinc-coated carbon steel.
b. Expansion Plug: Zinc-coated steel.
c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

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

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

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

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

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

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

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

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

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

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

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

B. Install two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more thanfour pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

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

E. Anchor Attachments:
   1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
   1. Anchor Attachment to Steel Structural Members: Attach by welding.
   2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

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

END OF SECTION

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

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

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

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

D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch **(**0.6-mm**)** minimum thickness; round tube closed with welded longitudinal joint.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 SLEEVE-SEAL SYSTEMS

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. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.
6. .

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

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. Presealed Systems.

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

2.4 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 (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.
1. Sleeves are not required for core-drilled holes.

C. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

D. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 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 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. Using grout, seal the space around outside of sleeve-seal fittings.

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 (DN 150) Sleeve-seal fittings
2. Exterior Concrete Walls below Grade:
   a. Piping Smaller Than NPS 6 (DN 150) : Sleeve-seal fittings .
      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
   a. Piping Smaller Than NPS 6 (DN 150): Sleeve-seal fittings .
      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
4. Interior Partitions:

a. Piping Smaller Than NPS 6 **(**DN 150**)**: Galvanized-steel-pipe sleeves .

END OF SECTION

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Liquid-in-glass thermometers.
   2. Test plugs.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

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

1.4 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flo Fab Inc.
      b. Miljoco Corporation.
      c. Tel-Tru Manufacturing Company.
      d. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
      e. Weiss Instruments, Inc.
      f. WIKA Instrument Corporation - USA.
   2. Standard: ASME B40.200.
   3. Case: Plastic ; 6-inch (152-mm) nominal size.
   4. Case Form: Straight unless otherwise indicated.
   5. Tube: Glass with magnifying lens and blue or red organic liquid.
   6. Tube Background: Nonreflective with permanently etched scale markings graduated in [deg F (deg C)] [deg F and deg C].
   7. Window: Glass or plastic.
   8. Stem: Aluminum or brass and of length to suit installation.
      a. Design for Thermowell Installation: Bare stem.
   9. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
   10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. National Meter, Inc.
   2. Peterson Equipment Co., Inc.
   3. Sisco Manufacturing Company, Inc.
   4. Trerice, H. O. Co.
   5. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   6. Weiss Instruments, Inc.

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

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 (DN 8) or NPS 1/2 (DN 15), ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C) .

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

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

F. Install test plugs in piping tees.

G. Install thermometers in the following locations:
1. Inlet and outlet of each water heater.
2. Inlets and outlets of each domestic water heat exchanger.
3. Inlet and outlet of each domestic hot-water storage tank.

3.2 CONNECTIONS

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

3.3 ADJUSTING

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

3.4 THERMOMETER SCHEDULE

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

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

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

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F **(**Minus 20 to plus 50 deg C**)**.

B. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F **(**0 to 150 deg C**)**.

END OF SECTION

SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze ball valves.
2. Steel ball valves.
3. Iron ball valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. RPTFE: Reinforced polytetrafluoroethylene.

C. WOG: Water, oil, gas.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

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

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 or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Standards:
1. Domestic water valves intended to convey or dispense water for human consumption must comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or must be certified to be in compliance with NSF 61 and NSF 372 (by an ANSI-accredited third-party certification body) that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. ASME Compliance:
1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 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 cast copper solder-joint connections.
6. ASME B16.22 for wrought copper and copper alloy solder-joint connections.
7. ASME B16.34 for flanged and threaded end connections
8. ASME B31.9 for building services piping valves.

C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

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

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

F. Valve Actuator Type:
1. Gear Actuator: For quarter-turn valves NPS 4 (DN 100)and larger.
2. Hand Lever: For quarter-turn valves smaller than NPS 4 (DN 100).

G. Valves in Insulated Piping:
1. Provide 2-inch (50-mm) extended neck stems.
2. Extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.3 BRONZE BALL VALVES

A. Bronze Ball Valves, Two Piece with Full Port and Stainless Steel Trim, Threaded or Soldered Ends:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Milwaukee Valve Company.
c. NIBCO INC.
d. WATTS.

2. Standard: MSS SP-110; MSS SP-145.
3. CWP Rating: 600 psig (4140 kPa).
4. Body Design: Two piece.
5. Body Material: Bronze.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.

2.4 STEEL BALL VALVES

A. Steel Ball Valves with Full Port, Class 150, Flanged or Threaded Ends:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
b. Hammond Valve.
c. Jomar Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. WATTS.
2. Standard: MSS SP-72; MSS SP-110.
3. CWP Rating: 285 psig (1964 kPa).
4. Body Design: Split body.
5. Body Material: Carbon steel, ASTM A216/A216M, Type WCB.
6. Ends: Flanged or threaded.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.

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. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

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

B. Provide support to piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access.

D. For valves in horizontal piping, install valves with stem at or above center of pipe.

E. Install valves in position to allow full valve actuation movement.

F. Valve Tags: Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

G. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

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 exhibiting leakage.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

B. Select valves with the following end connections:
1. For Copper Tubing, NPS 2 **(**DN 50**)** and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4 **(**DN 65 to DN 100**)**: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 **(**DN 125**)** and Larger: Flanged ends.
4. For Steel Piping, NPS 2 **(**DN 50**)** and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4 **(**DN 65 to DN 100**)**: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 **(**DN 125**)** and Larger: Flanged ends.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 **(**DN 50**)** and Smaller:
1. Bronze ball valves, two piece with full port, and stainless steel trim. Provide with threaded solder-joint ends.

B. Pipe NPS 2-1/2 **(**DN 65**)** and Larger:
1. Steel and Iron Valves, NPS 2-1/2 to NPS 4 **(**DN 65 to DN 100**)**: May be provided with threaded ends instead of flanged ends.

END OF SECTION

SECTION 220523.13 - BUTTERFLY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Iron, single-flange butterfly valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

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

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.
   1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set 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. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
   1. ASME B16.1 for flanges on iron valves.
   2. ASME B16.5 for flanges on steel valves.
   3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   4. ASME B31.9 for building service piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

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

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

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

G. Valve Actuator Types:
   1. Gear Actuator: For valves NPS 8 **(**DN 200) and larger.
   2. Handlever: For valves NPS 6 **(**DN 150**)** and smaller.
   3. Chainwheel: Device for attachment to gear, handlever, or stem; of size and with chain for mounting height, according to "Valve Installation" Article.

H. Valves in Insulated Piping: With 2-inch **(**50-mm**)** stem extensions.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following]:
      a. ABZ Valve and Controls.
      b. Apollo Valves; Conbraco Industries, Inc.

c. Cooper Cameron Valves.
d. DeZURIK.
e. Flo Fab Inc.
f. Hammond Valve.
g. Jenkins Valves; Crane Energy Flow Solutions.
h. KITZ Corporation.
i. Legend Valve & Fitting, Inc.
j. Milwaukee Valve Company.
k. NIBCO INC.
l. Norriseal.
m. Red White Valve Corp.
n. Spence Strainers International.
o. Stockham; Crane Energy Flow Solutions.
p. WATTS.
q. <Insert manufacturer's name>.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig **(**1380 kPa**)**.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Aluminum bronze.

B. Iron, Single-Flange Butterfly Valves with Ductile-Iron Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABZ Valve and Controls.
   b. American Valve, Inc.
   c. Apollo Valves; Conbraco Industries, Inc.
   d. Cooper Cameron Valves.
   e. DeZURIK.
   f. Flo Fab Inc.
   g. Hammond Valve.
   h. Jenkins Valves; Crane Energy Flow Solutions.
   i. Jomar Valve.
   j. KITZ Corporation.
   k. Legend Valve & Fitting, Inc.
   l. Milwaukee Valve Company.
   m. Mueller Steam Specialty; A WATTS Brand.
   n. NIBCO INC.
   o. Norriseal.
   p. Spence Strainers International.
   q. Stockham; Crane Energy Flow Solutions.
   r. Sure Flow Equipment Inc.
   s. WATTS.
   t. <Insert manufacturer's name>.
2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig **(**1380 kPa**)**.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Stem: One- or two-piece stainless steel.
   f. Disc: Nickel-plated ductile iron.

C. Iron, Single-Flange Butterfly Valves with Stainless-Steel Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following]:
   a. ABZ Valve and Controls.
   b. American Valve, Inc.
   c. Apollo Valves; Conbraco Industries, Inc.
   d. Cooper Cameron Valves.
   e. DeZURIK.

f. Flo Fab Inc.
g. Hammond Valve.
h. Jenkins Valves; Crane Energy Flow Solutions.
i. KITZ Corporation.
j. Legend Valve & Fitting, Inc.
k. Milwaukee Valve Company.
l. Mueller Steam Specialty; A WATTS Brand.
m. NIBCO INC.
n. Norriseal.
o. Red White Valve Corp.
p. Spence Strainers International.
q. Stockham; Crane Energy Flow Solutions.
r. Sure Flow Equipment Inc.
s. WATTS.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating, NPS 12 (DN 300) and Smaller: 200 psig (1380 kPa).
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Stem: One- or two-piece stainless steel.
   f. Disc: Stainless steel.

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 mating flange faces for damage. 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.

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

3.2 VALVE INSTALLATION

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

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

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

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

E. Install chainwheels on operators for butterfly valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

F. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing 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 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:
   1. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM seat, stainless-steel disc.

END OF SECTION

SECTION 220523.14 - CHECK VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Bronze swing check valves.
   2. Iron swing check valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

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

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.
   1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set check valves in either closed or open position.

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 Annex G and NSF 372.

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.

2.2 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 150:
   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. Crane; Crane Energy Flow Solutions.
d. Jenkins Valves; Crane Energy Flow Solutions.
e. Jomar Valve.
f. KITZ Corporation.
g. Macomb Groups (The).
h. Milwaukee Valve Company.
i. NIBCO INC.
j. Red White Valve Corp.
k. Stockham; Crane Energy Flow Solutions.
l. <Insert manufacturer's name>.

2. Description:
a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig **(**2070 kPa**)**.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded or soldered. See valve schedule articles.
f. Disc: Bronze.

B. Bronze Swing Check Valves, Press Ends:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Elkhart Products Corporation.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. <Insert manufacturer's name>.

2. Description:
a. Standard: MSS SP-80 and MSS SP-139.
b. CWP Rating: Minimum 200 psig **(**1380 kPa**)**.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 584, bronze.
e. Ends: Press.
f. Press Ends Connection Rating: Minimum 200 psig **(**1380 kPa**)**.
g. Disc: Brass or bronze.

2.3 IRON SWING CHECK VALVES

A. 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; Crane Energy Flow Solutions.
c. FNW; Ferguson Enterprises, Inc.
d. Hammond Valve.
e. Jenkins Valves; Crane Energy Flow Solutions.
f. KITZ Corporation.
g. Legend Valve & Fitting, Inc.
h. Macomb Groups (The).
i. Milwaukee Valve Company.
j. NIBCO INC.
k. Powell Valves.
l. Red White Valve Corp.
m. Stockham; Crane Energy Flow Solutions.
n. Sure Flow Equipment Inc.
o. WATTS.
p. <Insert manufacturer's name>.

2. Description:
a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig **(**1380 kPa**)**.
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged or threaded. See valve schedule articles.
f. Trim: Bronze.
g. Gasket: Asbestos free.

B. Iron Swing Check Valves with Metal Seats, Class 250:

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.
   i. <Insert manufacturer's name>.
2. Description:
   a. Standard: MSS SP-71, Type I.
   b. CWP Rating: 500 psig **(**3450 kPa**)**.
   c. Body Design: Clear or full waterway.
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged or threaded. See valve schedule articles.
   f. Trim: Bronze.
   g. Gasket: Asbestos free.

2.4 IRON, CENTER-GUIDED, SPRING-LOADED CHECK VALVES

A. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 125:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International.
   b. APCO Willamette Valve and Primer Corporation.
   c. Crispin Valve.
   d. DFT Inc.
   e. Flo Fab Inc.
   f. FNW; Ferguson Enterprises, Inc.
   g. GA Industries, Inc.
   h. Hammond Valve.
   i. Metraflex Company (The).
   j. Milwaukee Valve Company.
   k. Mueller Steam Specialty; A WATTS Brand.
   l. NIBCO INC.
   m. Spence Strainers International.
   n. Sure Flow Equipment Inc.
   o. Val-Matic Valve & Manufacturing Corp.
   p. WATTS.
   q. <Insert manufacturer's name>.
2. Description:
   a. Standard: MSS SP-125.
   b. CWP Rating: 200 psig **(**1380 kPa**)**.
   c. Body Material: ASTM A 126, gray iron.
   d. Style: Compact wafer, spring loaded.
   e. Seat: Bronze.

B. Iron Globe, Center-Guided Check Valves with Metal Seat, Class 125:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. DFT Inc.
   d. Flomatic Corporation.
   e. Hammond Valve.
   f. Metraflex Company (The).
   g. Milwaukee Valve Company.
   h. Mueller Steam Specialty; A WATTS Brand.
   i. NIBCO INC.
   j. Spence Strainers International.
   k. Sure Flow Equipment Inc.
   l. Val-Matic Valve & Manufacturing Corp.
   m. WATTS.
   n. <Insert manufacturer's name>.

2. Description:
   a. Standard: MSS SP-125.
   b. CWP Rating: 200 psig **(**1380 kPa**)**.
   c. Body Material: ASTM A 126, gray iron.
   d. Style: Globe, spring loaded.
   e. Ends: Flanged.
   f. Seat: Bronze.

C. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 150:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. Val-Matic Valve & Manufacturing Corp.
      d. <Insert manufacturer's name>.
   2. Description:
      a. Standard: MSS SP-125.
      b. CWP Rating: 300 psig **(**2070 kPa**)**.
      c. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      d. Style: Compact wafer, spring loaded.
      e. Seat: Bronze.

D. Iron Globe, Center-Guided Check Valves with Metal Seat, Class 150:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. Val-Matic Valve & Manufacturing Corp.
      d. <Insert manufacturer's name>.
   2. Description:
      a. Standard: MSS SP-125.
      b. CWP Rating: 300 psig **(**2070 kPa**)**.
      c. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      d. Style: Globe, spring loaded.
      e. Ends: Flanged.
      f. Seat: Bronze.

E. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 250:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. DFT Inc.
      d. Flo Fab Inc.
      e. Hammond Valve.
      f. Metraflex Company (The).
      g. Milwaukee Valve Company.
      h. NIBCO INC.
      i. Sure Flow Equipment Inc.
      j. Val-Matic Valve & Manufacturing Corp.
      k. <Insert manufacturer's name>.
   2. Description:
      a. Standard: MSS SP-125.
      b. CWP Rating: 400 psig **(**2760 kPa**)**.
      c. Body Material: ASTM A 126, gray iron.
      d. Style: Compact wafer, spring loaded.
      e. Seat: Bronze.

F. Iron Globe, Center-Guided Check Valves with Metal Seat, Class 250:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. DFT Inc.
      d. Flomatic Corporation.
      e. Hammond Valve.
      f. Metraflex Company (The).
      g. Milwaukee Valve Company.

h. Mueller Steam Specialty; A WATTS Brand.
i. NIBCO INC.
j. Val-Matic Valve & Manufacturing Corp.
k. <Insert manufacturer's name>.

2. Description:
a. Standard: MSS SP-125.
b. CWP Rating: 400 psig **(**2760 kPa**)**.
c. Body Material: ASTM A 126, gray iron.
d. Style: Globe, spring loaded.
e. Ends: Flanged.
f. Seat: Bronze.

G. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 300:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. APCO Willamette Valve and Primer Corporation.
b. Crispin Valve.
c. Val-Matic Valve & Manufacturing Corp.
d. <Insert manufacturer's name>.
2. Description:
a. Standard: MSS SP-125.
b. CWP Rating: 500 psig **(**3450 kPa**)**.
c. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
d. Style: Compact wafer, spring loaded.
e. Seat: Bronze.

H. Iron Globe, Center-Guided Check Valves with Metal Seat, Class 300:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. APCO Willamette Valve and Primer Corporation.
b. Crispin Valve.
c. Val-Matic Valve & Manufacturing Corp.
d. <Insert manufacturer's name>.
2. Description:
a. Standard: MSS SP-125.
b. CWP Rating: 500 psig **(**3450 kPa**)**.
c. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
d. Style: Globe, spring loaded.
e. Ends: Flanged.
f. Seat: Bronze.

I. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 125:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. APCO Willamette Valve and Primer Corporation.
b. Apollo Flow Controls; Conbraco Industries, Inc.
c. Crispin Valve.
d. DFT Inc.
e. Flo Fab Inc.
f. Hammond Valve.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Spence Strainers International.
j. Sure Flow Equipment Inc.
k. Val-Matic Valve & Manufacturing Corp.
l. <Insert manufacturer's name>.
2. Description:
a. Standard: MSS SP-125.
b. CWP Rating: 200 psig **(**1380 kPa**)**.
c. Body Material: ASTM A 126, gray iron.
d. Style: Compact wafer, spring loaded.
e. Seat: EPDM.

J. Iron Globe, Center-Guided Check Valves with Resilient Seat, Class 125:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Anvil International.
b. APCO Willamette Valve and Primer Corporation.

c. Apollo Flow Controls; Conbraco Industries, Inc.
d. Crispin Valve.
e. DFT Inc.
f. GA Industries, Inc.
g. Hammond Valve.
h. Milwaukee Valve Company.
i. NIBCO INC.
j. Sure Flow Equipment Inc.
k. Val-Matic Valve & Manufacturing Corp.
l. Zurn Industries, LLC.
m. <Insert manufacturer's name>.

2. Description:
a. Standard: MSS SP-125.
b. CWP Rating: 200 psig **(**1380 kPa**)**.
c. Body Material: ASTM A 126, gray iron.
d. Style: Globe, spring loaded.
e. Ends: Flanged.
f. Seat: EPDM.

K. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 150:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. APCO Willamette Valve and Primer Corporation.
b. Crispin Valve.
c. Val-Matic Valve & Manufacturing Corp.
2. Description:
a. Standard: MSS SP-125.
b. CWP Rating: 300 psig **(**2070 kPa**)**.
c. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
d. Style: Compact wafer, spring loaded.
e. Seat: EPDM.

L. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 150:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. APCO Willamette Valve and Primer Corporation.
b. Crispin Valve.
c. DFT Inc.
d. Val-Matic Valve & Manufacturing Corp.
2. Description:
a. Standard: MSS SP-125.
b. CWP Rating: 300 psig **(**2070 kPa**)**.
c. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
d. Style: Globe, spring loaded.
e. Ends: Flanged.
f. Seat: EPDM.

M. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 250:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. APCO Willamette Valve and Primer Corporation.
b. Crispin Valve.
c. DFT Inc.
d. Flo Fab Inc.
e. Hammond Valve.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Sure Flow Equipment Inc.
i. Val-Matic Valve & Manufacturing Corp.
2. Description:
a. Standard: MSS SP-125.
b. CWP Rating: 400 psig **(**2760 kPa**)**.
c. Body Material: ASTM A 126, gray iron.
d. Style: Compact wafer, spring loaded.
e. Seat: EPDM.

N. Iron Globe, Center-Guided Check Valves with Resilient Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. DFT Inc.
   d. Hammond Valve.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Val-Matic Valve & Manufacturing Corp.
2. Description:
   a. Standard: MSS SP-125.
   b. CWP Rating: 400 psig **(**2760 kPa**)**.
   c. Body Material: ASTM A 126, gray iron.
   d. Style: Globe, spring loaded.
   e. Ends: Flanged.
   f. Seat: EPDM.

O. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 300:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. Val-Matic Valve & Manufacturing Corp.
2. Description:
   a. Standard: MSS SP-125.
   b. CWP Rating: 500 psig **(**3450 kPa**)**.
   c. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
   d. Style: Compact wafer, spring loaded.
   e. Seat: EPDM.

P. Iron Globe, Center-Guided Check Valves with Resilient Seat, Class 300:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. Val-Matic Valve & Manufacturing Corp.
2. Description:
   a. Standard: MSS SP-125.
   b. CWP Rating: 500 psig **(**3450 kPa**)**.
   c. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
   d. Style: Globe, spring loaded.
   e. Ends: Flanged.
   f. Seat: EPDM.

2.5 IRON, PLATE-TYPE CHECK VALVES

A. Iron, Dual-Plate Check Valves with Metal Seat, Class 125:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane; Crane Energy Flow Solutions.
   c. Flomatic Corporation.
   d. Keckley Company.
   e. Mueller Steam Specialty; A WATTS Brand.
2. Standard: API 594.
3. CWP Rating: 200 psig **(**1380 kPa**)**.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A 126, gray iron.
6. Seat: Bronze.

B. Iron, Dual-Plate Check Valves with Metal Seat, Class 150:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following]:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane; Crane Energy Flow Solutions.
   c. Mueller Steam Specialty; A WATTS Brand.
   d. Val-Matic Valve & Manufacturing Corp.
2. Standard: API 594.
3. CWP Rating: 300 psig **(**2070 kPa**)**.

4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
6. Seat: Bronze.

C. Iron, Dual-Plate Check Valves with Metal Seat, Class 250:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane; Crane Energy Flow Solutions.
2. Standard: API 594.
3. CWP Rating: 400 psig **(**2760 kPa**)**.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A 126, gray iron.
6. Seat: Bronze.

D. Iron, Dual-Plate Check Valves with Metal Seat, Class 300:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane; Crane Energy Flow Solutions.
   c. Mueller Steam Specialty; A WATTS Brand.
   d. Val-Matic Valve & Manufacturing Corp.
2. Standard: API 594.
3. CWP Rating: 500 psig **(**3450 kPa**)**.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
6. Seat: Bronze.

E. Iron, Single-Plate Check Valves with Resilient Seat, Class 125:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flo Fab Inc.
   b. Keckley Company.
   c. Sure Flow Equipment Inc.
2. Standard: API 594.
3. CWP Rating: 200 psig **(**1380 kPa**)**.
4. Body Design: Wafer, spring-loaded plate.
5. Body Material: ASTM A 126, gray iron.
6. Seat: EPDM.

F. Iron, Dual-Plate Check Valves with Resilient Seat, Class 125:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Cooper Cameron Valves.
   c. Crane; Crane Energy Flow Solutions.
   d. Keckley Company.
   e. NIBCO INC.
   f. Spence Strainers International.
   g. Sure Flow Equipment Inc.
   h. WATTS.
2. Standard: API 594.
3. CWP Rating: 200 psig **(**1380 kPa**)**.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A 126, gray iron.
6. Seat: EPDM.

G. Iron, Dual-Plate Check Valves with Resilient Seat, Class 150:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane; Crane Energy Flow Solutions.
   c. Val-Matic Valve & Manufacturing Corp.
2. Standard: API 594.
3. CWP Rating: 300 psig **(**2070 kPa**)**.
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
6. Seat: EPDM.

H. Iron, Wafer, Single-Plate Check Valves with Resilient Seat, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Sure Flow Equipment Inc.
2. Standard: API 594.
3. CWP Rating: 400 psig (2760 kPa).
4. Body Design: Wafer, spring-loaded plate.
5. Body Material: ASTM A 126, gray iron.
6. Seat: EPDM.

I. Iron, Dual-Plate Check Valves with Resilient Seat, Class 250:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane; Crane Energy Flow Solutions.
   c. Sure Flow Equipment Inc.
2. Standard: API 594.
3. CWP Rating: 400 psig (2760 kPa).
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A 126, gray iron.
6. Seat: EPDM.

J. Iron, Dual-Plate Check Valves with Resilient Seat, Class 300:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Val-Matic Valve & Manufacturing Corp.
2. Standard: API 594.
3. CWP Rating: 500 psig (3450 kPa).
4. Body Design: Wafer, spring-loaded plates.
5. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
6. Seat: EPDM.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

3.2 VALVE INSTALLATION

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

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

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

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

E. Check Valves: Install check valves for proper direction of flow.
1. Swing Check Valves: In horizontal position with hinge pin level.
2. Check Valves: In horizontal or vertical position, between flanges.

F. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing 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 valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. End Connections:
1. For Copper Tubing, NPS 2 **(**DN 50**)** and Smaller: Threaded or soldered or press-ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4 **(**DN 65 to DN 100**)**: Flanged or threaded.
3. For Copper Tubing, NPS 5 **(**DN 125**)** and Larger: Flanged.
4. For Steel Piping, NPS 2 **(**DN 50**)** and Smaller: Threaded.
5. For Steel Piping, NPS 2-1/2 to NPS 4 **(**DN 65 to DN 100**)**: Flanged or threaded.
6. For Steel Piping, NPS 5 **(**DN 125) and Larger: Flanged.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
1. Bronze swing check valves with bronze disc, Class 150, with soldered or threaded end connections.
2. Bronze swing check valves with press-end connections.

B. Pipe NPS 2-1/2 **(**DN 65**)** and Larger:
1. Iron swing check valves with metal seats, Class 125, with flanged end connections.
2. Iron, center-guided check valves with compact wafer, Class 125 .
3. Iron, center-guided check valves with globe, resilient seat, Class 125 , with threaded or flanged end connections.
4. Iron, dual-plate check valves with resilient seat, Class 125 , with threaded or flanged end connections.
5. Iron, single-plate check valves with resilient seat, Class 125, with threaded orflanged end connections.

END OF SECTION

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Pipe positioning systems.
10. 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 220548.13 "Vibration Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.2 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for 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.

1.4 ACTION SUBMITTALS

A. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

B. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

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

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

2.2 TRAPEZE PIPE HANGERS

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

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

C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:
1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Stainless steel.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

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

F. Curb-Mounting-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.

2.4 EQUIPMENT SUPPORTS

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

2.5 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi **(**34.5-MPa**)**, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

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

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

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

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

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

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

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

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

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

L. Insulated Piping:
1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
   d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
   e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

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

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

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

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

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

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

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

H. 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 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.

3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 **(**DN 20 to DN 900**)**, requiring clamp flexibility and up to 4 inches **(**100 mm**)** of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 **(**DN 15 to DN 600**)** if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 **(**DN 15 to DN 100**)**, 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 **(**DN 20 to DN 200**)**.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 **(**DN 15 to DN 200**)**.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 **(**DN 15 to DN 200**)**.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 **(**DN 15 to DN 200**)**.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 **(**DN 10 to DN 200**)**.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 **(**DN 10 to DN 80**)**.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 **(**DN 15 to DN 750**)**.
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 **(**DN 100 to DN 900**)**, 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 **(**DN 100 to DN 900**)**, 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 **(**DN 65 to DN 900**)** 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 **(**DN 25 to DN 750**)**, 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 **(**DN 65 to DN 600**)**, 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 **(**DN 50 to DN 1050**)** if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 **(**DN 50 to DN 600**)** if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 **(**DN 50 to DN 750**)** if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

I. 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 **(**340 kg**)**.
    b. Medium (MSS Type 32): 1500 lb **(**680 kg**)**.
    c. Heavy (MSS Type 33): 3000 lb **(**1360 kg**)**.
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.

J. 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.

K. 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 **(**32 mm**)**.
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.

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

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

N. Use instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 220548.13 - VIBRATION CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient support.
9. Resilient pipe guides.
10. Air-spring isolators.
11. Restrained-air-spring isolators.
12. Elastomeric hangers.
13. Spring hangers.
14. Snubbers.
15. Restraints - rigid type.
16. Restraints - cable type.
17. Restraint accessories.
18. Post-installed concrete anchors.
19. Concrete inserts.
20. Vibration isolation equipment bases.

B. Related Requirements:
1. Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
2. Section 230548.13 "Vibration Controls for HVAC" for devices for HVAC equipment and systems.

1.2 DEFINITIONS

A. IBC: International Building Code.

B. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.3 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-load-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 wind-load-restraint]component.
4. Annotate to indicate application of each product submitted and compliance with requirements.
5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

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

C. Delegated-Design Submittal:
1. For each wind-load protection device that is required by this Section or is indicated on Drawings, submit the following:
a. Vibration Isolator and Wind-Load-Restraint Selection: Select vibration isolators 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, and spring deflection changes. 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 wind loads.
d. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
e. Qualified Professional Engineer: All designated-design submittals for wind-restraint calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.

2. All delegated-design submittals for wind-restraint detail Drawings are to be signed and sealed by qualified professional engineer responsible for their preparation.
3. Product Listing, Preapproval, and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and basis for approval (tests or calculations).
4. 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.
5. 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.

1.4 INFORMATIONAL SUBMITTALS

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

B. Qualification Data: For professional engineer.

C. Welding certificates.

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

E. Field quality-control reports.

F. Wind-Load Performance Certification: Provide special certification for plumbing components subject to high wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-load performance certification.
1. Provide equipment manufacturer's written certification for each designated plumbing 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. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.
3. The following plumbing systems and components require special certification for high wind performance. Written special certification of resistance to the effects of high wind load and impact damage must be provided by manufacturer.

1.5 CLOSEOUT SUBMITTALS

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

1.6 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. 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 agency acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design system.

B. Suspended piping:
1. Sping Hangers or Rubber Hangers shall be used for all piping in equipment rooms and up to 50 ft from vibration isolated equipment and pressure regulating valve (PRV) stations.
    a. The first three hangers from the equipment shall provide the same deflection as the equipment isolators, with a maximum limitation of 2 in. deflection.
    b. The remaining hangers shall be spring or combination spring and rubber with 0.75 in. deflection.
2. The first two hangers adjacent to the equipment shall be the positioning of precompressed type, to prevent load transfer to equipment flanges when the piping system is filled.
3. Piping over 2 in. in diameter that is suspended below or withing 50 ft of noise-sensitive areas shall be hung with combination spring and rubber hangers.
4. Noise-sensitive areas are as follows:
    a. Conference rooms.
    b. Auditoriums.
    c. Class rooms.
    d. Lecture halls.
    e. Performance halls.
    f. Museum galleries.
    g. Museum exhibits.
    h. Recording studios.

C. Floor-supported piping:
1. Floor supports for piping in equipment rooms and adjacent to isolated equipment shall use vibration isolators as described in Table 47, Chapter 49 of ASHRAE Handbook - HVAC Applications.
    a. The first two adjacent floor supports shall be the restrained spring type, with a blocking feature that prevents load transfer to equipment flanges as the piping is filled or drained.
2. Where the piping is subjected to large thermal movement, a slide plate (PTFE, graphite or steel) shall be installed on top of the isolator and a thermal barrier shall be used when rubber products are installed directly beneath steam or hot-water lines.

D. Fire/Smoke Resistance: All components 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 7-05 Section 13.6.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Ace Mountings Co., Inc.
    b. CADDY; a brand of nVent.
    c. California Dynamics Corporation.
    d. Isolation Technology, Inc.
    e. Kinetics Noise Control, Inc.
    f. Korfund.
    g. Mason Industries, Inc.
    h. Novia; A Division of C&P.
    i. Vibration Eliminator Co., Inc.
    j. Vibration Management Corp.
    k. Vibration Mountings & Controls, Inc.
2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.

4. Minimum deflection as indicated on Drawings.
5. Pad Material: Oil- and water-resistant rubber.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient.
    a. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Elastomeric Isolation Mounts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Ace Mountings Co., Inc.
    b. CADDY; a brand of nVent.
    c. California Dynamics Corporation.
    d. Isolation Technology, Inc.
    e. Kinetics Noise Control, Inc.
    f. Korfund.
    g. Mason Industries, Inc.
    h. Novia; A Division of C&P.
    i. Vibration Eliminator Co., Inc.
    j. Vibration Isolation.
    k. Vibration Management Corp.
    l. Vibration Mountings & Controls, Inc.

2. Mounting Plates:
    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
    b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Minimum deflection as indicated on Drawings.
4. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Ace Mountings Co., Inc.
    b. CADDY; a brand of nVent.
    c. California Dynamics Corporation.
    d. Isolation Technology, Inc.
    e. Kinetics Noise Control, Inc.
    f. Korfund.
    g. Mason Industries, Inc.
    h. Novia; A Division of C&P.
    i. Vibration Eliminator Co., Inc.
    j. Vibration Isolation.
    k. Vibration Management Corp.
    l. Vibration Mountings & Controls, Inc.

2. Description: All-directional isolator with 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.
3. Minimum deflection as indicated on Drawings.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Ace Mountings Co., Inc.
    b. CADDY; a brand of nVent.
    c. California Dynamics Corporation.
    d. Isolation Technology, Inc.
    e. Kinetics Noise Control, Inc.

f. Korfund.
g. Mason Industries, Inc.
h. Novia; A Division of C&P.
i. Vibration Eliminator Co., Inc.
j. Vibration Isolation.
k. Vibration Management Corp.
l. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psi **(**3447 kPa**)**.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
8. Minimum deflection as indicated on Drawings.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Ace Mountings Co., Inc.
b. CADDY; a brand of nVent.
c. California Dynamics Corporation.
d. Isolation Technology, Inc.
e. Kinetics Noise Control, Inc.
f. Korfund.
g. Mason Industries, Inc.
h. Vibration Eliminator Co., Inc.
i. Vibration Isolation.
j. Vibration Management Corp.
k. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum deflection as indicated on Drawings.
7. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi **(**3447 kPa**)**.
b. Top housing with threaded mounting holes and internal leveling device.

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Ace Mountings Co., Inc.
b. CADDY; a brand of nVent.
c. California Dynamics Corporation.
d. Isolation Technology, Inc.
e. Kinetics Noise Control, Inc.
f. Korfund.
g. Mason Industries, Inc.
h. Novia; A Division of C&P.
i. Vibration Eliminator Co., Inc.
j. Vibration Isolation.
k. Vibration Management Corp.

l. Vibration Mountings & Controls, Inc.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
   a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi **(**3447 kPa**)**.
   b. Top plate with threaded mounting holes.
   c. Internal leveling bolt that acts as blocking during installation.
3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Minimum deflection as indicated on Drawings.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation.
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund.
   g. Mason Industries, Inc.
   h. Vibration Eliminator Co., Inc.
   i. Vibration Isolation.
   j. Vibration Management Corp.
   k. Vibration Mountings & Controls, Inc.

2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi **(**3447 kPa**)**.
   b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Minimum deflection as indicated on Drawings.

2.9 PIPE-RISER RESILIENT SUPPORT

A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch-**(**13-mm-**)** Thick Neoprene:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc.
   d. Vibration Eliminator Co., Inc.
   e. Vibration Management Corp.

2. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
3. Maximum Load Per Support: 500 psi **(**3447 kPa**)** on isolation material providing equal isolation in all directions.

4. Minimum deflection as indicated on Drawings.

2.10 RESILIENT PIPE GUIDES

A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch- **(**13-mm-**)** Thick Neoprene:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. California Dynamics Corporation.
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc.
   d. Vibration Eliminator Co., Inc.
   e. Vibration Management Corp.
   f. Vibration Mountings & Controls, Inc.

2. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CADDY; a brand of nVent.
   b. Firestone Industrial Products Company.
   c. Mason Industries, Inc.
   d. Vibration Management Corp.

2. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
3. Maximum Natural Frequency: 3 Hz.
4. Operating Pressure Range: 25 to 100 psi **(**172 to 690 kPa**)**.
5. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
6. Minimum deflection as indicated on Drawings.
7. Automatic leveling valve.

2.12 RESTRAINED-AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows with Vertical-Limit Stop Restraint:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CADDY; a brand of nVent.
   b. Firestone Industrial Products Company.
   c. Mason Industries, Inc.
   d. Vibration Management Corp.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
   a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi **(**3447 kPa**)**.
   b. Top plate with threaded mounting holes.
   c. Internal leveling bolt that acts as blocking during installation.
3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Minimum deflection as indicated on Drawings.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
9. Maximum Natural Frequency: 3 Hz.
10. Operating Pressure Range: 25 to 100 psi **(**172 to 690 kPa**)**.
11. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
12. Automatic leveling valve.

2.13 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following]:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Novia; A Division of C&P.
   g. Vibration Eliminator Co., Inc.
   h. Vibration Isolation.
   i. Vibration Management Corp.
   j. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.
4. Minimum deflection as indicated on Drawings.

2.14 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ace Mountings Co., Inc.
      b. CADDY; a brand of nVent.
      c. California Dynamics Corporation.
      d. Kinetics Noise Control, Inc.
      e. Mason Industries, Inc.
      f. Novia; A Division of C&P.
      g. Vibration Eliminator Co., Inc.
      h. Vibration Isolation.
      i. Vibration Management Corp.
      j. Vibration Mountings & Controls, Inc.

   2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Minimum deflection as indicated on Drawings.
   7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   8. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
   10. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.15 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CADDY; a brand of nVent.
   2. Kinetics Noise Control, Inc.
   3. Mason Industries, Inc.
   4. Vibration Management Corp.
   5. 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 prequalified in accordance with ACI 355.2 testing and designated in accordance with [ACI 318-08 Appendix D for 2009 IBC] [ACI 318-11 Appendix D for 2012 IBC] [ACI 318-14 Ch. 17 for 2015 or 2018 IBC]
   2. Preset Concrete Inserts: 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 **(**6-mm**)** air gap, and minimum 1/4 inch **(**6 mm**)** thick.

2.16 RESTRAINTS - RIGID TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
2. CADDY; a brand of nVent.
3. California Dynamics Corporation.
4. Hilti, Inc.
5. Isolation Technology, Inc.
6. TOLCO.
7. Unistrut; Part of Atkore International.
8. Vibration Mountings & Controls, Inc.

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.

2.17 RESTRAINTS - CABLE TYPE

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. B-line, an Eaton business.
2. CADDY; a brand of nVent.
3. Loos & Co.
4. Vibration Mountings & Controls, Inc.

B. Restraint Cables: [ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel] [ASTM A492 stainless steel] cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.

C. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19-10. 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.

2.18 RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
2. CADDY; a brand of nVent.
3. Hilti, Inc.
4. Loos & Co.
5. Mason Industries, Inc.
6. TOLCO.
7. Unistrut; Part of Atkore International.

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.

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

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

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

2.19 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. B-line, an Eaton business.
   b. Hilti, Inc.
   c. Mason Industries, Inc.
   d. Powers Fasteners.
   e. Simpson Strong-Tie Co., Inc.
   f. Unistrut; Part of Atkore International.

2. 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 E488/E488M.

B. Adhesive Anchor Bolts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. B-line, an Eaton business.
   b. Hilti, Inc.
   c. Mason Industries, Inc.
   d. Powers Fasteners.
   e. Simpson Strong-Tie Co., Inc.
   f. Unistrut; Part of Atkore International.

2. 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.

C. 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 7-05, 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.

D. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp **(**7.46 kW**)** that is not vibration isolated.
1. Undercut expansion anchors are permitted.

2.20 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. Powers Fasteners.
5. Simpson Strong-Tie Co., Inc.
6. Unistrut; Part of Atkore International.

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

C. Comply with ANSI/MSS SP-58.

2.21 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CADDY; a brand of nVent.
2. California Dynamics Corporation.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.
5. Novia; A Division of C&P.
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation.

8. Vibration Management Corp.
9. 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 **(**25-mm**)** 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 **(**25-mm**)** 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 **(**25-mm**)** 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.
   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.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation 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 agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to wind load forces.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static forces within specified loading limits.

3.3 INSTALLATION OF VIBRATION-CONTROL DEVICES

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

B. Provide wind-load control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules, where indicated on Drawings, where the 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 must not cause any stresses, misalignment or change of position of equipment or piping.

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

F. Equipment Restraints:
1. Install snubbers on plumbing 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 **(**3.2 mm**)**.
3. Install wind-load-restraint devices using methods approved by 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 (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

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

I. Install wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

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

K. 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.

L. 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.

M. Post-Installed Concrete 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 Project 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. Mechanical-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 INSTALLATION OF AIR-SPRING ISOLATORS

A. Independent Isolator Installation:
1. Install automatic leveling valve into each air isolator.
2. Inflate each isolator to height and pressure specified on Drawings.

B. Pressure-Regulated Isolator Installation:
1. Coordinate the constant pressure-regulated air supply to air springs with requirements for piping and connections specified in Section 221513 "General-Service Compressed-Air Piping."
2. Connect all pressure regulators to a single dry, filtered facility air supply.
3. Inflate isolators to height and pressure specified on Drawings.

3.5 ACCOMMODATION OF DIFFERENTIAL MOTION

A. Provide flexible connections in piping systems where they cross structural 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 Section 221116 "Domestic Water Piping" and Section 221119 "Domestic Water Piping Specialties" for piping flexible connections.

3.6 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, bases, and concrete inertia bases, with requirements of isolated equipment specified in this and other Sections. Where dimensions of base are indicated on Drawings, they may require adjustment to accommodate actual isolated equipment.

3.7 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.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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

C. 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.
   10. Test and adjust restrained-air-spring isolator controls and safeties.

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

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

F. Prepare test and inspection reports.

END OF SECTION

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 ACTION SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

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

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Labels for Equipment:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Brady Corporation.
   b. Brimar Industries, Inc.
   c. Carlton Industries, LP.
   d. Champion America.
   e. Craftmark Identification Systems.
   f. emedco.
   g. Kolbi Pipe Marker Co.
   h. LEM Products Inc.
   i. Marking Services Inc.
2. Material and Thickness: plastic
3. Letter Color: White
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch **(**64 by 19 mm**)**.
5. Minimum Letter Size: 1/4 inch **(**6.4 mm**)** for name of units if viewing distance is less than 24 inches **(**600 mm**)**, 1/2 inch **(**13 mm**)** for viewing distances up to 72 inches **(**1830 mm**)**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.2 WARNING SIGNS AND LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. Champion America.
5. Craftmark Identification Systems.
6. emedco.
7. LEM Products Inc.
8. Marking Services Inc.
9. NMC.
10. Seton Identification Products.
11. Stranco, Inc.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: Yellow.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

G. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

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

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

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

2.3 PIPE LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Actioncraft Products, Inc.
2. Brady Corporation.
3. Brimar Industries, Inc.
4. Carlton Industries, LP.
5. Champion America.
6. Craftmark Identification Systems.
7. emedco.
8. Kolbi Pipe Marker Co.
9. LEM Products Inc.
10. Marking Services Inc.
11. Seton Identification Products.

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

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

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

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

2.4 VALVE TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Actioncraft Products, Inc.
2. Brady Corporation.
3. Brimar Industries, Inc.
4. Carlton Industries, LP.
5. Champion America.
6. Craftmark Identification Systems.
7. emedco.
8. Kolbi Pipe Marker Co.
9. LEM Products Inc.
10. Marking Services Inc.
11. Seton Identification Products.

B. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
   1. Tag Material: Brass, 0.032-inch (0.8-mm) , 0.032-inch (0.8-mm)minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: BrassS-hook.

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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.

2.5 WARNING TAGS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Brady Corporation.
   2. Brimar Industries, Inc.
   3. Carlton Industries, LP.
   4. Champion America.
   5. Craftmark Identification Systems.
   6. emedco.
   7. Kolbi Pipe Marker Co.
   8. LEM Products Inc.
   9. Marking Services Inc.
   10. 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 (75 by 133 mm) minimum .
   2. Fasteners: Reinforced grommet and wire or string.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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

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

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

3.3 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting." Section 099600 "High-Performance Coatings."

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. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

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

D. Pipe Label Color Schedule:
1. Domestic Cold Water Piping
   a. Background: Dark Green.
   b. Letter Colors: White.
2. Domestic Hot Water and Hot Water Return Piping
   a. Background: Pink
   b. Letter Colors: White
3. Sanitary Waste and Storm Drainage Piping:
   a. Background Color: Safety black .
   b. Letter Color: White.

3.5 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-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
1. Valve-Tag Size and Shape:
   a. Cold Water: 1 inches (38 mm), round.
   b. Hot Water: 1 inches (38 mm), round.
2. Valve-Tag Colors:
   a. Cold Water: Natural.
   b. Hot Water: Natural.
3. Letter Colors:
   a. Cold Water: Black.
   b. Hot Water: Black.

END OF SECTION

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:
   1. Domestic cold-water piping.
   2. Domestic hot-water piping.
   3. Domestic recirculating hot-water piping.
   4. Roof drains and rainwater leaders.

B. Related Requirements:
   1. Section 220716 "Plumbing Equipment Insulation."

1.2 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 application of field-applied jackets.
   7. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

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

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 specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.7 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 "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

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

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

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

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

F. Mineral-Fiber, Preformed Pipe Insulation:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Fibrex Insulations Inc.; Coreplus 1200.
   b. Johns Manville; Micro-Lok.
   c. Knauf Insulation; 1000-Degree Pipe Insulation.
   d. Manson Insulation Inc.; Alley-K.
2. Type I, 850 Deg F (454 Deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Armacell LLC; Tubolit.
   b. Nomaco Insulation; IMCOLOCK and NOMALOCK.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Ramco Insulation, Inc.; Thermokote V.
   b. Insert manufacturer's name; product name or designation.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

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. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
   b. Eagle Bridges - Marathon Industries; 225.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-20.
d. Mon-Eco Industries, Inc.; 22-25.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Dow Corning Corporation; 739, Dow Silicone.
b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

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

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm **(**0.009 metric perm**)** at 43-mil **(**1.09-mm**)** dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F **(**Minus 29 to plus 82 deg C**)**.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
b. Eagle Bridges - Marathon Industries; 501.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
d. Mon-Eco Industries, Inc.; 55-10.
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm **(**0.03 metric perm**)** at 35-mil **(**0.9-mm**)** dry film thickness.
3. Service Temperature Range: 0 to 180 deg F **(**Minus 18 to plus 82 deg C**)**.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.

5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
b. Eagle Bridges - Marathon Industries; 570.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Products: Subject to compliance with requirements, provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
b. Eagle Bridges - Marathon Industries; 550.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
d. Mon-Eco Industries, Inc.; 55-50.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
1. 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).
2. Products: Subject to compliance with requirements, provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
c. Vimasco Corporation; 713 and 714.
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:
1. Joint Sealants for Cellular-Glass and Phenolic Products: Subject to compliance with requirements, provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Eagle Bridges - Marathon Industries; 405.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
d. Mon-Eco Industries, Inc.; 44-05.
e. Pittsburgh Corning Corporation; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F **(**Minus 40 to plus 121 deg C**)**.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 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.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 428 AWF ASJ.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
   c. Compac Corporation; 104 and 105.
   d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches **(**75 mm**)**.
3. Thickness: 11.5 mils **(**0.29 mm**)**.
4. Adhesion: 90 ounces force/inch **(**1.0 N/mm**)** in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch **(**7.2 N/mm**)** in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 491 AWF FSK.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   c. Compac Corporation; 110 and 111.
   d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
2. Width: 3 inches **(**75 mm**)**.
3. Thickness: 6.5 mils **(**0.16 mm**)**.
4. Adhesion: 90 ounces force/inch **(**1.0 N/mm**)** in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch **(**7.2 N/mm**)** in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 370 White PVC tape.
   b. Compac Corporation; 130.
   c. Venture Tape; 1506 CW NS.
2. Width: 2 inches **(**50 mm**)**.
3. Thickness: 6 mils **(**0.15 mm**)**.

4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.
2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.9 SECUREMENTS

A. Bands:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. ITW Insulation Systems; Gerrard Strapping and Seals.
   b. RPR Products, Inc.; Insul-Mate Strapping and Seals.
2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.
3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

C. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. C & F Wire.

2.10 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers,
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Engineered Brass Company.
   b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
   c. McGuire Manufacturing.
   d. Plumberex.
   e. Truebro; a brand of IPS Corporation.
   f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
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; a brand of IPS Corporation.
   b. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
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 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.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

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

L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches **(**38 mm**)**. 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 **(**50 mm**)** 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 **(**100 mm**)** 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. Cleanouts.

3.4 PENETRATIONS

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

B. 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.

3.5 GENERAL PIPE INSULATION INSTALLATION

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

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

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

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

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches **(**50 mm**)** over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF 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 **(**150 mm**)** 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 **(**25 mm**)**, 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.

3.7 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

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

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

3.9 PIPING INSULATION SCHEDULE, GENERAL

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

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.10 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:
1. NPS 1 **(**DN 25**)** and Smaller: Insulation shall be the following:
a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch **(**13 mm**)** thick.
2. NPS 1-1/4 **(**DN 32**)** and Larger: Insulation shall be the following:
a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch **(**25 mm**)** thick.

B. Domestic Hot and Recirculated Hot Water:
1. NPS 1-1/4 **(**DN 32**)** and Smaller: Insulation shall be the following:
a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch **(**25 mm**)** thick.
2. NPS 1-1/2 **(**DN 40**)** and Larger: Insulation shall be the following:
a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch **(**25 mm**)** thick.

C. Stormwater and Overflow:
1. All Pipe Sizes: Insulation shall be the following:
a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch **(**25 mm**)** thick.

END OF SECTION

SECTION 220800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes Cx process requirements for the following plumbing systems, assemblies, and equipment:
   1. Domestic hot- and cold-water piping.
   2. Sanitary waste and vent piping.
   3. Storm drainage piping.
   4. Plumbing equipment.

B. Related Requirements:
   1. For construction checklists, comply with requirements in various Division 22 Sections specifying plumbing systems, system components, equipment, and products.

1.2 DEFINITIONS

A. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For plumbing testing technician.

B. Construction Checklists: Draft construction checklists will be created by CxA for Contractor review.

C. Construction Checklists: Material, installation, and performance test checklists for systems, assemblies, subsystems, equipment, and components to be part of the Cx process and according to requirements.
   1. Domestic water piping, including the following:
      a. Domestic cold- and hot-water piping, fittings, and specialties inside the building.
      b. Pumps, motors, accessories, and controls.
      c. Sleeves and sleeve seals.
      d. Indoor water-storage tanks.
      e. Meters and gages.
      f. General-duty and specialty valves.
      g. Hangers and supports.
   2. Sanitary waste and vent piping, including the following:
      a. Drains.
      b. Sleeves and sleeve seals.
      c. General-duty and specialty valves.
      d. Hangers and supports.
   3. Storm-water piping, including the following:
      a. Drainage piping, fittings, and specialties.
      b. Drains and collection basins.
      c. Sleeves and sleeve seals.
      d. Hangers and supports.
      e. Vibration isolation.

D. Test equipment and instrumentation list, identifying the following:
   1. Equipment/instrument identification number.
   2. Planned Cx application or use.
   3. Manufacturer, make, model, and serial number.
   4. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
   5. Equipment manufacturers' proprietary instrumentation and tools. For each instrument or tool, identify the following:
      a. Instrument or tool identification number.
      b. Equipment schedule designation of equipment for which the instrument or tool is required.
      c. Manufacturer, make, model, and serial number.
      d. Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

1.4 QUALITY ASSURANCE

A. Plumbing Testing Technician Qualifications: Technicians to perform plumbing construction checklist verification tests, construction checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
   1. Journey level or equivalent skill level with knowledge of plumbing system, electrical concepts, and building operations.
   2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.

B. Testing Equipment and Instrumentation Quality and Calibration:
   1. Capable of testing and measuring performance within the specified acceptance criteria.
   2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
   3. Be maintained in good repair and operating condition throughout duration of use on Project.
   4. Be recalibrated/repaired if dropped or damaged in any way since last calibrated.

C. Proprietary Test Instrumentation and Tools:
   1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
      a. Be calibrated by manufacturer with current calibration tags permanently affixed.
      b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
      c. Plumbing system proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLISTS

A. Prepare detailed construction checklists for plumbing systems, assemblies, subsystems, equipment, and components.
   1. Domestic hot- and cold-water piping.
   2. Sanitary waste and vent piping.
   3. Plumbing equipment, including the following:
      a. Water storage tanks.
      b. Domestic water heating equipment.

3.2 CONSTRUCTION CHECKLIST REVIEW

A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.

B. Return draft construction checklist review comments within 10 days of receipt.

C. When review comments have been resolved, the CxA will provide final construction checklists, marked "Approved for Use, (date)."

D. Use only construction checklists, marked "Approved for Use, (date)."

3.3 Cx TESTING PREPARATION

A. Certify that plumbing systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved submittals.

B. Certify that plumbing systems instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved submittals, and that pretest set points have been recorded.

C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.4 Cx TEST CONDITIONS

A. Perform tests using design conditions, whenever possible.
   1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
   2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
   3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

B. If tests cannot be completed because of a deficiency outside the scope of the plumbing system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.

C. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.5 Cx TESTS COMMON TO PLUMBING

A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.

B. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response according to acceptance criteria.

C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.

D. Comply with construction checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Division 22 Sections specifying plumbing systems and equipment.

E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
   1. Construction checklist verification tests.
   2. Construction checklist verification test demonstrations.
   3. Cx tests.
   4. Cx test demonstrations.

END OF SECTION

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.

1.2 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.3 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

1.4 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 two 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 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."

2.2 COPPER TUBE AND FITTINGS

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

B. Soft Copper Tube: water tube, annealed temper.

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

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

E. 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 or threaded ends.

F. Copper Pressure-Seal-Joint Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following
      a. Elkhart Products Corporation.
      b. NIBCO Inc.
      c. Viega LLC.
   2. Fittings for NPS 2 **(**DN 50**)** and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
   3. Fittings for NPS 2-1/2 to NPS 4 **(**DN 65 to DN 100**)**: Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end.

G. Copper-Tube, Extruded-Tee Connections:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. T-Drill Industries Inc.
   2. Description: Tee formed in copper tube according to ASTM F 2014.

H. Appurtenances for Grooved-End Copper Tubing:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following
      a. Anvil International; a subsidiary of Mueller Water Products, Inc.

b. Shurjoint Piping Products.
c. Victaulic Company.

2. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B 75 **(**ASTM B 75M**)** copper tube or ASTM B 584 bronze castings.
3. Mechanical Couplings for Grooved-End Copper Tubing:
   a. Copper-tube dimensions and design similar to AWWA C606.
   b. Ferrous housing sections.
   c. EPDM-rubber gaskets suitable for hot and cold water.
   d. Bolts and nuts.
   e. Minimum Pressure Rating: 300 psig **(**2070 kPa**)**.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:
1. AWWA C110/A21.10, rubber, flat face, 1/8 inch **(**3.2 mm**)** 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.

2.4 TRANSITION FITTINGS

A. General Requirements:
1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.
1. Manufacturers: Subject to compliance with requirements, provide products by the following :
   a. Cascade Waterworks Manufacturing Co.
   b. Dresser, Inc.
   c. Ford Meter Box Company, Inc. (The).
   d. JCM Industries, Inc.
   e. Romac Industries, Inc.
   f. Smith-Blair, Inc.
   g. Viking Johnson.

2.5 DIELECTRIC FITTINGS

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

B. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by the following :
   a. A.Y. McDonald Mfg. Co.
   b. Capitol Manufacturing Company.
   c. Central Plastics Company.
   d. Hart Industries International, Inc.
   e. Jomar Valve.
   f. Matco-Norca.
   g. Watts; a Watts Water Technologies company.
   h. Wilkins.
2. Standard: ASSE 1079.
3. Pressure Rating: 125 psig **(**860 kPa**)** minimum at 180 deg F **(**82 deg C**)** .
4. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by the following :
   a. Elster Perfection Corporation.
   b. Grinnell Mechanical Products.
   c. Matco-Norca.
   d. Precision Plumbing Products, Inc.

e. Victaulic Company.
2. Standard: IAPMO PS 66.
3. Electroplated steel nipple complying with ASTM F 1545.
4. Pressure Rating and Temperature: 300 psig (2070 kPa) at 225 deg F (107 deg C)
5. End Connections: Male threaded or grooved.
6. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

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

3.2 PIPING INSTALLATION

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

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

C. Install domestic water piping level without pitch and plumb.

D. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

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

F. 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.

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

H. Install piping to permit valve servicing.

I. 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.

J. Install piping free of sags and bends.

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

L. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."

3.3 JOINT CONSTRUCTION

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

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

C. 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."

D. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

E. 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.

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

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
1. Fittings for NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.

2. Fittings for NPS 2 (DN 50) and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings.

3.5 DIELECTRIC FITTING INSTALLATION

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

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric couplings or nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

E. Install supports for vertical copper tubing every 10 feet (3 m).

F. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

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

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

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

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
2. 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 (DN 65) and larger.

3.8 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.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Piping Inspections:
      a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
      b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
         1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
         2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
      c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
      d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
   2. Piping Tests:
      a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
      b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
      c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
      d. Cap and subject piping to static water pressure of 50 psig **(**345 kPa**)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
      e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
      f. Prepare reports for tests and for corrective action required.

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

C. Prepare test and inspection reports.

3.10 ADJUSTING

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

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Fill and isolate system according to either of the following:
         1) Fill system or part thereof with water/chlorine solution with at least 50 ppm **(**50 mg/L**)** 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 (200 mg/L) 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.

3. Secondary disinfection is required for projects constructed in phases before building is turned over to the owner, to prevent Legionella and other pathogens growth in standing domestic water system.

B. Clean non-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 procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.

b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

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

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

3.12 PIPING SCHEDULE

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

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

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Aboveground domestic water piping, NPS 2 (DN 50) and smaller, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); wrought-copper, solder-joint fittings; and soldered joints.

2. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); copper pressure-seal-joint fittings; and pressure-sealed joints.

E. Aboveground domestic water piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); wrought-copper, solder-joint fittings; and soldered joints.

2. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); copper pressure-seal-joint fittings; and pressure-sealed joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball for piping NPS 2 and smaller. Use butterfly, with flanged ends for piping NPS 2-1/2 (DN 65) and larger.

2. 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

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Vacuum breakers.
2. Backflow preventers.
3. Strainers.
4. Trap-seal primer systems.

B. Related Requirements:
1. Section 220519 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 221116 "Domestic Water Piping" for water meters.

1.2 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.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

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 and NSF 14.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig **(**860 kPa**)** unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers :
1. Manufacturers: Subject to compliance with requirements, provide products by the following :
a. Ames Fire & Waterworks.
b. Cash Acme.
c. Conbraco Industries, Inc.
d. FEBCO.
e. Rain Bird Corporation.
f. Toro Company (The).
g. Watts; a Watts Water Technologies company.
h. Zurn Industries, LLC.
2. Standard: ASSE 1001.
3. Size: NPS 1/4 to NPS 3 **(**DN 8 to DN 80**)**, as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Rough bronze.

B. Pressure Vacuum Breakers:
1. Manufacturers: Subject to compliance with requirements, provide products by the following :
a. Ames Fire & Waterworks.
b. Conbraco Industries, Inc.
c. FEBCO.
d. Flomatic Corporation.
e. Toro Company (The).
f. Watts; a Watts Water Technologies company.

g. Zurn Industries, LLC.
2. Standard: ASSE 1020.
3. Accessories:
a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
1. Manufacturers: Subject to compliance with requirements, provide products by the following :
a. Ames Fire & Waterworks.
b. Conbraco Industries, Inc.
c. FEBCO.
d. Watts; a Watts Water Technologies company.
e. Zurn Industries, LLC.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
5. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
6. Configuration: Designed for horizontal, straight-through flow.
7. Accessories:
a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Backflow-Preventer Test Kits :
1. Manufacturers: Subject to compliance with requirements, provide products by the following :
a. Conbraco Industries, Inc.
b. FEBCO.
c. Flomatic Corporation.
d. Watts; a Watts Water Technologies company.
e. Zurn Industries, LLC.
2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.5 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers <Insert drawing designation if any>:
1. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 (DN 65) and larger.
3. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
a. Strainers NPS 2 (DN 50) and Smaller: 0.020 inch (0.51 mm) .
b. Strainers NPS 2-1/2 to NPS 4 (DN 65 to DN 100): 0.045 inch (1.14 mm).
c. Strainers NPS 5 (DN 125) and Larger: 0.10 inch (2.54 mm).
6. Drain: Pipe plug.

2.6 TRAP-SEAL PRIMER SYSTEMS

A. Barrier Type Trap-Seal Primer Systems:
1. Manufacturers: Subject to compliance with requirements, provide products by the following :
a. Precision Plumbing Products, Inc.
b. ProFlo
c. JR Smith
d. Zurn
e. Mifab
2. Standard: ASSE 1072

PART 3 - EXECUTION

3.1 INSTALLATION

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

3.2 CONNECTIONS

A. Comply with requirements for ground equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Fire-retardant-treated-wood blocking is specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Test each pressure vacuum breaker according to authorities having jurisdiction and the device's reference standard.

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

C. Prepare test and inspection reports.

3.4 ADJUSTING

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

END OF SECTION

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless, cast-iron soil pipe and fittings.

1.2 ACTION SUBMITTALS

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

B. Sustainable Design Submittals:
1. Product Data: For adhesives, indicating VOC content.
2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and elevations, or Building Information Model (BIM) drawn to scale, showing items described in this Section and coordinated with all building trades.

B. Field quality-control reports.

1.4 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 in accordance with requirements indicated:
1. Notify Owner no fewer than two 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.

1.5 WARRANTY

A. Listed manufacturers to provide labeling and warranty of their respective products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation are capable of withstanding the following minimum working pressure unless otherwise indicated:
1. Soil, Waste, and Vent Piping: 10 ft. head of water **(**30 kPa head of water**)**.

2.2 PIPING MATERIALS

A. Piping materials to bear label, stamp, or other markings of specified testing agency.

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

2.3 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; a part of the McWane family of companies.
2. Charlotte Pipe and Foundry Company.
3. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings:
1. Marked with CISPI collective trademark.
2. ASTM A74, service and extra-heavy cast iron.

C. Gaskets: ASTM C564, 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; a part of the McWane family of companies.
2. Charlotte Pipe and Foundry Company.

3. Tyler Pipe; a part of McWane family of companies.

B. Pipe and Fittings:
1. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.
a. Plainly marked with date of manufacture (pipe only).
b. Country of origins.
c. Name of manufacturer or manufacturer's registered trademark by which the manufacturer can be readily identified after installation.
2. ASTM A888 or CISPI 301.
3. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.
4. Listed by NSF International.

C. Single-Stack Aerator Fittings: ASME B16.45, hubless, cast-iron aerator and deaerator drainage fittings.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Conine Manufacturing Co., Inc.
b. SE Sovent.

D. CISPI, 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. Fernco Inc.
d. Mission Rubber Company, LLC; a division of MCP Industries.
e. Tyler Pipe; a subsidiary of McWane Inc.
2. Standards: ASTM C1277 and CISPI 310.
3. Description: Stainless steel corrugated shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.
4.

PART 3 - EXECUTION

3.1 EARTH MOVING

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

3.2 INSTALLATION OF PIPING

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 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. 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: Two percent downward in direction of flow for piping NPS 3 **(**DN 80**)** and smaller; Two percent downward in direction of flow for piping NPS 4 **(**DN 100**)** and larger.
2. Horizontal Sanitary Waste Piping: Two percent downward in direction of flow.
3. Vent Piping: One percent down toward vertical fixture vent or toward vent stack.

M. Install cast-iron soil piping in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

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.
   b. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."
2. Install drains in sanitary waste gravity-flow piping.
   a. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."

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 walls, ceilings, and floors.
1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

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

R. Install escutcheons for piping penetrations of 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 in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hubless, Cast-Iron Soil Piping Coupled Joints:
1. Join hubless, cast-iron soil piping in accordance with 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 storm drainage piping joints to comply with the following conditions:
   a. Provide axial restraint for pipe and fittings 5 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 4 inches **(**100 mm**)** and larger, upstream and downstream of all changes in direction 45 degrees and greater.
   c. Provide rigid sway bracing for pipe and fittings 5 inches **(**125 mm**)** and larger, upstream and downstream of all changes in direction and branch openings.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

A. All piping shall be supported according to the International Plumbing Code (IPC), Section 220511, COMMON WORK RESULTS FOR PLUMBING, and these specifications. Where conflicts arise between these the code and Section 220511, COMMON WORK RESULTS FOR PLUMBING the most restrictive or the requirement that specifies supports with highest loading or shortest spacing shall apply

B. Install hangers for cast-iron, steel, stainless steel, and copper soil 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.

C. Support horizontal piping and tubing within 12 inches **(**300 mm**)** of each fitting**,** valve**,** and coupling.

D. Support vertical runs of cast-iron, steel, stainless steel, and copper soil piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 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.
5. Equipment: Connect waste piping as indicated.
   a. Provide shutoff valve if indicated and union for each connection.
   b. Use flanges instead of unions for connections NPS 2-1/2 **(**DN 65**)** and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections in accordance with the following unless otherwise indicated:
1. Install unions, in piping NPS 2 **(**DN 50**)** and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 **(**DN 65**)** and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.6 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."

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping in accordance with 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: Test waste and vent piping except outside leaders on completion of roughing-in.
   a. Close openings in piping system and fill with water to point of overflow, but not less than 10 ft. head of water **(**30 kPa head of water**)**.
   b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
   c. 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 **(**250 Pa**)**.
   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.

3.8 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.

3.9 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 **(**DN 100**)** and smaller are to be the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.

C. Aboveground, vent piping NPS 4 **(**DN 100**)** is to be the following:
   1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.

D. Underground, soil, waste, and vent piping NPS 4 **(**DN 100**)** and smaller are to be the following:
   1. Service cast-iron soil piping; gaskets; and gasketed joints.

END OF SECTION

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Cleanouts.
   2. Miscellaneous sanitary drainage piping specialties.

1.2 DEFINITIONS

A. ABS: Acrylonitrile butadiene styrene.

B. PVC: Polyvinyl chloride.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Show fabrication and installation details for frost-resistant vent terminals.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

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

2.2 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Jay R. Smith Mfg Co; a division of Morris Group International.
      b. Josam Company.
      c. MIFAB, Inc.
      d. Tyler Pipe; a subsidiary of McWane Inc.
      e. WATTS.
      f. Zurn Industries, LLC.

   2. Standard: ASME A112.36.2M.
   3. Size: Same as connected drainage piping
   4. Body Material: as required to match connected piping.
   5. Closure: Countersunk Countersunk or raised-head, brass plug.
   6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Jay R. Smith Mfg Co; a division of Morris Group International.
      b. Josam Company.
      c. MIFAB, Inc.
      d. Sioux Chief Manufacturing Company, Inc.
      e. WATTS.
      f. Zurn Industries, LLC.

2. Standard: ASME A112.36.2M for heavy-duty, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Heavy-duty, adjustable housing.
5. Body or Ferrule: Cast iron.
6. Closure: Brass plug with straight threads and gasket .
7. Adjustable Housing Material: Cast iron with threads.
8. Frame and Cover Material and Finish: Nickel-bronze, copper alloy .
9. Frame and Cover Shape: Round.
10. Top-Loading Classification: Heavy Duty.
11. Riser: ASTM A74, Extra-Heavy Class, cast-iron drainage pipe fitting and riser to cleanout.

2.3 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 (DN 50): 4-inch- (100-mm-) minimum water seal.
b. NPS 2-1/2 (DN 65) and Larger: 5-inch- (125-mm-) minimum water seal.

B. Air-Gap Fittings:
1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. 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 (DN 100). Use NPS 4 (DN 100) 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 (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
4. Locate at base of each vertical soil and waste stack.

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

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

D. Assemble open drain fittings and install with top of hub 1 inch (25 mm) above floor.

E. Install deep-seal traps on floor drains and other waste outlets, if indicated.

F. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

G. Install wood-blocking reinforcement for wall-mounting-type specialties.

H. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 PIPING CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment, to allow service and maintenance.

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.
   1. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 221319.13 - SANITARY DRAINS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Floor drains.

1.2 DEFINITIONS

A. ABS: Acrylonitrile-butadiene styrene.

B. FRP: Fiberglass-reinforced plastic.

C. HDPE: High-density polyethylene.

D. PE: Polyethylene.

E. PP: Polypropylene.

F. PVC: Polyvinyl chloride.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.

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

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Commercial Enameling Company.
      b. Jay R. Smith Mfg. Co.
      c. Josam Company.
      d. MIFAB, Inc.
      e. Prier Products, Inc.
      f. Sioux Chief Manufacturing Company, Inc.
      g. Wade; a subsidiary of McWane Inc.
      h. WATTS.
      i. Zurn Industries, LLC.
   2. Standard: ASME A112.6.3.
   3. Pattern: Area drain.
   4. Body Material: Gray iron.
   5. Outlet: Bottom.
   6. Sediment Bucket: Yes.
   7. Top or Strainer Material: Gray iron.
   8. Top of Body and Strainer Finish: Nickel bronze .
   9. Top Shape: Round.
   10. Top Loading Classification: Heavy Duty.
   11. Trap Material: Cast iron.
   12. Trap Pattern: Deep-seal P-trap.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.

2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radii:
   a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.
   b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.
   c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.
4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
   a. Maintain integrity of waterproof membranes where penetrated.
5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 221319 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.

C. Install piping adjacent to equipment to allow service and maintenance.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 221413 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.

1.2 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
   1. Storm Drainage Piping: 10-foot head of water (30 kPa).

1.3 QUALITY ASSURANCE

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

1.4 PROJECT CONDITIONS

A. Interruption of Existing Storm-Drainage 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 Architect no fewer than two days in advance of proposed interruption of storm-drainage service.
   2. Do not proceed with interruption of storm-drainage service without Architect's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Heavy-Duty, Hubless-Piping Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ANACO-Husky.
      b. Clamp-All Corp.
      c. Dallas Specialty & Mfg. Co.
      d. Ideal Tridon.
      e. MIFAB, Inc.
      f. Mission Rubber Company; a division of MCP Industries, Inc.
      g. Stant.
      h. Tyler Pipe.
   2. Standards: ASTM C 1277 and ASTM C 1540.
   3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

PART 3 - EXECUTION

3.1 EARTH MOVING

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

3.2 PIPING INSTALLATION

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

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

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

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

E. Install piping 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. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

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

L. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
   1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
   2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

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

3.3 JOINT CONSTRUCTION

A. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
   3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
   5. Vertical Piping: MSS Type 8 or Type 42, clamps.
   6. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
   7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   8. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting and coupling.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
   3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
   4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
   5. NPS 10 and NPS 12 (DN 250 and DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.

6. Spacing for 10-foot (3-m) pipe lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

F. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

G. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

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

B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

C. Make connections according to the following unless otherwise indicated:
1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.6 IDENTIFICATION

A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test new storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Test Procedure: Test storm drainage piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

3.8 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.9 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground storm drainage piping NPS 6 (DN 150) and smaller shall be the following:
1. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.

END OF SECTION

SECTION 223500 - DOMESTIC-WATER HEAT EXCHANGERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Noncirculating, storage, domestic-water heat exchangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heat exchanger indicated.[Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.]

B. Shop Drawings:
   1. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Domestic-Water, Heat-Exchanger Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

B. Source quality-control reports.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic-water heat exchangers to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label heat-exchanger storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."

1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of domestic-water heat exchangers that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures including heat exchanger, storage tank, and supports.
      b. Faulty operation of controls.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   2. Warranty Periods: From date of Substantial Completion.
      a. Noncirculating, Storage, Domestic-Water Heat Exchangers:
         1) Storage Tank: Five years.
         2) Tube Coil: Five years.
         3) Controls and Other Components: Three years.
      b. Compression Tanks: One year(s).

PART 2 - PRODUCTS

2.1 NONCIRCULATING, DOMESTIC-WATER HEAT EXCHANGERS

A. Noncirculating, Storage, Domestic-Water Heat Exchangers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings :
   a. PVI Industries, LLC.
2. Description: Assembly of hot-water storage tanks with separate heat-exchanger coils, controls, and specialties for heating domestic water with heating hot water in coil.
3. Storage-Tank Construction: ASME-code steel with 150-psig (1035-kPa) working-pressure rating. Include nozzle and head for heat-exchanger tube coil.
   a. Configuration: Vertical.
   b. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.
      1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
      2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
   c. Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle except connections and controls.
   d. Anode Rods: Factory installed, magnesium.
4. Temperature Control: Adjustable temperature aquastat, mounted in storage-tank shell head, unless otherwise indicated.
5. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
6. Support: Factory mounted on skids.

2.2 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heat exchangers specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test domestic-water heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Domestic-water heat exchangers will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER, HEAT-EXCHANGER INSTALLATION

A. Domestic-Water, Heat-Exchanger Mounting: Install domestic-water heat exchangers on concrete base. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."
   1. 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.
   2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   4. Install anchor bolts to elevations required for proper attachment to supported equipment.
   5. Anchor heat exchangers to substrate.

B. Install domestic-water heat exchangers level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
   1. Install shutoff valves on domestic-water-supply piping to heat exchangers and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
   2. Install shutoff valves on heating hot-water piping to heat exchangers. Comply with requirements for shutoff valves specified in Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

3. Install shutoff valves on steam and condensate piping to heat exchangers. Comply with requirements for shutoff valves specified in Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

C. Install temperature and pressure relief valves in top portion of storage-tank shells of domestic-water heat exchangers with domestic-water storage. Use relief valves with sensing elements that extend into shells. Extend relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Install pressure relief valves in water piping for domestic-water heat exchangers without storage. Extend relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install heat-exchanger drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heat exchangers that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

F. Install thermometer on each domestic-water, heat-exchanger, inlet and outlet piping, and install thermometer on each domestic-water, heat-exchanger, heating-fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

G. Install pressure gages on domestic-water, heat-exchanger, heating-fluid piping. Comply with requirements for pressure gages specified in Section 220519 "Meters and Gages for Plumbing Piping."

H. Fill domestic-water heat exchangers with water.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping."

B. Comply with requirements for heating hot-water piping specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."

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

D. Where installing piping adjacent to domestic-water heat exchangers, allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of domestic-water heat exchangers.

3.3 IDENTIFICATION

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

END OF SECTION

SECTION 230100 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes basic requirements for divisions 22, 23, as well as applicable specification sections in division 26 (variable frequency drives).

1.3 QUALITY ASSURANCE

A. Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment or accessories into the system and for obtaining the performance from the system into which these items are placed. This may include changes found necessary during the testing, adjusting, and balancing phase of the project.

B. Equipment Design
   1. Design equipment and accessories not specifically described or identified by manufacturer's catalog numbers in conformity with applicable technical standards and suitable for maximum working pressure, test pressure and temperatures required.

C. Equipment Installation
   1. Obtain manufacturer's printed installation instructions to aid in properly executing work of installing equipment whenever such instructions are available.
   2. Erect equipment in a neat and workmanlike manner. Align, level and adjust for satisfactory operation. Install so that connecting and disconnecting of piping and accessories can be made readily, and so that parts are easily accessible for inspection, operation, maintenance and repair. Minor deviation from arrangements indicated may be made, as approved.

D. Packaged Equipment
   1. Provide packaged equipment, where specified, which is completely factory assembled, including all mechanical and electrical components mounted on a common base or in a common enclosure with all piping, controls and wiring factory installed ready to be incorporated into the mechanical system.

E. Quietness of Operation
   1. Pumps, fans, motors and other equipment with moving parts have been especially selected for quietness of operation.
   2. For equipment other than that specified, submitted by the Contractor for approval, submit written statements from the manufacturer and the Contractor that said equipment is at least as quiet as that specified and include certified sound test data to support the claims made.

F. Vibration Isolation
   1. Vibration isolation devices for isolating equipment, ductwork and piping from the building structure are specified under Section 230548. Procure these devices from a single vibration materials manufacturer through a local representative. Furnish the local representative with copies of Shop Drawings of all equipment requiring vibration isolation and access to the Drawings that show the ductwork and piping that require vibration isolation.
   2. For equipment requiring factory installation of vibration isolators, furnish the equipment manufacturer with the identity of the supplier of the vibration isolation manufacturer selected for the Project. Submittals for equipment not equipped with the product of the vibration isolation manufacturer selected for the Project will be rejected.

G. Vibration Testing of Rotating Equipment
   1. Pumps
      a. Provide for the services of a qualified vibration consultant to take vibration velocity measurements on all base mounted pumps in accordance with ANSI HI1.4.6.
      b. Take measurements on the bearing caps of each pump with a driver 5 HP and larger in the vertical, horizontal and axial directions.
      c. Maximum allowable self-excited, total unfiltered vibration velocity: 0.0875 mm (3.5 mils) per second peak to peak. If the measured velocity exceeds this figure, determine the source of the vibration and make the necessary corrections to bring the velocity figure to within the specified maximum.

d. Submit on approved data sheets the vibration measurements for each pump along with the relevant charts and data from ANSI H19.6.4.

2. Fans
   a. Provide the services of a qualified vibration consultant to take vibration velocity measurements on all base mounted or suspended fans in accordance with AMCA 204-6.1.
   b. Take measurements on the bearing caps of each fan in the vertical, horizontal and axial directions.
   c. The following table, taken from AMCA 204, lists the fan application categories for the maximum allowable self-excited, total unfiltered, peak-to-peak vibration velocity.

	Fan Application Category	IN./S
2)	BV-1	0.60
3)	BV-2	0.30
4)	BV-3	0.20
5)	BV-4	0.15
6)	BV-5	0.10

   d. Apply Fan Application Category BV-3 for fan drivers 5 HP to 25 HP and BV-4 for fan drivers 30 HP and larger. Fans less than 5 HP do not require testing.
   e. If fan vibrations exceed the AMCA allowable levels for the specified vibration category, make the necessary corrections to bring the vibrations to within the allowable levels.

1.4 SEQUENCING AND SCHEDULING

A. Coordinate mechanical equipment installation with other building components.

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

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

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

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

F. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

1.5 COORDINATION

A. Furnish one can of touch up paint for each different color factory finish which is to be the final finished surface of the product. Deliver touch up paint with other "loose and detachable parts" as covered in the General Requirements.Motor controllers.
   1. Use zinc rich paint on galvanized surfaces prior to providing finish coat.

B. Seal and firestop all penetrations of fire rated partitions.
   1. Sealing and firestopping of sleeves/openings between ductwork, piping, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening. The contractor responsible shall hire individuals skilled in such work to do the sealing and fireproofing. These individuals hired shall normally and routinely be employed in the sealing and fireproofing occupation.

1.6 REFERENCE TO DESIGN DRAWING STANDARDS

A. Maximum and minimum requirements
   1. Refer to equipment schedules for equipment identification number and corresponding area location, capacity, and design requirements.
   2. Where ever schedules or notes appear in the Contract Documents in which sizes and capacities of equipment are indicated or specified, provide equipment under the contract which meets the following requirements under operating conditions:
      a. The RPM, the outlet velocities, tip speeds and the NC ratings specified are the maximum that will be accepted.
      b. The cfm, the static pressure on fans, the gpm and the total head on pumps, are the minimum that will be accepted.

3. Motor horsepower ratings specified or shown: the minimum acceptable indicated; motor speeds: the maximum acceptable. If a motor is provided having a larger horsepower rating than specified, provide the associated increased wire, breaker, starter, fuses, overload protection, etc., at no additional cost. Provide the increased motor circuit in accordance with the "Motor Circuit Sizing Schedule" indicated. Do not provide increased motor horsepower which together add more than 5 percent to the load of an electrical distribution equipment item (i.e., Motor Control Center, Power Panel, etc.).

1.7 OPERATION AND MAINTENANCE DATA

A. All operations and maintenance data shall comply with the submission and content requirements specified under section Division 01.

B. In addition to the general content specified under General Requirements, supply the following additional documentation.
1. Records of tests performed to certify compliance with system requirements.
2. Certification of inspections by regulatory agencies.
3. Valve schedules.
4. Lubrication instructions, including list/frequency of lubrication.

1.8 CERTIFICATIONS AND INSPECTIONS

A. Obtain and pay for all required installation inspections except those provided by the Architect/Engineer. Include copies of the certificates in the Operating and Maintenance Manuals.

1.9 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Provide 2 copies of O&M manuals in three ring or post binders, using an index at the front of each volume and tabs for each system or type of equipment. Provide an electronic PDF of the same material.
1. Prior to printing the O&M documents provide electronic PDF documents to the architect for approval. PDF documents shall be organized identical to the intended layout of the 3-ring binders. Provide digital bookmarks for each piece of equipment, similar to the indexed layout of the 3-ring binder.

B. In addition to the data indicated in the General Requirements, include the following information:
1. Copies of all approved shop drawings.
2. Manufacturer's wiring diagrams for electrically powered equipment.
3. Records of tests performed to certify compliance with system requirements.
4. Certificates of inspection by regulatory agencies.
5. Temperature control record drawings and control sequences.
6. Parts lists for manufactured equipment.
7. Valve schedules.
8. Lubrication instructions, including list/frequency of lubrication done during construction
9. Warranties.
10. Additional information as indicated in the technical specification sections.

1.10 TRAINING OF OWNER PERSONNEL

A. Instruct Owner personnel in the proper operation and maintenance of systems and equipment provided as part of this project; video tape all training sessions. Use hours indicated in individual specification sections. Where hours are not indicated within an individual specification section, include not less than 4 hours of instruction for each piece of equipment, using the Operating and Maintenance manuals during this instruction. Demonstrate startup and shutdown procedures for all equipment. All training to be during normal working hours.

1.11 RECORD DRAWINGS

A. In addition to the data indicated in the General Requirements, maintain temperature control record drawings on originals prepared by the installing contractor/subcontractor. Include copies of these record drawings with the Operating and Maintenance manuals.

PART 2 - PRODUCTS

2.1 ACCESS PANELS AND DOORS

A. Lay-in Ceilings
1. Removable lay in ceiling tiles in 2 X 2 foot or 2 X 4 foot configuration provided under Division 9 are sufficient; no additional access provisions are required unless specifically indicated.

a. Provide tagging system using colored dots for identifying where equipment is located above the ceiling. Coordinate coloring system with Owner.

2. Plaster walls and ceilings
   a. 16 gauge frame with not less than a 20 gauge hinged door panel, prime coated steel for general applications, stainless steel for use in toilets, showers, and similar wet areas, concealed hinges, screwdriver operated cam latch for general applications, key lock for use in public areas, UL listed for use in fire rated partitions if required by the application. Use the largest size access opening possible, consistent with the space and the equipment needing service; minimum size is 12" by 12".

2.2 SEALING AND FIRESTOPPING

A. Fire and/or Smoke Rated Penetrations
   1. Manufacturers: Subject to compliance with the requirements, provide products by one of the following:
      a. 3M
      b. Hilti,
      c. Rectorseal,
      d. STI/SpecSeal
      e. Tremco
   2. General
      a. Fire stop systems shall be UL listed or tested by an independent testing laboratory approved by the Department of Commerce.
      b. Use a product that has a rating not less than the rating of the wall or floor being penetrated. Reference architectural and life safety drawings for identification of fire and/or smoke rated walls and floors.
      c. Contractor shall use firestop putty, caulk sealant, intumescent wrap strips, intumescent firestop collars, firestop blocks, firestop mortar or a combination of these products to provide a UL listed system for each application required for this project. Provide mineral wool backing where specified in manufacturer's application detail.

B. Non-Rated Penetrations
   1. Pipe Penetrations
      a. At pipe penetrations of non-rated interior partitions, floors and exterior walls above grade, use urethane caulk in annular space between pipe insulation and sleeve. For non-rated drywall, plaster or wood partitions where sleeve is not required use urethane caulk in annular space between pipe insulation and wall material.
   2. Duct Penetrations
      a. Annular space between duct (with or without insulation) and the non-rated partition or floor opening shall not be larger than 2".
      b. Where shown or specified, pack annular space with fiberglass batt insulation or mineral wool insulation. Provide 4" sheet metal escutcheon around duct on both sides of partition or floor to cover annular space.

PART 3 - EXECUTION

3.1 ERECTION, INSTALLATION, APPLICATION

A. Dimension and Design
   1. Provide apparatus and equipment of such dimensions and design as to be adapted to the arrangement of the installation and to fit within the limits of the space available.

B. Stand-off Brackets
   1. Provide insulated equipment, piping and duct work with stand-off brackets for attaching components to allow full insulation thickness.

C. Special Tools
   1. Provide tools required to operate, adjust, or make minor repairs to the equipment and install them in a wall mounted wood or metal case. Provide the case with a lock and two keys.

D. Standard Products
   1. Provide products and equipment that are essentially the standard product of the manufacturer. Where two or more units of the same product or type of equipment are required, provide these units as products of the same manufacturer.

2. Where the requirements of the Contract Documents exceed that of a manufacturer's standard product in terms of quality, performance or efficiency, the manufacturer shall make special provisions to ensure that the product proposed meets the requirements of the Contract Documents.

E. Substituted Items
1. Should a substitute item be offered and accepted and the substitute item requires services or utilities other than required by the item substituted for, provide those other services or utilities at no additional cost to the Owner.

F. Equipment Locations
1. Mechanical equipment and devices have been shown on the Drawings in the approximate location required for reasons of access, noise control or maintainability. Minor adjustments in location dictated by coordination with other work are permitted. Major relocations for reasons other than these are not to be made without specific written approval.

G. Interferences
1. Before proceeding with the installation of piping and ductwork, inspect the Contract Documents and determine that the location of the Work does not interfere with other work. In case of interference request clarification from the Architect in writing.

H. Holes Through Previously Constructed Walls and Floors
1. Cut holes for the passage of piping and ductwork through previously constructed walls and floors in a neat workman-like manner.
2. Make holes through floors and masonry walls by coring or saw-cutting the hole with minimum oversizing to allow for firesafing or caulking the peripheral space between the pipe or duct and the structure.
3. Make holes through gypsum board walls by sawing with minimum oversizing to allow for firesafing or caulking or for a flange or escutcheon to be placed in a manner to fill or cover the peripheral space between the pipe or duct and the wall.

I. Piping and Ductwork – Prohibited Locations
1. Do not run piping over electrical equipment such as transformers, switchgear and panelboards.
2. When possible, do not install piping and ductwork of any kind in Electrical Rooms, telecommunications rooms, or elevator equipment rooms, except that which serves these rooms.
3. If installing piping or ductwork in Electrical rooms cannot be avoided, maintain a clear space over the equipment and 36 inches in front of equipment from floor to ceiling.

J. Offsets and Transitions
1. In general, most main offsets and transitions of piping and duct work are shown on the drawings in order to indicate approximate locations in plan and elevation where the systems are intended to be run.
2. The Contract Documents are not intended to serve as coordinated construction drawings showing all minor adjustments in locations and duct cross sections that are required for a fully coordinated installation that respects the work of all trades.
3. Fully coordinate the mechanical work within itself and with the work of other trades to ensure the avoidance of all interferences.

K. Lines and Grades
1. Construct Work in conformity with lines and grades as indicated.
2. Lay out the Work and be responsible for lines, elevations and measurements required for the installation of the Work.
3. Space axis lines within building on each floor level so that mechanical work may be laid out with metal tape measure having length of 30.5 meters (100 feet) maximum. The use of cloth tape for lay-out will not be permitted.
4. Use bench marks outside building from which lines and grades required for installation of mechanical work may be set.

L. Fan Inlet and Outlet Guards
1. Provide screen guards with rigid angle frames on fan inlet and outlet openings which are accessible to personnel.

3.2 CUTTING AND PATCHING

A. Refer to Division 1 for cutting and patching requirements.

3.3 CONCRETE WORK

A. Provide cast in place concrete per Division 3 requirements. Provide all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to form concrete for support of mechanical equipment.

3.4 SEALING AND FIRESTOPPING

A. Fire and/or Smoke Rated Penetrations
   1. Install approved product in accordance with the manufacturer's instructions where pipes penetrate a fire/smoke rated surface. When pipe is insulated, use a product which maintains the integrity of the insulation and vapor barrier.
   2. Where firestop mortar is used to infill large fire-rated floor openings that could be required to support weight, provide permanent structural forming. Firestop mortar alone is not adequate to support any substantial weight.

B. Non-Rated Partitions
   1. In exterior wall openings below grade, assemble rubber links of mechanical seal to the proper size for the pipe and tighten in place, in accordance with manufacturer's instructions.
   2. At all interior partitions and exterior walls, pipe penetrations are required to be sealed. Apply sealant to both sides of the penetration in such a manner that the annular space between the pipe sleeve or cored opening and the pipe or insulation is completely blocked.

C. Duct penetrations through non-rated partitions shall require sheet metal escutcheons with fiberglass or mineral wool insulation fill for spaces that include laboratories, kitchens/servery, janitor closets, toilet rooms, mechanical rooms, conference rooms, private consultation rooms, and where noted on drawings elsewhere.

D. Sealing and firestopping of sleeves/openings between ductwork, piping, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening. The contractor responsible shall hire individuals skilled in such work to do the sealing and fireproofing. These individuals hired shall normally and routinely be employed in the sealing and fireproofing occupation.

END OF SECTION

SECTION 230413 - COMMON SUBMITTAL REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
1. Division 01 submittal requirements.

1.2 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract, including but not limited to a Construction Manager.
1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
1. Shop Drawings.
2. Product Data.
3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Informational Submittals: Written and graphic information and physical samples that do not require Architect's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

E. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.

1.3 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
   a. reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
1. Initial Review: Allow business days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required.

2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.
3. Resubmittal Review: Allow business days for review of each resubmittal.
4. Sequential Review: Where sequential review of submittals by Architect's consultants, Owner, or other parties is indicated, allow business days for initial review of each submittal.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

1.4 DELEGATED-DESIGN SERVICES

A. Definitions:
1. Delegated Design: A portion or component of the Work identified by the Contract Documents to be designed by the Contractor, or an entity assigned by the Contractor, to satisfy performance and design criteria specified in the Contract Documents for that portion or component.
2. Registered Design Professional: Design professional, assigned by the Contractor, who is responsible for providing the delegated design work, and for certifying that the work is in compliance with the specified performance requirements and design criteria. Design professional shall be legally qualified to practice in jurisdiction where Project is located and shall be experienced in providing delegated design services of the kind indicated. Delegated design services are defined as those performed for installation of the system, assembly or product that are similar in material, design, and extent to those indicated for this Project.

B. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.

C. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally signed PDF electronic file copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.
1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Combine with Submittal Review Sheet before submitting to Architect .

B. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

C. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

D. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

E. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal.

3.2 ARCHITECT'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.

D. The Final Review Code on the Submittal Review Sheet prevails and governs the action of the overall submittal.

E. Review Code meanings are as follows:
1. Action Codes Permitting Use:
   a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
   b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
   c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
   d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.
2. Action Code Prohibiting Use:
   a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.
3. Action Code for Items Not Required:
   a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.
1. Action Code for Information Only:
   a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Architect will submittals received from sources other than the Contractor.

J. Submittals not required by the Contract Documents may be returned by the Architect without action.
1. Do not submit Material Safety Data Sheets. They will be returned without review.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
1. Submittal Numbering: See below.
2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
1. Each submittal consists of items from only ONE Specifications section.
2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.

3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).
4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering
1. Number submittals as described below to assist tracking.
2. Number each submittal in the format nnnnnn-nn.
   a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
   b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
   c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
   d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
   e. Examples:
      1) Initial Complete Submittal: 044200-01. First Re-Submittal: 044200-01-R1.
      2) Initial Partial Submittal: 044200-01-P1. Second Partial Submittal: 044200-01-P2.
      3) First Re-submittal of Second Partial Submittal: 044200-R1-P2.

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 COORDINATION

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. EC motor line filter requirements: Provide passive filtering components as required to limit total harmonic voltage distortion (THDv) and total harmonic current distortion (THDi) caused by electronically commutated motors (ECM) and/or loads controlled by silicon controlled rectifiers (SCR) to 5% and 20% respectively. The specified THD performance shall be achieved with the attached motor operating throughout its entire speed and load ranges, with the input voltage to the motor controller at the nominal line voltage. The point of measurement for the specified THD performance shall be at the electrical panelboard where the ECM/SCR branch circuit connects to the power distribution system. The manufacturer shall provide additional line conditioning equipment, if necessary, to meet this requirement. Provide wiring diagram documentation indicating installed location of filtration.

C. Provide a maintenance free, circumferential conductive micro fiber grounding ring installed on the AC motor to discharge shaft currents to ground. Grounding ring shall be AEGIS SGR (Shaft Grounding Ring).

D. Motors protected by the AEGIS SGR shall be warranted for the term of the manufacturer's motor warranty from induced bearing current damage.

E. Motors up to 100 HP shall be provided with a shaft grounding ring installed on either the drive end or non-drive end. Motors over 100 HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor. Grounding rings shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with the shaft grounding ring manufacturer's recommendations.

F. All motors operated on variable frequency drives shall be bonded from the motor foot to system ground with a high-frequency ground strap made of flat braided tinned copper with terminations to accommodate motor foot and system ground connection.

2.2 MOTOR CHARACTERISTICS

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

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

2.3 POLYPHASE MOTORS

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

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Rotor: Random-wound, squirrel cage.

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

F. Temperature Rise: Match insulation rating.

G. Insulation: Class F.

H. 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.

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

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

2.5 SINGLE-PHASE MOTORS

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

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.

2.6 ELECTRONICALLY COMMUTATED (EC) MOTORS

A. Description: EC, variable-speed, dc, programmable brushless motor.

B. Features:
1. Integral controller/inverter operates wound stator and senses rotor position to electronically commutate the stator.
2. Controller shall control motor speed through a remote 0- to 10-V-dc control signal.
3. Motor Mounting: Coordinate with driven equipment; suitable for mounting with motor shaft in either horizontal or vertical position.

C. Performance:
1. Altitude: Suitable for operation at site altitude.
2. Electrical Characteristics: Suitable for operation with field power source. Coordinate with electrical Installer.
3. Energy Efficiency: Complying with governing energy codes; 80 percent or higher maintained throughout entire operating range.
4. Power Factor: 0.9 or higher at full load.
5. Service Factor: 1.0 or higher.
6. Speed Control: Variable, zero to 100 percent.
a. Synchronous speed rotation with no slip losses.
b. Gradual ramp-up to set point upon receiving a start signal.
c. Soft speed change ramps.
d. Able to overcome reverse rotation without impact.
e. Control airflow within 5 percent of set point regardless of static pressure.
7. Temperature: Suitable for operation in ambient temperature range encountered.
8. Thermal Protection:
a. Automatically breaks electrical power to motor when temperature exceeds a safe value.

b. Automatically resets and restores power when temperature returns to normal range.

D. Bearings: Sealed and permanently lubricated ball bearings.

E. Enclosure: ODP or TEFC.

F. Insulation: Class B or Class F.

G. Rotor: Permanent magnet with near zero rotor losses that operates independent of motor current.

H. Materials and Construction:
1. Enclosure and Frame: Aluminum, painted steel, or stainless steel.
2. End Brackets: Cast aluminum..Motor Leads: Pin or screw terminals.
3. Shaft: Steel or stainless steel.
4. Motor Leads: Pin or screw terminals.
5. Nameplates: Manufacturer's standard.
6. Paint: Manufacturer's standard.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Packless expansion joints.
   2. Grooved-joint expansion joints.
   3. Alignment guides and anchors.

B. Related Requirements:
   1. Refer to Section 013573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated Design Submittals: For each anchor, expansion joint and alignment guide provide the following that is signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
   2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
   3. Alignment Guide Details: Detail field assembly and attachment to building structure.
   4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Provide products suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Provide products and installations that will accommodate maximum axial movement as scheduled or indicated on Drawings.

2.2 PACKLESS EXPANSION JOINTS

A. Metal, Compensator Packless Expansion Joints: MCEJ-01.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flexicraft Industries.
      b. Mason Industries, Inc.
      c. Metraflex Company (The).
   2. Source Limitations: Obtain metal compensator packless expansion joints from single manufacturer.
   3. Minimum Pressure Rating: 200 psig **(**1380 kPa**)** unless otherwise indicated.
   4. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
   5. Joint Axial Movement: 2 inches **(**50 mm**)** of compression and 1/2 inch **(**12 mm**)** of extension.
   6. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.
      a. End Connections for Copper Tubing NPS 2 **(**DN 50**)** and Smaller: threaded.
      b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4 **(**DN 65 to DN 100**)**: Threaded.
   7. Configuration for Steel Piping: Multi-ply, stainless steel bellows; steel-pipe end connections; and carbon-steel shroud.
      a. End Connections for Steel Pipe NPS 2 **(**DN 50**)** and Smaller: Threaded.

b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4 **(**DN 65 to DN 100**)**: Flanged.

B. Rubber Union Connector Expansion Joints: RUEJ-01.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Flexicraft Industries.
b. Mason Industries, Inc.
c. Metraflex Company (The).
d. Unisource Manufacturing, Inc.
2. Source Limitations: Obtain rubber union connector expansion joints from single manufacturer.
3. Material: Twin reinforced-rubber spheres with external restraining cables.
4. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C) unless otherwise indicated.
5. End Connections for NPS 2 **(**DN 50**)** and Smaller: Threaded.

C. Flexible-Hose Packless Expansion Joints: FHEJ-01.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Flexicraft Industries.
b. Mason Industries, Inc.
c. Metraflex Company (The).
d. Unisource Manufacturing, Inc.
2. Source Limitations: Obtain flexible-hose packless expansion joints from single manufacturer.
3. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
4. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
5. Expansion Joints for Steel Piping NPS 2 **(**DN 50**)** and Smaller: Carbon-steel fittings with threaded end connections.
a. Stainless steel hoses and single-braid, stainless steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
6. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 **(**DN 65 to DN 150**)**: Carbon steel fittings with flanged end connections.
a. Stainless steel hoses and double-braid, stainless steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.
7. Expansion Joints for Steel Piping NPS 8 to NPS 12 **(**DN 200 to DN 300**)**: Carbon steel fittings with flanged end connections.
a. Stainless steel hoses and double-braid, stainless steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.

2.3 GROOVED-JOINT EXPANSION JOINTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Shurjoint; a part of Aalberts Integrated piping Systems.
2. Victaulic Company.

B. Source Limitations: Obtain grooved-joint expansion joints from single manufacturer.

C. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

D. Standard: AWWA C606, for grooved joints.

E. Nipples: Galvanized, ASTM A53/A53M, Schedule 40, Type E or S, steel pipe with grooved ends.

F. Couplings: 12, flexible type for steel-pipe dimensions. Include ferrous housing sections, EPDM rubber gasket suitable for cold and hot water, and bolts and nuts.

2.4 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides: AG-01.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Flexicraft Industries.
b. Mason Industries, Inc.
c. Metraflex Company (The).
2. Source Limitations: Obtain alignment guides from single manufacturer.
3. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36/A36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
   a. Stud: Threaded, stainless steel.
   b. Expansion Plug: Stainless steel.
   c. Washer and Nut: Stainless steel.
5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
   a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
   b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
   c. Washer and Nut: Zinc-coated carbon steel.

PART 3 - EXECUTION

3.1 INSTALLATION OF EXPANSION JOINTS - GENERAL

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

3.2 INSTALLATION OF PACKLESS EXPANSION JOINTS

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

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

3.3 INSTALLATION OF GROOVED-JOINT EXPANSION JOINTS

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

3.4 INSTALLATION OF ALIGNMENT GUIDES AND ANCHORS

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

B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

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

E. Anchor Attachments:
   1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9.
   2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-58, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
   1. Anchor Attachment to Steel Structural Members: Attach by welding.
   2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
   3. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

3.5 INSTALLATION OF PIPE LOOPS AND SWING CONNECTIONS

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

END OF SECTION

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.

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

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

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, zinc coated, with plain ends and integral welded waterstop collar.

D. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Jay R. Smith Mfg. Co.
2. Zurn Industries, LLC.

B. Description: Manufactured, galvanized cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).

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 (137-kPa) minimum).
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
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.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

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

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch **(**25-mm**)** annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches **(**50 mm**)** above finished floor level.
   3. Using **grout**, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch **(**6.4-mm**)** annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and 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 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch **(**6.4-mm**)** annular clear space between sleeve and pipe or pipe insulation.
   2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
   3. Install section of cast-iron soil pipe to extend sleeve to 3 inches **(**76 mm**)** above finished floor level.
   4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

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

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.4 SLEEVE-SEAL-FITTING INSTALLATION

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

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

C. Secure nailing flanges to concrete forms.

D. Using **grout**, seal space around outside of sleeve-seal fittings.

3.5 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 **(**DN 150**)**: **Steel pipe sleeves**.
      b. Piping NPS 6 **(**DN 150**)** and Larger: **Steel pipe sleeves**.
   2. Interior Partitions:
      a. Piping Smaller Than NPS 6 **(**DN 150**)**: **Steel pipe sleeves** .
      b. Piping NPS 6 **(**DN 150**)** and Larger: **Galvanized-steel sheet sleeves**.

END OF SECTION

SECTION 230519 - METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Liquid-in-glass thermometers.
2. Dial-type pressure gages.
3. Gage attachments.
4. Flowmeters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
1. Include diagrams for power, signal, and control wiring.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
   a. Flo Fab inc.
   b. Miljoco Corporation.
   c. Palmer Wahl Instrumentation Group.
   d. Tel-Tru Manufacturing Company.
   e. Trerice, H. O. Co.
   f. Weiss Instruments, Inc.
   g. Weksler Glass Thermometer Corp.
   h. Winters Instruments - U.S.
3. Standard: ASME B40.200.
4. Case: Cast aluminum; 9-inch (229-mm) nominal size unless otherwise indicated.
5. Case Form: Adjustable angle unless otherwise indicated.
6. Tube: Glass with magnifying lens and blue[or red] organic liquid.
7. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C).
8. Window: Glass.
9. Stem: Aluminum and of length to suit installation.
   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.
10. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
11. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 DIAL-TYPE PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Trerice, H. O. Co.
   b. Weiss Instruments, Inc.
2. Standard: ASME B40.100.
3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 (DN 8), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa).
8. Pointer: Dark-colored metal.
9. Window: Glass.

10. Ring: Stainless steel.
11. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

2.3 FLOW METERS

A. Basis of Design: ONICON Model FT-3200 Series Inline Electromagnetic Flow Meter. Manufacturers approved to bid, subject to compliance with requirements include:
1. Description: Provide an inline electromagnetic flowmeter complete with NIST traceable, wet calibrated flow-measuring element, transmitter, visual display, ANSI Class 300 mounting flanges, and calibration certificate.
2. Application Range: This contractor shall be responsible for selecting the flowmeter options submitted based on the application. Flowmeter shall be constructed, calibrated and scaled for the intended application in terms of pipe size, pipe material, installation requirements, expected flow rate, ambient conditions and fluid characteristics which include but are not limited to pressure, temperature, conductivity and viscosity.
3. Sensing Technology: Electromagnetic velocity-measuring element.
4. Design: Electromagnetic sensing element shall utilize a minimum of two 316L stainless steel electrodes to measure the average flow rate velocity.
5. Construction: Flowmeter shall consist of epoxy painted carbon steel outer body, 304 stainless steel flow tube and integral liner to be selected based on operating temperature and fluid. Individual calibration tag shall be attached indicating calibration and programming information.
6. Maximum Pressure Rating: 580 psig.
7. Maximum Temperature Rating: 266 deg F.
8. End Connections for NPS 1.0” and Larger: ANSI Class 150 Flange typical.
9. Flow Range: Flow-measuring element and transmitter shall cover operating range of equipment or system served.
10. Accuracy**:** Flowmeter shall provide calibrated outputs directly from the transmitter, throughout the operating range with the accuracy stated as follows:
11. Plus or minus 0.2% of rate from 1.6 to 33.0 ft/sec velocity.
12. Plus or minus 0.0033 ft/s at flow rates < 1.6 ft/s
13. Calibration: Each flowmeter shall receive a wet calibration, within the expected operating range, against a primary volumetric standard directly traceable to international standards in accordance with ISO 9104:1991 and ISO 17025:2005.
14. Transmitter Enclosure: Transmitter enclosure shall be cast aluminum, IP67 rated
15. Display: Menu driven via three (3) button programming keys and shall include 16 character, 8 line graphic LCD backlit display. Display shall provide instantaneous flow rate information, totalized flow information, flow velocity, flow direction, short term trend data and shall be factory configured for a specific flowmeter application.
16. Warranty: Each flowmeter shall be covered by the manufacturer’s three-year warranty.

2.4 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 (DN 8), ASME B1.20.1 pipe threads and piston -type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of stainless-steel pipe with NPS 1/4 (DN 8) pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS 1/4 (DN 8), ASME B1.20.1 pipe threads.

2.5 TEST PLUGS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

B. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
1. Flow Design, Inc.
2. Miljoco Corporation.
3. Nexus Valve, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts; a Watts Water Technologies company.
8. Weiss Instruments, Inc.

9. Weksler Glass Thermometer Corp.

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

D. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

E. Thread Size: [NPS 1/4 (DN 8)] [or] [NPS 1/2 (DN 15)], ASME B1.20.1 pipe thread.

F. Minimum Pressure and Temperature Rating: [500 psig at 200 deg F (3450 kPa at 93 deg C)] <Insert ratings>.

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

2.6 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. Flow Design, Inc.
2. Miljoco Corporation.
3. Nexus Valve, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts; a Watts Water Technologies company.
8. Weiss Instruments, Inc.

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

C. Low-Range Thermometer: Small, bimetallic insertion type with [1- to 2-inch- **(**25- to 51-mm-**)**] <Insert dimension> diameter dial and tapered-end sensing element. Dial range shall be at least [25 to 125 deg F (minus 4 to plus 52 deg C)] <Insert temperature range>.

D. High-Range Thermometer: Small, bimetallic insertion type with [1- to 2-inch- **(**25- to 51-mm-**)**] <Insert dimension> diameter dial and tapered-end sensing element. Dial range shall be at least [0 to 220 deg F (minus 18 to plus 104 deg C)] <Insert temperature range>.

E. Pressure Gage: Small, Bourdon-tube insertion type with [2- to 3-inch- **(**51- to 76-mm-**)**] <Insert dimension> diameter dial and probe. Dial range shall be at least [0 to 200 psig **(**0 to 1380 kPa**)**] <Insert range>.

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches **(**51 mm**)** into fluid or one-third of pipe diameter to center of pipe and in vertical position in piping tees.

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

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

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

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

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

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

I. Install remote-mounted pressure gages on panel.

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

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

L. Install test plugs in piping tees.

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

N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

O. Install flowmeter elements in accessible positions in piping systems.

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

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

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

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

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

U. Install thermometers in the following locations:
1. Inlet and outlet of each hydronic boiler.

V. Install pressure gages in the following locations:
1. Discharge of each pressure-reducing valve.
2. Suction and discharge of each pump.

3.2 CONNECTIONS

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

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

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

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

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic boiler shall be the following:
1. Industrial-style, liquid-in-glass type.
2. Test plug with EPDM self-sealing rubber inserts.

B. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be the following:
1. Industrial-style, liquid-in-glass type.
2. Test plug with EPDM self-sealing rubber inserts.

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

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 200 psi **(**0 to 1400 kPa**)**.

B. Scale Range for Condenser-Water Piping: 0 to 200 psi **(**0 to 1400 kPa**)**.

C. Scale Range for Heating, Hot-Water Piping: 0 to 200 psi **(**0 to 1400 kPa**)**.

3.6 FLOWMETER SCHEDULE

A. Flowmeters for Heating, Hot-Water Piping: Electromagnetic type.

END OF SECTION

SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene-propylene-diene monomer.

C. FKM: Fluoroelastomer.

D. NBR: Nitrile butadiene rubber (also known as "Buna-N").

E. NRS: Nonrising stem.

F. OS&Y: Outside screw and yoke.

G. PTFE: Polytetrafluoroethylene.

H. RPTFE: Reinforced polytetrafluoroethylene.

I. RS: Rising stem.

J. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include material descriptions and dimensions of individual components.
   2. Include operating characteristics and furnished accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooved ends, press ends, solder ends, and weld ends.
   3. Set ball valves open to minimize exposure of functional surfaces.
   4. Set butterfly valves closed or slightly open.
   5. Block check valves in either closed or open position.
   6. Set gate valves closed to prevent rattling.
   7. Set plug valves to open to minimize exposure of functional surfaces.

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 or stems or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. 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 cast-copper solder-joint connections.
6. ASME B16.22 for wrought copper and copper-alloy solder-joint connections.
7. ASME B16.34 for flanged- and threaded-end connections.
8. ASME B16.51 for press joint connections.
9. ASME B31.1 for power piping valves.
10. ASME B31.9 for building services piping valves.

B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

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

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

F. Valve Actuator Type:
1. Gear Actuator: For quarter-turn ball valves NPS 4 **(**DN 100**)** and larger.
2. Hand Lever: For quarter-turn ball valves smaller than NPS 4 **(**DN 100**)**.

G. Valves in Insulated Piping:
1. Provide 2-inch **(**50-mm**)** extended neck stems.
2. Provide extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Provide memory stops that are fully adjustable after insulation is applied.

2.3 GLOBE VALVES

A. Globe Valves, Threaded Ends - Bronze, Class 300:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Fluid Systems; Crane Co.
   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. NIBCO INC.
   e. Red-White Valve Corp.
   f. Valve Solutions, Inc.
2. Standard: MSS SP-80, Type 2.
3. CWP Rating: 300 psig **(**2070 kPa**)**.
4. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
5. Ends: Threaded.
6. Stem: Bronze.
7. Disc: PTFE or stainless steel. See Part 3 globe valve schedule articles.
8. Packing: Asbestos free.
9. Handwheel: Malleable iron, bronze, or aluminum.

B. Globe Valves, Flanged Ends - Iron, Class 250:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   b. Hammond Valve.
   c. Jenkins Valves; a Crane Co. brand.
   d. Milwaukee Valve Company.
   e. NIBCO INC.
   f. Siemens Industry, Inc., Building Technologies Division.
   g. Stockham; a Crane Co. brand.
2. Standard: MSS SP-85, Type I.
3. CWP Rating: 500 psig **(**3450 kPa**)**.
4. Body Material: ASTM A126, gray iron with bolted bonnet.
5. Ends: Flanged.
6. Trim: Bronze.
7. Packing and Gasket: Asbestos free.
8. Operator: Handwheel or chainwheel.

2.4 BALL VALVES

A. Ball Valves, Threaded Ends - Bronze, Three Piece with Full Port and Stainless Steel Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   b. DynaQuip Controls.
   c. NIBCO INC.
2. Standard: MSS SP-110.
3. SWP Rating: 150 psig **(**1035 kPa**)**.
4. CWP Rating: 600 psig **(**4140 kPa**)**.
5. Body Design: Three piece.
6. Body Material: Bronze.
7. Ends: Threaded.
8. Seats: PTFE.
9. Stem: Stainless steel.
10. Ball: Stainless steel, vented.
11. Port: Full.

B. Ball Valves, Threaded or Flanged Ends - Stainless Steel, Two Piece with Full Port:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   b. Bray International, Inc.
   c. FNW; Ferguson Enterprises, Inc.
   d. Hammond Valve.
   e. Jomar Valve.
2. Standard: MSS SP-110.
3. SWP Rating:150 psig **(**1030 kPa**)**.
4. WOG Rating: 1000 psig **(**6895 kPa**)**.
5. Body Design: Split body.
6. Body Material: Type 316 stainless steel.
7. Ends: Threaded or flanged. See Part 3 ball valve schedule articles.
8. Seats: PTFE.
9. Stem: Type 316 stainless steel.
10. Ball: Type 316 stainless steel.
11. Port: Full.

2.5 BUTTERFLY VALVES

A. Butterfly Valves, Single Flange (Lug Type) - High Performance, Class 300:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABZ Valve; an ASC Engineered Solution.
   b. Bray International, Inc.
   c. NIBCO INC.
   d. Process Development & Control, Inc.
   e. XOMOX; Crane ChemPharma & Energy.
2. Standard: MSS SP-68.
3. CWP Rating: 720 psig **(**4965 kPa**)** at 100 deg F (38 deg C).
4. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
5. Body Material: Carbon or stainless steel. See Part 3 butterfly valve schedule articles.
6. Seat: Reinforced PTFE or metal.
7. Stem: Stainless steel; offset from seat plane.

2.6 CHECK VALVES

A. Check Valves, Swing Type, Threaded Ends - Bronze, with Bronze Disc, Class 150:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. A.Y. McDonald Mfg. Co.
   b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   c. Crane Fluid Systems; Crane Co.
   d. Hammond Valve.
   e. Jenkins Valves; a Crane Co. brand.
   f. Jomar Valve.
   g. Lance Valves.

h. Legend Valve & Fitting, Inc.
i. Milwaukee Valve Company.
j. NIBCO INC.
k. Powell Valves.
l. Red-White Valve Corp.
m. Stockham; a Crane Co. brand.

2. Standard: MSS SP-80, Type 3.
3. CWP Rating: 300 psig **(**2070 kPa**)**.
4. Body Design: Horizontal flow.
5. Body Material: ASTM B62, bronze.
6. Ends: Threaded.
7. Disc: Bronze.

B. Check Valves, Swing Type, Flanged Ends - Iron, with Metal Seats, Class 250:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Bray International, Inc.
b. Crane Fluid Systems; Crane Co.
c. DeZURIK.
d. Hammond Valve.
e. Jenkins Valves; a Crane Co. brand.
f. Milwaukee Valve Company.
g. Victaulic Company.
2. Standard: MSS SP-71, Type I.
3. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 500 psig **(**3450 kPa**)**.
4. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): 300 psig **(**2070 kPa**)**.
5. Body Design: Clear or full waterway.
6. Body Material: ASTM A126, gray iron with bolted bonnet.
7. Ends: Flanged.
8. Trim: Bronze.
9. Gasket: Asbestos free.

C. Check Valves, Center Guided - Iron, Compact Wafer, with Metal Seat, Class 300:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Anvil; an ASC Engineered Solution.
b. Cooper Valves.
c. Crispin Valve.
d. DFT Inc.
e. Flomatic Valves; Flomatic Corporation.
f. Keckley Company.
g. Metraflex Company (The).
h. Victaulic Company.
2. Standard: MSS SP-125.
3. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 500 psig **(**3450 kPa**)**.
4. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): 400 psig **(**2760 kPa**)**.
5. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
6. Style: Compact wafer, spring loaded.
7. Seat: Bronze.

2.7 GATE VALVES

A. Gate Valves, Threaded Ends - Bronze, NRS, Class 150:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Fluid Systems; Crane Co.
b. Jenkins Valves; a Crane Co. brand.
c. Milwaukee Valve Company.
d. Powell Valves.
e. Red-White Valve Corp.
f. Stockham; a Crane Co. brand.
g. WATTS; A Watts Water Technologies Company.
2. Standard: MSS SP-80, Type 1.
3. CWP Rating: 300 psig **(**2070 kPa**)**.
4. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
5. Ends: Threaded.
6. Stem: Bronze.

7. Disc: Solid wedge, bronze.
8. Packing: Asbestos free.
9. Handwheel: Malleable iron, bronze, or aluminum.

B. Gate Valves, Flanged Ends - Iron, NRS, Class 250:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Fluid Systems; Crane Co.
   b. Flomatic Valves; Flomatic Corporation.
   c. Jenkins Valves; a Crane Co. brand.
   d. Victaulic Company.
   e. Zurn Industries, LLC.
2. Standard: MSS SP-70, Type I.
3. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 500 psig **(**3450 kPa**)**.
4. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): 300 psig **(**2070 kPa**)**.
5. Body Material: ASTM A126, gray iron with bolted bonnet.
6. Ends: Flanged.
7. Trim: Bronze.
8. Disc: Solid wedge.
9. Packing and Gasket: Asbestos free.

2.8 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries; Rotork.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.
1. Sprocket Rim with Chain Guides: Bronze, of type and size required for valve. Include zinc or epoxy coating.
2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 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. Examine press fittings to verify they have been properly pressed.

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

3.2 INSTALLATION OF VALVES

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

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. For valves in horizontal piping, install valves with stem at or above center of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and actuator or manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.

H. Chainwheels: Install chainwheels on manual operators for butterfly valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

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

J. Valve Tags: Comply with requirements for valve tags and schedules in Section 230553 "Identification for HVAC Piping and Equipment."

K. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's written recommended maximum.

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 valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

3.5 HEATING-WATER ANGLE OR GLOBE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
1. Globe valves, threaded ends - bronze, Class 300; disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Globe valves, flanged ends - iron, Class 250.

3.6 LOW-PRESSURE STEAM ANGLE OR GLOBE VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS 2 (DN 50) and Smaller:
1. Globe valves, threaded ends - bronze, Class 300; disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Globe valves, flanged ends - iron, Class 250.

3.7 HIGH-PRESSURE STEAM ANGLE OR GLOBE VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS (DN 50) and Smaller:
1. Globe valves, threaded ends - bronze, Class 300; disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Globe valves, flanged ends - iron, Class 250.

3.8 STEAM-CONDENSATE ANGLE OR GLOBE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
1. Globe valves, threaded ends - bronze, Class 300; disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Globe valves, flanged ends - iron, Class 250.

3.9 HEATING-WATER BALL VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
1. Ball valves, threaded ends - bronze, three piece with full port and stainless steel trim.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.

3.10 LOW-PRESSURE STEAM BALL VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS (DN 50) and Smaller:
1. Ball valves, threaded ends - bronze, three piece with full port and stainless steel trim.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.

3.11 HIGH-PRESSURE STEAM BALL VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2 (DN 50) and Smaller:
1. Ball valves, threaded ends - bronze, three piece with full port and stainless steel trim.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.

3.12 STEAM-CONDENSATE BALL VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
1. Ball valves, threaded ends - bronze, three piece with full port and stainless steel trim.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.

3.13 HEATING-WATER BUTTERFLY VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - high performance, Class 300; carbon steel body.

3.14 LOW-PRESSURE STEAM BUTTERFLY VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - high performance, Class 300; carbon steel body.

3.15 HIGH-PRESSURE STEAM BUTTERFLY VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - high-performance, Class 300 carbon steel body.

3.16 STEAM-CONDENSATE BUTTERFLY VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - high performance, Class 300; carbon steel body.

3.17 HEATING-WATER CHECK VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.

3.18 LOW-PRESSURE STEAM CHECK VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS 2 (DN 50) and Smaller:
1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
2. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.

3.19 HIGH-PRESSURE STEAM CHECK VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2 (DN 50) and Smaller:
1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.

3.20 STEAM-CONDENSATE CHECK VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.

3.21 PUMP-DISCHARGE CHECK VALVE SCHEDULE

A. Heating-Water Pump Discharge:
   1. Pipe NPS 2 (DN 50) and Smaller:
      a. Check valves, swing type, threaded or soldered ends - bronze, with bronze disc, Class 150.
   2. Pipe NPS 2-1/2 (DN 65) and Larger:
      a. Check valves, center guided - iron, spring loaded, compact wafer, with metal seat, Class 300.

3.22 HEATING-WATER GATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
   1. Gate valves, threaded ends - bronze, NRS, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
   1. Gate valves, flanged ends - iron, NRS, Class 250.

3.23 LOW-PRESSURE STEAM GATE VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS 2 (DN 50) and Smaller:
   1. Gate valves, threaded ends - bronze, NRS, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
   1. Gate valves, flanged ends - iron, NRS, Class 250.

3.24 HIGH-PRESSURE STEAM GATE VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2 (DN 50) and Smaller:
   1. Gate valves, threaded ends - bronze, NRS, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
   1. Gate valves, flanged ends - iron, NRS, Class 250.

3.25 STEAM-CONDENSATE GATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
   1. Gate valves, threaded ends - bronze, NRS, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
   1. Gate valves, flanged ends - iron, NRS, Class 250.

END OF SECTION

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment stands.
8. 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 230100 "Common Work Results for HVAC" for pipe guides and anchors.
3. **Section 230548.13 "Vibration Controls for HVAC"** for vibration isolation devices.
4. Section 233113 "Metal Ducts" for duct hangers and supports.
5. Section 013573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: **Signed and sealed by a qualified professional engineer.** Show fabrication and installation details and include calculations for the following; include Product Data for components:
1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports, including supports for the boiler flue exhaust fans

C. Delegated Design Submittals: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.3 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

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

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-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated 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 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:
   a. ABB, Electrification Business.
   b. Cooper B-line; brand of Eaton, Electrical Sector.
   c. Flex-Strut Inc.
   d. G-Strut.
   e. Haydon Corporation.
   f. MIRO Industries.
   g. Rooftop Support Systems; Eberl Iron Works, Inc.
   h. Unistrut; Atkore International.
   i. Wesanco, Inc.
2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted **carbon-steel** channel with inturned lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of **stainless steel**.
8. Metallic Coating: **Pregalvanized** G90 **(**Z275**)**.
9. Paint Coating: **Green epoxy, acrylic, or urethane**.
10. Plastic Coating: **PVC**.

B. Non-MFMA Manufacturer Metal Framing Systems:
1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:
   a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
   b. CADDY; brand of nVent Electrical plc.
   c. Carpenter & Paterson, Inc.
   d. MIRO Industries.
   e. PHD Manufacturing, Inc.
   f. RectorSeal HVAC; a CSW Industrials Company.
2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted **carbon-steel** channel with inturned lips.
5. Channel Width: Select for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.

8. Metallic Coating: **Pregalvanized** G90 **(**Z275**)**.
9. Paint Coating: **Green epoxy, acrylic, or urethane**.
10. Plastic Coating: **PVC**.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:
1. Buckaroos, Inc.
2. CADDY; brand of nVent Electrical plc.
3. Carpenter & Paterson, Inc.
4. KB Enterprise.
5. National Pipe Hanger Corporation.
6. Pipe Shields Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: **ASTM C552, Type II cellular glass with** 100-psi **(**688-kPa**) ASTM C591, Type VI, Grade 1 polyisocyanurate with** 125-psi **(**862-kPa**)** minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: **Water-repellent-treated, ASTM C533, Type I calcium silicate with** 100-psi **(**688-kPa**)** 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 and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches **(**50 mm**)** beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

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

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. Cooper B-line; brand of Eaton, Electrical Sector.
   b. Empire Industries, Inc.
   c. Hilti, Inc.
   d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
   e. MKT Fastening, LLC.
2. Indoor Applications: [**Zinc-coated**] [**or**] [**stainless**] steel.
3. Outdoor Applications: Stainless steel.

2.7 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. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:
   a. MIRO Industries.
   b. PHP Systems/Design.
   c. RectorSeal HVAC; a CSW Industrials Company.
2. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
4. Hardware: Galvanized steel or polycarbonate.
5. Accessories: Protection pads.

C. Low-Profile, Single Base, Single-Pipe Stand:
1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:
   a. MIRO Industries.
   b. PHP Systems/Design.
2. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
4. Vertical Members: Two, **galvanized-** steel, continuous-thread 1/2-inch **(**12-mm**)** rods.
5. Horizontal Member: Adjustable horizontal, **galvanized-** steel pipe support channels.
6. Pipe Supports: **Roller**.
7. Hardware: **Galvanized** steel.
8. Accessories: Protection pads.
9. Height: [12 inches **(**300 mm**) above roof**] <**Insert lesser dimension above roof**>.

D. High-Profile, Single Base, Single-Pipe Stand:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIRO Industries.
   b. PHP Systems/Design.
2. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
3. Base: Single vulcanized rubber or molded polypropylene.
4. Vertical Members: Two, **galvanized-** steel, continuous-thread 1/2-inch **(**12-mm**)** rods.
5. Horizontal Member: One, adjustable height, **galvanized-** steel pipe support slotted channel or plate.
6. Pipe Supports: **Roller**.
7. Hardware: **Galvanized** steel.
8. Accessories: Protection pads**,** 1/2-inch **(**12-mm**) continuous-thread galvanized-steel rod**.
9. Height: 36 inches **(**900 mm**) above roof**.

E. High-Profile, Multiple-Pipe Stand:
1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:
   a. MIRO Industries.
   b. PHP Systems/Design.
   c. RectorSeal HVAC; a CSW Industrials Company.
2. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
3. Bases: Two or more; vulcanized rubber.
4. Vertical Members: Two or more, galvanized- steel channels.
5. Horizontal Members: One or more, adjustable height, galvanized- steel pipe support.
6. Pipe Supports: **Roller**.
7. Hardware: **Galvanized** steel.
8. Accessories: Protection pads[**,** 1/2-inch **(**12-mm**) continuous-thread rod**].
9. Height: 36 inches **(**900 mm**) above roof**.

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.

2.8 EQUIPMENT SUPPORTS

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

2.9 OUTDOOR EQUIPMENT STANDS

A. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:
1. MIRO Industries.
2. RectorSeal HVAC; a CSW Industrials Company.

B. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof supported outdoor equipment components, without roof membrane penetration, in a pre-fabricated system that can be modularly-assembled on site.

C. Foot Material: Rubber or polypropylene.

D. Rails Material: Hot dip galvanized carbon steel.

E. Wind/Sliding Load Resistance: Up to 100 mph (44 mps) minimum.

2.10 MATERIALS

A. Aluminum: ASTM B221 **(**ASTM B221M**)**.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.

D. Stainless Steel: ASTM A240/A240M.

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 C1107/C1107M, 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 **(**34.5-MPa**)**, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

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

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb **(**90 kg**)**.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

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 A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

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

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

F. Pipe Stand Installation:
1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

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 (DN 65) 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 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
    b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
    c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
    d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
    e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 INSTALLATION OF 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 .

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

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches **(**40 mm**)**.

3.6 PAINTING

A. Touchup:
1. 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.
   a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils **(**0.05 mm**)**.
2. Comply with requirements in **Section 099123 "Interior Painting"** for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

3.7 HANGER AND SUPPORT SCHEDULE

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

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

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

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

E. Use carbon-steel and attachments for general service applications.

F. Use and attachments for hostile environment applications.

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

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

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

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 **(**DN 15 to DN 750**)**.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 **(**DN 100 to DN 600**)**, requiring up to 4 inches **(**100 mm**)** of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 **(**DN 20 to DN 900**)**, requiring clamp flexibility and up to 4 inches **(**100 mm**)** of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 **(**DN 15 to DN 600**)** if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 **(**DN 15 to DN 100**)**, 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 **(**DN 20 to DN 200**)**.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 **(**DN 15 to DN 200**)**.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 **(**DN 15 to DN 200**)**.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 **(**DN 15 to DN 200**)**.

10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 **(**DN 10 to DN 200**)**.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 **(**DN 10 to DN 80**)**.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 **(**DN 15 to DN 750**)**.
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 **(**DN 100 to DN 900**)**, 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 **(**DN 100 to DN 900**)**, 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 **(**DN 65 to DN 900**)** 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 **(**DN 25 to DN 750**)**, 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 **(**DN 65 to DN 600**)**, 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 **(**DN 50 to DN 1050**)** 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 **(**DN 50 to DN 600**)** 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 **(**DN 50 to DN 750**)** if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 **(**DN 24 to DN 600**)**.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 **(**DN 20 to DN 600**)** if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches **(**150 mm**)** for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) 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 (49 to 232 deg C) piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb **(**340 kg**)**.
    b. Medium (MSS Type 32): 1500 lb **(**680 kg**)**.
    c. Heavy (MSS Type 33): 3000 lb **(**1360 kg**)**.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

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

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches **(**32 mm**)**.
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.

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

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

R. Use **powder-actuated fasteners** instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 230548.13 - VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Housed-spring isolators.
5. Restrained-spring isolators.
6. Housed-restrained-spring isolators.
7. Pipe-riser resilient support.
8. Resilient pipe guides.
9. Elastomeric hangers.
10. Spring hangers.
11. Snubbers.
12. Restraints - rigid type.
13. Restraints - cable type.
14. Restraint accessories.
15. Post-installed concrete anchors.
16. Concrete inserts.
17. Vibration isolation equipment bases.
18. Restrained isolation roof-curb rails.

B. Related Requirements:
1. Section 013573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.
2. Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
3. Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.

1.2 DEFINITIONS

A. IBC: International Building Code.

B. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.3 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 wind-force-restraint]component.
4. Annotate to indicate application of each product submitted and compliance with requirements.
5. 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: Refer to Section 013573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.
1. For each vibration isolator and wind-load protection device that is required by this Section or is indicated on Drawings, submit the following:
a. Vibration Isolator and Wind-Load-Restraint Selection: Select vibration isolators, 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, and spring deflection changes. 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 wind loads.
d. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
e. Qualified Professional Engineer: All designated-design submittals for wind-restraint calculations are to be signed and sealed by qualified professional engineer responsible for their preparation.

2. Wind-Restraint Detail Drawing:
a. Design Analysis: To support selection and arrangement of 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 wind events. Indicate association with vibration isolation devices.
c. Coordinate 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 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 OSHPD, 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.

1.4 INFORMATIONAL SUBMITTALS

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

B. Qualification Data: For testing agency.

C. Welding certificates.

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

E. Field quality-control reports.

F. 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.
4. The following HVAC systems and components require special certification for high wind performance. Written special certification of resistance to the effects of high wind force and impact damage must be provided by manufacturer:
a. <Insert list>.

1.5 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. 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 agency acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a registered design professional, as defined in Section 013573 "Delegated Design Requirements and Procedures" to design system.
   1. Material properties indicated in this Section shall be considered as minimum properties.
   2. Wind-Load Performance: Equipment shall withstand the effects of high wind events determined in accordance with ASCE/SEI 7-22 .

B. Suspended piping:
   1. Sping Hangers or Rubber Hangers shall be used for all piping in equipment rooms and up to 50 ft from vibration isolated equipment and pressure regulating valve (PRV) stations.
      a. The first three hangers from the equipment shall provide the same deflection as the equipment isolators, with a maximum limitation of 2 in. deflection.
      b. The remaining hangers shall be spring or combination spring and rubber with 0.75 in. deflection.
   2. The first two hangers adjacent to the equipment shall be the positioning of precompressed type, to prevent load transfer to equipment flanges when the piping system is filled.
   3. Piping over 2 in. in diamteter that is suspended below or withing 50 ft of noise-sensitive areas shall be hung with combination spring and rubber hangers.
   4. Noise-sensitive areas are as follows:
      a. Conference rooms.
      b. Auditoriums.
      c. Class rooms.
      d. Lecture halls.
      e. Performance halls.
      f. Museum galleries.
      g. Museum exhibits.
      h. Recording studios.

C. Floor-supported piping:
   1. Floor supports for piping in equipment rooms and adjacent to isolated equipment shall use vibration isolators as described in Table 47, Chapter 49 of ASHRAE Handbook - HVAC Applications.
      a. The first two adjacent floor supports shall be the restrained spring type, with a blocking feature that prevents load transfer to equipment flanges as the piping is filled or drained.
   2. Where the piping is subjected to large thermal movement, a slide plate (PTFE, graphite or steel) shall be installed on top of the isolator and a thermal barrier shall be used when rubber products are installed directly beneath steam or hot-water lines.

D. Fire/Smoke Resistance: All components 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.

2.2 ELASTOMERIC ISOLATION PADS

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

a. Ace Mountings Co., Inc.
b. CADDY; a brand of nVent.
c. California Dynamics Corporation.
d. Isolation Technology, Inc.
e. Kinetics Noise Control, Inc.
f. Korfund.
g. Mason Industries, Inc.
h. Novia; A Division of C&P.
i. Vibration Eliminator Co., Inc.
j. Vibration Management Corp.
k. Vibration Mountings & Controls, Inc.
l. <Insert manufacturer's name>.

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. Minimum deflection as indicated on Drawings.
5. Pad Material: Oil- and water-resistant rubber.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.
   a. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Elastomeric Isolation Mounts: .
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation.
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund.
   g. Mason Industries, Inc.
   h. Novia; A Division of C&P.
   i. Vibration Eliminator Co., Inc.
   j. Vibration Isolation.
   k. Vibration Mountings & Controls, Inc.
2. Mounting Plates:
   a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded[with threaded studs or bolts].
   b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Minimum deflection as indicated on Drawings.
4. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts: Insert drawing designation.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation.
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund.
   g. Vibration Eliminator Co., Inc.
   h. Vibration Isolation.
   i. Vibration Mountings & Controls, Inc.
2. Description: All-directional isolator with 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.
3. Minimum deflection as indicated on Drawings.

2.5 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing: .
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation.
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund.
   g. Mason Industries, Inc.
   h. Vibration Eliminator Co., Inc.
   i. Vibration Isolation.
   j. Vibration Management Corp.
   k. Vibration Mountings & Controls, Inc.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum deflection as indicated on Drawings.
7. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi **(**3447 kPa**)**.
   b. Top housing with [attachment and leveling bolt] [threaded mounting holes and internal leveling device] [elastomeric pad].

2.6 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint: <Insert drawing designation>.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation.
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund.
   g. Mason Industries, Inc.
   h. Novia; A Division of C&P.
   i. Vibration Eliminator Co., Inc.
   j. Vibration Isolation.
   k. Vibration Management Corp.
   l. Vibration Mountings & Controls, Inc.
2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
   a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi **(**3447 kPa**)**.
   b. Top plate with [threaded mounting holes] [elastomeric pad].
   c. Internal leveling bolt that acts as blocking during installation.
3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Minimum deflection as indicated on Drawings.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing: .
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ace Mountings Co., Inc.
      b. CADDY; a brand of nVent.
      c. California Dynamics Corporation.
      d. Isolation Technology, Inc.
      e. Kinetics Noise Control, Inc.
      f. Korfund.
      g. Mason Industries, Inc.
      h. Vibration Eliminator Co., Inc.
      i. Vibration Isolation.
      j. Vibration Management Corp.
      k. Vibration Mountings & Controls, Inc.
   2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with [adjustable] [non-adjustable] snubbers to limit vertical movement.
      a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi **(**3447 kPa**)**.
      b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   7. Minimum deflection as indicated on Drawings.

2.8 PIPE-RISER RESILIENT SUPPORT

A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch- **(**13-mm-**)** Thick Neoprene: <Insert drawing designation>.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. California Dynamics Corporation.
      b. Kinetics Noise Control, Inc.
      c. Mason Industries, Inc.
      d. Vibration Eliminator Co., Inc.
      e. Vibration Management Corp.
   2. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
   3. Maximum Load Per Support: 500 psi **(**3447 kPa**)** on isolation material providing equal isolation in all directions.
   4. Minimum deflection as indicated on Drawings.

2.9 RESILIENT PIPE GUIDES

A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch- **(**13-mm-**)** Thick Neoprene: <Insert drawing designation>.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. California Dynamics Corporation.
      b. Kinetics Noise Control, Inc.
      c. Mason Industries, Inc.
      d. Vibration Eliminator Co., Inc.
      e. Vibration Management Corp.
      f. Vibration Mountings & Controls, Inc.
   2. 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.

2.10 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: <Insert drawing designation>.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Novia; A Division of C&P.
   g. Vibration Eliminator Co., Inc.
   h. Vibration Isolation.
   i. Vibration Management Corp.
   j. Vibration Mountings & Controls, Inc.
2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.
4. Minimum deflection as indicated on Drawings.

2.11 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: <Insert drawing designation>.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ace Mountings Co., Inc.
      b. CADDY; a brand of nVent.
      c. California Dynamics Corporation.
      d. Kinetics Noise Control, Inc.
      e. Mason Industries, Inc.
      f. Novia; A Division of C&P.
      g. Vibration Eliminator Co., Inc.
      h. Vibration Isolation.
      i. Vibration Management Corp.
      j. Vibration Mountings & Controls, Inc.
   2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Minimum deflection as indicated on Drawings.
   7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   8. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
   10. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.12 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CADDY; a brand of nVent.
   2. Kinetics Noise Control, Inc.
   3. Mason Industries, Inc.
   4. Vibration Management Corp.
   5. 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 prequalified in accordance with ACI 355.2 testing and designated in accordance with [ACI 318-08 Appendix D for 2009 IBC] [ACI 318-11 Appendix D for 2012 IBC] [ACI 318-14 Ch. 17 for 2015 or 2018 IBC].
   2. Preset Concrete Inserts: 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 **(**6-mm**)** air gap, and minimum 1/4 inch **(**6 mm**)** thick.

2.13 RESTRAINTS - RIGID TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
2. CADDY; a brand of nVent.
3. California Dynamics Corporation.
4. Hilti, Inc.
5. Isolation Technology, Inc.
6. TOLCO.
7. Unistrut; Part of Atkore International.
8. Vibration Mountings & Controls, Inc.

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.

2.14 RESTRAINTS - CABLE TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
2. CADDY; a brand of nVent.
3. Loos & Co.
4. Vibration Mountings & Controls, Inc.

B. Restraint Cables: [ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel] [ASTM A492 stainless steel] cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.

C. Restraint cable assembly and cable fittings must comply with [ASCE/SEI 19-10] [ASCE/SEI 19-16]. 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.

2.15 RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
2. CADDY; a brand of nVent.
3. Hilti, Inc.
4. Loos & Co.
5. Mason Industries, Inc.
6. TOLCO.
7. Unistrut; Part of Atkore International.

B. Hanger-Rod Stiffener: [Steel tube or steel slotted-support-system sleeve with internally bolted connections] [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.

2.16 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. B-line, an Eaton business.

b. Hilti, Inc.
c. Mason Industries, Inc.
d. Powers Fasteners.
e. Simpson Strong-Tie Co., Inc.
f. Unistrut; Part of Atkore International.

2. 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.

B. Adhesive Anchor Bolts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. B-line, an Eaton business.
b. Hilti, Inc.
c. Mason Industries, Inc.
d. Powers Fasteners.
e. Simpson Strong-Tie Co., Inc.
f. Unistrut; Part of Atkore International.
2. 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.

C. 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 7-16, 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.

D. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp **(**7.46 kW**)** that is not vibration isolated.
1. Undercut expansion anchors are permitted.

2.17 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. Powers Fasteners.
5. Simpson Strong-Tie Co., Inc.
6. Unistrut; Part of Atkore International.

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

C. Comply with ANSI/MSS SP-58.

2.18 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CADDY; a brand of nVent.
2. California Dynamics Corporation.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.
5. Novia; A Division of C&P.
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation.
8. Vibration Management Corp.
9. 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 **(**25-mm**)** 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 **(**25-mm**)** 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] [or] [field-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 **(**25-mm**)** 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.
   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.

2.19 RESTRAINED ISOLATION ROOF-CURB RAILS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CADDY; a brand of nVent.
   2. California Dynamics Corporation.
   3. Kinetics Noise Control, Inc.
   4. Novia; A Division of C&P.
   5. Thybar Corporation.
   6. Vibration Eliminator Co., Inc.
   7. Vibration Management Corp.
   8. Vibration Mountings & Controls, Inc.

B. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment.

C. Upper Frame: Shall provide continuous and captive support for equipment.

D. Lower Support Assembly: Shall be formed sheet metal section containing adjustable and removable steel springs that support upper frame. 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 **(**50 mm**)** of rigid glass-fiber insulation on inside of assembly.
   1. 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 integrity of roof.
   2. Minimum deflection as indicated on Drawings.

E. 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.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and wind-load 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 agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to wind-load forces.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static and wind force loads within specified loading limits.

3.3 INSTALLATION OF VIBRATION AND WIND-LOAD CONTROL DEVICES

A. Provide vibration and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

B. 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."

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

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

E. Equipment Restraints:
1. Install 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 **(**3.2 mm**)**.
3. Install wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

F. Piping Restraints:
1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

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

H. Install wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

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

J. 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.

K. 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.

L. Post-Installed Concrete 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 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 MOTION

A. Provide flexible connections in piping systems where they cross structural 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 Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" 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 equipment bases with requirements of isolated equipment specified in this and other Sections. Where dimensions of base are indicated on Drawings, they may require adjustment to accommodate 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. Testing Agency: [Owner will engage] [Engage] a qualified testing agency to perform tests and inspections.

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

C. Perform tests and inspections[with the assistance of a factory-authorized service representative].

D. 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] <Insert number> of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Test and adjust restrained-air-spring isolator controls and safeties.

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

F. Prepare test and inspection reports.

END OF SECTION

SECTION 230553 - IDENTIFICATION FOR HVAC, PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Equipment labels.
2. Pipe labels.
3. Duct labels.
4. Valve tags.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

C. Valve numbering scheme.

D. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Brady Corporation.
   b. Champion America.
   c. Seton Identification Products.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
4. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
5. Fasteners: Stainless-steel rivets.

2.2 PIPE LABELS

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

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

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

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

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

2.3 DUCT LABELS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide roduct by one of the following:
1. Brady Corporation.

2. Champion America.
3. Seton Identification Products.

C. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets.

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

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.4 VALVE TAGS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:
1. Brady Corporation.
2. Champion America.
3. Seton Identification Products.

C. Description: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
1. Tag Material: stainless steel, 0.025-inch (0.64-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain.

D. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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

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

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

3.3 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.

C. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

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

E. Pipe Label Color Schedule:
1. Chilled-Water Piping: White letters on a safety-green background.
2. Condenser-Water Piping: White letters on a safety-green background.
3. Heating Water Piping: Black letters on a safety-orange background.
4. Refrigerant Piping: White letters on a safety-purple background .

3.5 DUCT LABEL INSTALLATION

A. Install plastic-laminated duct labels with permanent adhesive on air ducts in the following color codes:
1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

B. Stenciled Duct Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

C. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

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

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
1. Valve-Tag Size and Shape:
   a. Chilled Water: 1-1/2 inches (38 mm), round .
   b. Condenser Water: 1-1/2 inches (38 mm), round .
   c. Refrigerant: 1-1/2 inches (38 mm), round .
   d. Hot Water: 1-1/2 inches (38 mm), round.
   e. Gas: 1-1/2 inches (38 mm), round.
   f. Low-Pressure Steam: 1-1/2 inches (38 mm), round.
   g. High-Pressure Steam: 1-1/2 inches (38 mm), round.
   h. Steam Condensate: 1-1/2 inches (38 mm), round.

END OF SECTION

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Balancing Air Systems:
      a. Combustion air supply systems. Boiler flue induction draft fan systems.
   2. Balancing Hydronic Piping Systems:
      a. Variable-flow hydronic systems.
      b. Primary-secondary hydronic systems.
   3. Balancing steam systems.
   4. Testing, Adjusting, and Balancing Equipment:
      a. Heat exchangers.
      b. Motors.
      c. Chillers.
      d. Condensing units.
      e. Heat-transfer coils.
   5. Testing, adjusting, and balancing existing systems and equipment.
   6. Sound tests.
   7. Vibration tests.
   8. Duct leakage tests.
   9. Control system verification.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

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

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

G. TDH: Total dynamic head.

1.3 PREINSTALLATION MEETINGS

A. TAB Conference: If requested by the Owner, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
   1. Minimum Agenda Items:
      a. The Contract Documents examination report.
      b. The TAB plan.
      c. Needs for coordination and cooperation of trades and subcontractors.
      d. Proposed procedures for documentation and communication flow.

1.4 ACTION SUBMITTALS

A. HVAC Flush Report: Documentation indicating that building HVAC system flush complies with Green Globes Section 3.2.4.4"IAQ During Construction."
   1. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

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

F. Certified TAB reports.

G. Sample report forms.

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

1.6 QUALITY ASSURANCE

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

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

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

D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

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.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

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

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

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

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

O. Examine operating safety interlocks and controls on HVAC equipment.

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

3.2 PREPARATION

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

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
1. Airside:
   a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
   b. Duct systems are complete with terminals installed.
   c. Volume, smoke, and fire dampers are open and functional.
   d. Clean filters are installed.
   e. Fans are operating, free of vibration, and rotating in correct direction.
   f. Variable-frequency controllers' startup is complete and safeties are verified.
   g. Automatic temperature-control systems are operational.
   h. Ceilings are installed.
   i. Windows and doors are installed.
   j. Suitable access to balancing devices and equipment is provided.
2. Hydronics:
   a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
   b. Piping is complete with terminals installed.
   c. Water treatment is complete.
   d. Systems are flushed, filled, and air purged.
   e. Strainers are pulled and cleaned.
   f. Control valves are functioning per the sequence of operation.
   g. Shutoff and balance valves have been verified to be 100 percent open.
   h. Pumps are started and proper rotation is verified.

i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

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

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

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

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

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check for proper sealing of air-handling-unit components.

K. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
1. Measure total airflow.
a. 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 not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
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 Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Architect, 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, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.7 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:
1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:
1. Adjust pumps to deliver total design gpm.
a. Measure total water flow.
1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.
   a. Measure flow in main and branch pipes.
   b. Adjust main and branch balance valves for design flow.
   c. Re-measure each main and branch after all have been adjusted.
3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
   a. Measure flow at terminals.
   b. Adjust each terminal to design flow.
   c. Re-measure each terminal after it is adjusted.
   d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
   e. Perform temperature tests after flows have been balanced.
4. For systems with pressure-independent valves at terminals:
   a. Measure differential pressure and verify that it is within manufacturer's specified range.
   b. Perform temperature tests after flows have been verified.
5. For systems without pressure-independent valves or flow-measuring devices at terminals:
   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
6. Prior to verifying final system conditions, determine the system differential-pressure set point.
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 water flow is within design.
   b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
   c. Mark final settings.
10. Verify that memory stops have been set.

D. For systems with diversity:
   1. Determine diversity factor.
   2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
   3. Adjust pumps to deliver total design gpm.
      a. Measure total water flow.
         1) Position valves for full flow through coils.
         2) Measure flow by main flow meter, if installed.
         3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
      b. Measure pump TDH as follows:
         1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
         2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
         3) Convert pressure to head and correct for differences in gage heights.
         4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
         5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
      c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.
    a. Measure flow in main and branch pipes.
    b. Adjust main and branch balance valves for design flow.
    c. Re-measure each main and branch after all have been adjusted.
5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
    a. Measure flow at terminals.
    b. Adjust each terminal to design flow.
    c. Re-measure each terminal after it is adjusted.
    d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
    e. Perform temperature tests after flows have been balanced.
6. For systems with pressure-independent valves at terminals:
    a. Measure differential pressure, and verify that it is within manufacturer's specified range.
    b. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:
    a. Measure and balance coils by either coil pressure drop or temperature method.
    b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
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, and static profile.
    c. Mark final settings.
13. Verify that memory stops have been set.

3.8 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first.

B. Balance the secondary circuits after the primary circuits are complete.

C. Adjust pumps to deliver total design gpm.
1. Measure total water flow.
    a. Position valves for full flow through coils.
    b. Measure flow by main flow meter, if installed.
    c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
2. Measure pump TDH as follows:
    a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    c. Convert pressure to head and correct for differences in gage heights.
    d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

D. Adjust flow-measuring devices installed in mains and branches to design water flows.
1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

E. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.

4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

F. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

I. Verify that memory stops have been set.

3.9 PROCEDURES FOR BOILERS

A. Hydronic Boilers:
1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Record relief valve pressure setting.

3.10 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:
1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

B. Measure, adjust, and record the following data for each electric heating coil:
1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:
1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:
1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.11 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.12 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:
1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.

7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.13 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.14 TOLERANCES

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

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.15 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare 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.

3.16 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

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

C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches **(**mm**)**, and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches **(**mm**)**.
    j. Number, make, and size of belts.

k. Number, type, and size of filters.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches (mm), and bore.
   f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan rpm.
   d. Discharge static pressure in inches wg (Pa).
   e. Filter static-pressure differential in inches wg (Pa).
   f. Preheat-coil static-pressure differential in inches wg (Pa).
   g. Cooling-coil static-pressure differential in inches wg (Pa).
   h. Heating-coil static-pressure differential in inches wg (Pa).
   i. Outdoor airflow in cfm (L/s).
   j. Return airflow in cfm (L/s).
   k. Outdoor-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

F. Apparatus-Coil Test Reports:
1. Coil Data:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch (mm) o.c.
   f. Make and model number.
   g. Face area in sq. ft. (sq. m).
   h. Tube size in NPS (DN).
   i. Tube and fin materials.
   j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm (L/s).
   b. Average face velocity in fpm (m/s).
   c. Air pressure drop in inches wg (Pa).
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
   e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
   f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
   g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
   h. Water flow rate in gpm (L/s).
   i. Water pressure differential in feet of head or psig (kPa).
   j. Entering-water temperature in deg F (deg C).
   k. Leaving-water temperature in deg F (deg C).
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig (kPa).
   n. Refrigerant suction temperature in deg F (deg C).
   o. Inlet steam pressure in psig (kPa).

G. 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 (kW).
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches (mm), and bore.
n. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

2. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm (L/s).
b. Entering-air temperature in deg F (deg C).
c. Leaving-air temperature in deg F (deg C).
d. Air temperature differential in deg F (deg C).
e. Entering-air static pressure in inches wg (Pa).
f. Leaving-air static pressure in inches wg (Pa).
g. Air static-pressure differential in inches wg (Pa).
h. Low-fire fuel input in Btu/h (kW).
i. High-fire fuel input in Btu/h (kW).
j. Manifold pressure in psig (kPa).
k. High-temperature-limit setting in deg F (deg C).
l. Operating set point in Btu/h (kW).
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h (kW).

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
1. Unit Data:
a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h (kW).
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm (L/s).
i. Face area in sq. ft. (sq. m).
j. Minimum face velocity in fpm (m/s).
2. Test Data (Indicated and Actual Values):
a. Heat output in Btu/h (kW).
b. Airflow rate in cfm (L/s).
c. Air velocity in fpm (m/s).
d. Entering-air temperature in deg F (deg C).
e. Leaving-air temperature in deg F (deg C).
f. Voltage at each connection.
g. Amperage for each phase.

I. 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 (mm), and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
2. Motor Data:
a. Motor make, and frame type and size.

b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Suction static pressure in inches wg (Pa).

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F (deg C).
d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).
f. Duct area in sq. ft. (sq. m).
g. Indicated airflow rate in cfm (L/s).
h. Indicated velocity in fpm (m/s).
i. Actual airflow rate in cfm (L/s).
j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

K. 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. (sq. m).
2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm (L/s).
b. Air velocity in fpm (m/s).
c. Preliminary airflow rate as needed in cfm (L/s).
d. Preliminary velocity as needed in fpm (m/s).
e. Final airflow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in deg F (deg C).

L. 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 (L/s).
b. Entering-water temperature in deg F (deg C).
c. Leaving-water temperature in deg F (deg C).
d. Water pressure drop in feet of head or psig (kPa).
e. Entering-air temperature in deg F (deg C).

f. Leaving-air temperature in deg F (deg C).

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
1. Unit Data:
a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm (L/s).
g. Water pressure differential in feet of head or psig (kPa).
h. Required net positive suction head in feet of head or psig (kPa).
i. Pump rpm.
j. Impeller diameter in inches (mm).
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.
2. Test Data (Indicated and Actual Values):
a. Static head in feet of head or psig (kPa).
b. Pump shutoff pressure in feet of head or psig (kPa).
c. Actual impeller size in inches (mm).
d. Full-open flow rate in gpm (L/s).
e. Full-open pressure in feet of head or psig (kPa).
f. Final discharge pressure in feet of head or psig (kPa).
g. Final suction pressure in feet of head or psig (kPa).
h. Final total pressure in feet of head or psig (kPa).
i. Final water flow rate in gpm (L/s).
j. Voltage at each connection.
k. Amperage for each phase.

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

3.17 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Architect.

B. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Architect.

C. Architect 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.
1. 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. Recheck the following measurements in their entirety:
1. Airside:
a. All outside air intake flow rates
b. All exhaust/relief flow rates
c. Supply, return, relief and exhaust airflow rates (as applicable) for all AHUs / RTU/s / DOAUs in the entire project
d. 10 percent of all other measurements recorded as randomly selected by the Architect. Submit RFI to the Architect to identify the associated measurements that need to be rechecked.
2. Waterside:

a. Pump performance for all pumps, in all hydronic systems in the project.
b. Hydronic coil balancing for all coils in AHUs / RTU/s / DOAUs with a minimum design airflow of 5,000 CFM, in the entire project.
c. 10 percent of all other measurements recorded as randomly selected by the Architect. Submit RFI to the Architect to identify the associated measurements that need to be rechecked.

E. 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.

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

G. Prepare test and inspection reports.

3.18 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:
   1. Indoor, exposed supply and outdoor air.

B. Related Requirements:
   1. Section 230716 "HVAC Equipment Insulation."
   2. Section 230719 "HVAC Piping Insulation."

1.2 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
   3. Detail application of field-applied jackets.
   4. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
   1. Sheet Form Insulation Materials: 12 inches **(**300 mm**)** square.
   2. Sheet Jacket Materials: 12 inches **(**300 mm**)** square.
   3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 INFORMATIONAL SUBMITTALS

A. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

B. Field quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.6 SCHEDULING

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, 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 "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.

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

C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

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

F. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F (232 deg C) in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Certainteed; SAINT-GOBAIN.
      b. Johns Manville; a Berkshire Hathaway company.
      c. Knauf Insulation.
      d. Manson Insulation Inc.
      e. Owens Corning.

G. Glass-Fiber, Pipe and Tank: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F (1.7 deg C) and 850 deg F (454 deg C), in accordance with ASTM C411. Comply with ASTM C1393.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Certainteed; SAINT-GOBAIN.
      b. Knauf Insulation.
      c. Manson Insulation Inc.
      d. Owens Corning.
   2. Semirigid board material with factory-applied FSK jacket.
   3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 ADHESIVES

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

B. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Eagle Bridges - Marathon Industries.
      c. Foster Brand; H. B. Fuller Construction Products.
      d. Mon-Eco Industries, Inc.
   2. Fiberglass adhesive shall have a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Eagle Bridges - Marathon Industries.
      c. Foster Brand; H. B. Fuller Construction Products.
   2. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.
   1. VOC Content: 300 g/L or less.

B. Vapor-Retarder Mastic, Water Based, Interior Use: Suitable for indoor use on below ambient services.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Knauf Insulation.
      d. Vimasco Corporation.
   2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
   3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
   5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Eagle Bridges - Marathon Industries.
      c. Foster Brand; H. B. Fuller Construction Products.
      d. Knauf Insulation.
      e. Vimasco Corporation.
   2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm **(**0.66 metric perm**)** at manufacturer's recommended dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   4. Color: [White] <Insert color>.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Vimasco Corporation.
   2. Adhesives shall have a VOC content of 50 g/L or less.
   3. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
   4. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Eagle Bridges - Marathon Industries.
      c. Foster Brand; H. B. Fuller Construction Products.
   2. Materials are compatible with insulation materials, jackets, and substrates.
   3. Fire- and water-resistant, flexible, elastomeric sealant.
   4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   5. Color: Aluminum.
   6. Sealant shall have a VOC content of 420 g/L or less.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
   2. Materials are compatible with insulation materials, jackets, and substrates.
   3. Fire- and water-resistant, flexible, elastomeric sealant.
   4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   5. Color: White.
   6. Sealant shall have a VOC content of 420 g/L or less.

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 C1136, Type I.

2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.
2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.
2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Ideal Tape Co., Inc., an American Biltrite Company.
2. Width: 2 inches (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.
   e. Sekisui Voltek, LLC.
2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.9 SECUREMENTS

A. Bands:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Johns Manville; a Berkshire Hathaway company.
   b. RPR Products, Inc.
   c. <Insert manufacturer's name>.

2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 3/4 inch (19 mm) wide with wing seal.
3. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:
1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) AGM Industries, Inc.
      2) Gemco.
      3) Midwest Fasteners, Inc.
      4) Nelson Stud Welding.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [0.106-inch- (2.6-mm-)] [0.135-inch- (3.5-mm-)] diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) AGM Industries, Inc.
      2) Gemco.
      3) Midwest Fasteners, Inc.
      4) Nelson Stud Welding.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) AGM Industries, Inc.
      2) Gemco.
      3) Midwest Fasteners, Inc.
   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   c. Spindle: Aluminum, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Gemco.
      2) Midwest Fasteners, Inc.
   b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) AGM Industries, Inc.
2) Gemco.
3) Midwest Fasteners, Inc.

b. Nelson Stud Welding.Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- **(**19-mm-**)** wide, stainless steel or Monel.

D. Wire: 0.062-inch **(**1.6-mm**) soft-annealed, galvanized steel**.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. C & F Wire.
b. Johns Manville; a Berkshire Hathaway company.
c. RPR Products, Inc.

2.10 CORNER ANGLES

A. Stainless Steel Corner Angles: 0.024 inch **(**0.61 mm**)** thick, minimum 1 by 1 inch **(**25 by 25 mm**)**, stainless steel in accordance with ASTM A240/A240M, Type 304.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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.

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 ducts and fittings.

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

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

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

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

F. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents.

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

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

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

K. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches (100 mm) o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation.

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

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

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 (50 mm) below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).
1. Comply with requirements in Section 078413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:
1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF GLASS-FIBER AND MINERAL-WOOL INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

B. Comply with manufacturer's written installation instructions.
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 (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
    b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) 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 (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops 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 (75 mm).
5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) 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- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

C. Board Insulation Installation on Ducts : 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 (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
    b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) 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 (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops 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 (75 mm).

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-(150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

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

3.7 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:
1. Indoor, exposed supply and outdoor air.

B. Items Not Insulated:
1. Factory-insulated plenums and casings.
2. Flexible connectors.
3. Vibration-control devices.
4. Factory-insulated access panels and doors.

3.8 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Exposed, rectangular, supply and outdoor-air duct insulation is the following:
1. Glass-Fiber Blanket: 2 inches (50 mm) thick and 3 lb/cu. ft. (48 kg/cu. m) nominal density.

END OF SECTION

SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating HVAC equipment that is not factory insulated.

B. Related Sections:
1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. 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 removable insulation at equipment connections.
2. Detail application of field-applied jackets.
3. Detail application at linkages of control devices.
4. Detail field application for each equipment type.

1.3 INFORMATIONAL SUBMITTALS

A. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program[, certified by the Department of Labor, Bureau of Apprenticeship and Training].

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation system **materials are to be delivered to the Project site in unopened containers**. The packaging is to include, the name of the manufacturer, fabricator, type, description, and size, as well as ASTM standard designation, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, 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 "Breeching Insulation Schedule," "Indoor Equipment Insulation Schedule," and "Outdoor, Aboveground Equipment Insulation Schedule" articles for where insulating materials are applied.

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

C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

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

F. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F (232 deg C) in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, Type III, with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
      a. CertainTeed Corporation; Saint-Gobain North America.
      b. Johns Manville; a Berkshire Hathaway company.
      c. Knauf Insulation.
      d. Manson Insulation Inc.
      e. Owens Corning.

G. Glass-Fiber Board: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F (1.7 deg C) and 250 deg F (121 deg C) for jacketed and between 35 deg F (1.7 deg C) and 450 deg F (232 deg C) for unfaced in accordance with ASTM C411. Comply with ASTM C612, Type IA or Type IB. Provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Manufacturers: Subject to compliance with requirements, [provide products by the following][provide products by one of the following][available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
      a. CertainTeed Corporation; Saint-Gobain North America.
      b. Johns Manville; a Berkshire Hathaway company.
      c. Knauf Insulation.
      d. Manson Insulation Inc.
      e. Owens Corning.

2.3 INSULATING CEMENTS

A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ramco Insulation, Inc.

2.4 ADHESIVES

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

B. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Mon-Eco Industries, Inc.

C. PVC Jacket Adhesive: Compatible with PVC jacket.
   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.

2.5 SEALANTS

A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.
   d. Owens Corning.
2. Permanently flexible, elastomeric sealant.
3. Color: White or gray.

C. FSK and Metal Jacket Flashing Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Mon-Eco Industries, Inc.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
4. Color: Aluminum.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.
2. Width: 3 inches **(**75 mm**)**.
3. Thickness: 11.5 mils **(**0.29 mm**)**.
4. Adhesion: 90 ounces force/inch **(**1.0 N/mm**)** in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch **(**7.2 N/mm**)** in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. 3M Industrial Adhesives and Tapes Division.
   b. Avery Dennison Corporation, Specialty Tapes Division.
   c. Ideal Tape Co., Inc., an American Biltrite Company.
   d. Knauf Insulation.
2. Width: 3 inches **(**75 mm**)**.
3. Thickness: 6.5 mils **(**0.16 mm**)**.
4. Adhesion: 90 ounces force/inch **(**1.0 N/mm**)** in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch **(**7.2 N/mm**)** in width.

7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. 3M Industrial Adhesives and Tapes Division.
b. Ideal Tape Co., Inc., an American Biltrite Company.
2. Width: 2 inches (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: [18 lbf/inch (3.3 N/mm)]<Insert value> in width.

2.9 SECUREMENTS

A. Bands:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Johns Manville; a Berkshire Hathaway company.
b. RPR Products, Inc.
2. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.

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. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range of between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

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

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

F. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents.

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

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached 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 insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

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

K. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch- **(**75-mm-**)** wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches **(**100 mm**)** o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches **(**38 mm**)**. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at [2 inches **(**50 mm**)**][4 inches **(**100 mm**)**] o.c.
4. For below-ambient services, apply vapor-barrier mastic over staples.
5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation.

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

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches **(**100 mm**)** beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

O. 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 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. , Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive, anchor pins, and speed washers.
1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.

4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints and 16 inches (400 mm) o.c. in both directions.
   d. Do not compress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins, and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches (75 mm).
8. Install insulation in removable and replaceable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
   1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:
   1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a field-adjustable latching mechanism.
   2. Fabricate boxes from aluminum, at least 0.050 inch (1.3 mm) thick.
   3. For below-ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Install in accordance with manufacturer's written installation instructions and ASTM C1710.

B. 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.

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
   5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

3.7 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
   1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
      a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

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

3.8 FIELD QUALITY CONTROL

A. Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to [one]<Insert number> location(s) for each type of equipment defined in "Indoor Equipment Insulation Schedule" and "Outdoor, Aboveground Equipment Insulation Schedule" articles. For large equipment, remove only a portion adequate to determine compliance.

C. All insulation applications will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 EQUIPMENT INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. Acceptable 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 is Contractor's option.

3.10 BREECHING INSULATION SCHEDULE

A. Rectangular, exposed breeching and connector insulation is the following:
   1. High-Temperature Glass-Fiber Board: 3 inches **(**75 mm**)** thick and [3 lb/cu. ft. (48 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)] nominal density.

3.11 INDOOR EQUIPMENT INSULATION SCHEDULE

A. Insulate indoor and outdoor equipment that is not factory insulated.
   1. Glass-Fiber Blanket: 2 inches **(**50 mm**)** thick and 3 lb/cu. ft. (48 kg/cu. m) nominal density.
   2. Glass-Fiber Board: 2 inches **(**50 mm**)** thick and 3 lb/cu. ft. (48 kg/cu. m) nominal density.

B. Chilled-water pump insulation is the following:
   1. Glass-Fiber Board: 2 inches **(**50 mm**)** thick and 3 lb/cu. ft. (48 kg/cu. m) nominal density.
   2. Glass-Fiber Board: 2 inches **(**50 mm**)** thick and 2 lb/cu. ft. (32 kg/cu. m) nominal density.

C. Heating-hot-water pump insulation is the following:
   1. Glass-Fiber Board: 2 inches **(**50 mm**)** thick and 3 lb/cu. ft. (48 kg/cu. m) nominal density.
   2. Glass-Fiber Board: 2 inches **(**50 mm**)** thick and 3 lb/cu. ft. (48 kg/cu. m) nominal density.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Equipment, Concealed:
   1. FSK.

D. Equipment, Exposed, up to 48 Inches **(**1200 mm**)** in Diameter or with Flat Surfaces of up to 72 Inches **(**1800 mm**)**:

1. PVC.

E. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
1. FSK.

END OF SECTION

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulation for HVAC piping systems.

B. Related Requirements:
1. Section 230713 "Duct Insulation" for duct insulation.
2. Section 230716 "HVAC Equipment Insulation" for equipment insulation.

1.2 ACTION SUBMITTALS

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

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

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.
1. Preformed Pipe Insulation Materials: 12 inches **(**300 mm**)** long by NPS 2 **(**DN 50**)**.
2. Sheet Form Insulation Materials: 12 inches **(**300 mm**)** square.
3. Jacket Materials for Pipe: 12 inches **(**300 mm**)** long by NPS 2 **(**DN 50**)**.
4. Sheet Jacket Materials: 12 inches **(**300 mm**)** square.
5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 INFORMATIONAL SUBMITTALS

A. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program[, certified by the Department of Labor, Bureau of Apprenticeship and Training].

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of manufacturer, fabricator, type, description, and size.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.7 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, 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 "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials are applied.

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

C. Products that come into contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials do 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. Comply with ASTM C552.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Owens Corning.
   2. Preformed Pipe Insulation with Jacket: Type II, Class 2, with factory-applied ASJ jacket.
   3. Fabricated shapes in accordance with ASTM C450, ASTM C585, and ASTM C1639.
   4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

G. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F (454 deg C) in accordance with ASTM C411. Comply with ASTM C547.
   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. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ.
   3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
   4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Glass-Fiber, Pipe and Tank: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F (1.7 deg C) and 850 deg F (454 deg C), in accordance with ASTM C411. Comply with ASTM C1393.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation; Saint-Gobain North America.
      b. Johns Manville; a Berkshire Hathaway company.
      c. Manson Insulation Inc.
      d. Owens Corning.
   2. Semirigid board material with factory-applied ASJ jacket.
   3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 INSULATING CEMENTS

A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ramco Insulation, Inc.

2.4 ADHESIVES

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

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus73 to plus 93 deg C).
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Foster Brand; H. B. Fuller Construction Products.
   2. Adhesive: As recommended by cellular glass manufacturer and with a VOC content of 80 g/L or less.

C. PVC Jacket Adhesive: Compatible with PVC jacket.
   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.
      e. The Dow Chemical Company.

2.5 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.
   1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Knauf Insulation.
      d. Mon-Eco Industries, Inc.
      e. Vimasco Corporation.
   2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
   3. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
   4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
   5. Color: White.

C. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
   2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
   3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
   4. Color: White.

2.6 SEALANTS

A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Mon-Eco Industries, Inc.
      d. Owens Corning.
   2. Permanently flexible, elastomeric sealant.
      a. Service Temperature Range: [Minus 150 to plus 250 deg F (Minus 101 to plus 121 deg C)][Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C)].
      b. Color: White or gray.
   3. Sealant shall have a VOC content of 420 g/L or less.

C. FSK and Metal Jacket Flashing Sealants:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products.
      c. Mon-Eco Industries, Inc.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: Aluminum.

D. ASJ Flashing Sealants and PVDC and PVC Jacket Flashing Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Childers Brand; H. B. Fuller Construction Products.
b. Foster Brand; H. B. Fuller Construction Products.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
4. Color: White.
5. Sealant shall have a VOC content of 420 g/L or less.

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 C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
5. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C1136, 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 D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Airex Manufacturing.
b. Johns Manville; a Berkshire Hathaway company.
c. P.I.C. Plastics, Inc.
d. Proto Corporation.
e. 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.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. 3M Industrial Adhesives and Tapes Division.
b. Avery Dennison Corporation, Specialty Tapes Division.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.
2. Width: 3 inches **(**75 mm**)**.
3. Thickness: [11.5 mils **(**0.29 mm**)**]<Insert value>.
4. Adhesion: 90 ounces force/inch **(**1.0 N/mm**)** in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch **(**7.2 N/mm**)** in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. 3M Industrial Adhesives and Tapes Division.
b. Avery Dennison Corporation, Specialty Tapes Division.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.

2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: [90 ounces force/inch (1.0 N/mm)]<Insert value> in width.
5. Elongation: [2]<Insert number> percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. 3M Industrial Adhesives and Tapes Division.
b. Ideal Tape Co., Inc., an American Biltrite Company.
2. Width: 2 inches (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. 3M Industrial Adhesives and Tapes Division.
b. Avery Dennison Corporation, Specialty Tapes Division.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.
2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Johns Manville; a Berkshire Hathaway company.
2. Width: 3 inches (75 mm).
3. Film Thickness: 2 mils (0.05 mm).
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 120 percent.
6. Tensile Strength: 20 psi (138 kPa) in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Johns Manville; a Berkshire Hathaway company.
2. Width: 3 inches (75 mm).
3. Film Thickness: [6 mils (0.15 mm)]<Insert value>.
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 psi (379 kPa) in width.

2.10 SECUREMENTS

A. Bands:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Johns Manville; a Berkshire Hathaway company.
b. RPR Products, Inc.
2. Stainless Steel: ASTM A240/A240M, Type 304; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with .
3. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4 inch (19 mm) wide, stainless steel or Monel.

C. Wire: [0.080-inch **(**2.0-mm**) nickel-copper alloy**][0.062-inch **(**1.6-mm**) soft-annealed, stainless steel**][0.062-inch **(**1.6-mm**) soft-annealed, galvanized steel**].
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. C & F Wire.
      b. Johns Manville; a Berkshire Hathaway company.
      c. RPR Products, Inc.
      d. <Insert manufacturer's name>.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

B. Coordinate insulation installation with the tradesman 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 piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of 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, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) 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 storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents.

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 attached to structure with vapor-barrier mastic.
   3. Install insert materials and 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, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). 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 (50 mm) o.c.
4. For below-ambient services, apply vapor-barrier mastic over staples.
5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
6. 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.

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 (100 mm) beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

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

3.4 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 (50 mm) 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 (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

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

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

F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.

2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

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

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using prefabricated fitting insulation made from same material and density as that of adjacent pipe insulation. Each piece is 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 prefabricated fitting insulation of same material and thickness as that 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 prefabricated fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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 prefabricated fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
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 reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.

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. Installation conforms 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 that of adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 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 **(**50 mm**)** over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure single-layer insulation with stainless steel bands at 12-inch (300-mm) intervals, and tighten bands without deforming insulation materials.
   2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless steel bands at 12-inch (300-mm) 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 (25 mm). 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 prefabricated 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 that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
   4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   2. When prefabricated 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 pipe insulation, quads, hex sections, or beveled lag segments, adhered together, of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   2. Install insulation to flanges as specified for flange insulation application.
   3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:
   1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
   2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
   4. For insulation with 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 prefabricated 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 that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
   4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
   1. Install prefabricated sections of same material as that of 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 or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:
1. Install prefabricated 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 GLASS-FIBER AND MINERAL WOOL 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 jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches **(**150 mm**)** o.c.
4. For insulation with 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 prefabricated 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 glass-fiber or mineral-wool blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch **(**25 mm**)**, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:
1. Install prefabricated sections of same material as that of 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 prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated sections are not available, install fabricated 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 INSTALLATION OF FIELD-APPLIED JACKETS

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 **(**50-mm**)** overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- **(**1.6-mm-**)** 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 **(**38-mm**)** laps at longitudinal seams and 3-inch- **(**75-mm-**)** 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 and for horizontal applications, install with 1-inch **(**25-mm**)** 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 (50-mm) 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 (300 mm) o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:
1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap presized jackets around individual pipe insulation sections, with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.10 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless steel jackets.

3.11 FIELD QUALITY CONTROL

A. Engage a qualified testing agency to perform tests and inspections.

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

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

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

E. All insulation applications will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.12 PIPING INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. 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.

3.13 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
1. All Pipe Sizes: Insulation is the following:
a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.

B. Chilled Water and Brine, Above 40 Deg F (5 Deg C):
1. NPS 12 (DN 300) and Smaller: Insulation is the following:
a. Cellular Glass: 1-1/2 inches (38 mm) thick.

C. Condenser-Water Supply and Return:
1. NPS 12 (DN 300) and Smaller: Insulation is the following:
a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
b. .

D. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:
1. NPS 12 (DN 300) and Smaller: Insulation is one of the following:
a. Cellular Glass: 2 inches (50 mm) thick.
b. Glass-Fiber, Preformed Pipe, Type I: 2 inches (50 mm) thick.
c. Mineral Wool, Preformed Pipe, Type II: 2 inches (50 mm) thick.

E. Steam and Steam Condensate, Boiler Blowdown, Vents, Drains[, and Safety Relief Vents] 350 Deg F (177 Deg C) and Below:
1. NPS 3/4 (DN 20) and Smaller: Insulation is one of the following:
a. Cellular Glass: 3 inches (75 mm) thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 thick.
c. Mineral Wool, Preformed Pipe Insulation, Type II: 3 thick.
2. NPS 1 (DN 25) and Larger: Insulation is one of the following:
a. Cellular Glass: 3 inches (75 mm) thick.
b. Glass-Fiber, [Preformed Pipe Insulation, Type I][or][Pipe and Tank Insulation]: 3 inches (75 mm) thick.
c. Mineral Wool, [Preformed Pipe Insulation, Type II][or][Pipe and Tank Insulation]: 3 inches (75 mm) thick.

F. Steam and Steam Condensate, Boiler Blowdown, Vents, Drains, and Safety Relief Vents Above 350 Deg F (177 Deg C):
1. NPS 3/4 (DN 20) and Smaller: Insulation is one of the following:
a. Cellular Glass: 3 inches (75 mm) thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 3 inches (50 mm) thick.
2. NPS 1 (DN 25) and Larger: Insulation is one of the following:
a. Cellular Glass: 3 inches (75 mm) thick.

3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:
1. All Pipe Sizes: Insulation is[one of] the following:
a. Cellular Glass: 3 inches (75 mm) thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
c. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches (50 mm) thick.

3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Piping, Concealed:
1. None.

D. Piping, Exposed:
1. 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. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
   1. Aluminum, Stucco Embossed: 0.040 inch **(**1.0 mm**)** thick.

D. Piping, Exposed:
   1. Aluminum, Stucco Embossed: 0.040 inch **(**1.0 mm**)** thick.

END OF SECTION

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes Cx process requirements for the following HVAC systems, assemblies, and equipment:
   1. Heat generation systems.
   2. Air, and hydronic distribution systems.
   3. BUILDING AUTOMATION SYSTEM (BAS) COMMISSIONING.
   4. TAB verification.

B. Related Requirements:
   1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
   2. For construction checklists, comply with requirements in various Division 23 Sections specifying HVAC systems, system components, equipment, and products.

1.2 DEFINITIONS

A. BAS: Building automation system.

B. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."

C. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."

D. IgCC: International Green Construction Code.

E. CM : Construction Manager.

F. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they mean "as-built" systems, assemblies, subsystems, equipment, and components.

G. TAB: Testing, adjusting, and balancing.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For **BAS** testing technician.

B. Construction Checklists:
   1. Draft Cx plan, including draft construction checklists to be prepared by CxA under Section 019113 "General Commissioning Requirements." Div. 23 Subcontractor is to review Construction Checklist in accordance with requirements in Section 019113 "General Commissioning Requirements" and ASHRAE 202 and to resolve any issues with the CxA.
   2. Cx plan, including material, installation, and performance construction checklists for systems, assemblies, subsystems, equipment, and components relating to **HVAC** to be part of the Cx process and in accordance with requirements in Section 019113 "General Commissioning Requirements and ASHRAE 202."

C. Test Equipment and Instruments: For all test equipment and instruments to be used in conducting Cx tests by Div. 23 Subcontractor, provide the following:
   1. Equipment/instrument identification number.
   2. Planned Cx application or use.
   3. Manufacturer, make, model, and serial number.
   4. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
   5. Equipment manufacturers' proprietary instrumentation and tools. For each instrument or tool, identify the following:
      a. Instrument or tool identification number.
      b. Equipment schedule designation of equipment for which the instrument or tool is required.
      c. Manufacturer, make, model, and serial number.
      d. Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

1.4 ADDITIONAL RESPONSIBILITIES

A. Refer to Section 019113: Detailed Contractor responsibilities common to all Divisions are specified in Section 019113. The following are additional responsibilities or notable responsibilities specific to Division 23.

B. Construction Phase
1. Provide skilled technicians qualified to perform the work required.
2. Provide factory-trained and authorized technicians where required by the Contract Documents.
3. Prepare and submit required draft Start-Up Documentation and submit along with the manufacturer¢s application, installation and start-up information.
4. Provide assistance to the CxA in preparation of the specific Functional Performance Test (FPT) procedures. Contractors, subcontractors and vendors shall review FPT procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests. Damage caused to equipment performed in accordance with the approved procedures will be the responsibility of the Contractor.
5. Thoroughly complete and inspect installation of systems and equipment as detailed throughout Contract Documents, as required by reference or industry standards, and as specifically indicated elsewhere this Section.
6. Start-Up, test/adjust/balance, and Turn-Over systems and equipment prior to functional performance testing by the CxA. Approved Start-Up Documentation shall be in accordance with Contract Documents, reference or industry standards, and specifically elsewhere in Part I of this Section.
7. Record Start-Up on approved Start-Up Documentation forms and certify that the systems and equipment have been started and or tested in accordance with the requirements specified above and in Section 010900. Each task or item shall be indicated with the Party actually performing the task or procedure.
8. TAB: As outlined in Section 230593. Specifically as it relates to Cx:
   a. Attend Construction Phase Cx Kick-Off Meeting and Cx progress meetings beginning within 3 months of start of TAB work;
   b. Submit TAB Plan as indicated above;
   c. Meet with Cx team to review TAB procedures and documentation required;
   d. Demonstrate TAB procedures for repetitive tasks (zone balancing, AHU adjusting) as called for by the CxA;
   e. Participate in Action List dialogue;
   f. Provide all documentation electronically.
   g. Attend a meeting convened by the CxA to coordinate with the safety certifying agency. The point of the meeting will be to coordinate protocols and measurement approaches to ensure that devices such as fume hoods and biosafety cabinets will be set up to achieve certification.

C. Acceptance Phase
1. Assist CxA in Functional Performance Testing. Assistance will typically include the following:
   a. Manipulate systems and equipment to facilitate Functional Performance Testing
   b. Provide any specialized instrumentation necessary for Functional Performance Testing;
   c. Manipulate BAS and other control systems to facilitate Functional Performance Testing.
   d. Provide a TAB technician to work at the direction of CxA for up to 16 hours beyond assistance specified above.
   e. Provide a BAS technician to work at the direction of CxA for up to 16 hours beyond assistance specified above.
   f. Maintain trends and monitor the facility throughout the Endurance Period.

D. Warranty Phase
1. Maintain record documentation of any configurations, setpoints, parameters, etc. that change throughout the Warranty Period.
2. Provide representative for off-season testing as required by CxA.
3. Respond to warranty issues as required by Division 01 and the General Conditions.

1.5 PIPING CLEANING, FLUSH, AND FILL PLAN

A. Contractors shall provide a Piping Cleaning, Flush, and Fill Plan• t to the CxA that provides a descriptive narrative and supporting calculations of the means and methods that will be used to clean out, flush, and fill the piping systems.

B. The Piping Cleaning, Flush, and Fill Plan• shall incorporate and be inclusive of all requirements of individual Sections relating to piping and pipe cleaning and flushing. In addition to the requirements of any other related Section, this document shall consist of the following at a minimum for each individual hydronic loop:
   1. Overview schematic diagram of each of the hydronic systems, showing individual flow components such as chillers, boilers, pumps, heat exchangers, cooling towers, control valves, and strainers.
   2. Narrative and illustration indicating the equipment that will either participate or be bypassed by fluid flow during the clean and flush process.
   3. For equipment to be bypassed, description of the means for providing the bypass, including the type, size, and length of hoses or piping to be used.
   4. Description of how flow is to be induced (permanent pumps, temporary pumps, etc.) and flow rates to be imposed during the flush process.
   5. Calculation of resultant flow velocities in various portions of the piping system, with specific identification of the minimum velocity sections of the piping loop. Velocities should generally be shown to be above a 7 feet-per-second minimum speed to provide for adequate capability to flush and carry debris through the system to the appropriate strainer or clean-out location.
   6. Description of cleaning methods and materials to be used to flush the system. Description shall include cleaning material and concentration, details of the cleaning process including duration of circulation and flushing intervals, criteria for determining a clean• flush, and name and qualifications of cleaning or chemical treatment subcontractors to be used.
   7. Identification and discussion of any isolated sections or dead-legs that will be present, including means to provide cleaning and flushing for these sections.
   8. Details of the strainers to be used for the flush and clean process, as well as final strainers to be used after cleaning. Contractor shall clean all strainers prior to turning over the system for commissioning.
   9. If the cleaning and flushing process is to be phased in sections, details should be provided to clarify how clean sections will be protected as other sections are flushed.

1.6 TEMPORARY OPERATION AND CONDITIONING PLAN

A. Contractor shall be allowed to use permanent building equipment to provide temporary conditioning ONLY upon the approval of the A/E, Owner, and the CxA. Approval for such will only be given upon acceptance of a detailed Temporary Operating and Conditioning Plan provided by the individually involved subcontractors and compiled by the Construction Manager. The Temporary Operating and Conditioning Plan shall consider/address the following at a minimum:
   1. Contractor shall address how equipment will be maintained in good, clean condition. Specifically address:
      a. Temporary Filtering of Air: Air filters used for construction shall be as or more effective than those specified for permanent use. Contractor shall remove construction filters and replace with new filters prior to FPT. Filters shall be maintained and replaced at the specified final pressure drop. Contractor shall install a magnehelic gauge for visual indication of pressure drop as well as setting and adjusting the loaded filter DP switch for monitoring on the BAS.
      b. Temporary Filtering of Water and Condensate: Construction strainers shall be used while circulating fluid during construction. Construction strainer shall be finer than that specified for final strainers.
      c. Sealing/Filtering of Open Ducts: Address that all open ducts shall be either sealed or protected with filter media. Return or exhaust systems shall not be used during construction unless otherwise approved.
      d. Lubrication and Maintenance: Contractor shall maintain the systems and equipment in accordance with the manufacturer¢s instructions. Contractor shall coordinate lubricants used with Owner's operators. Frequency of lubrication and inspection shall be as recommended by manufacturer¢s literature. Applicable maintenance lubrication schedules shall be included in the Plan. Draft maintenance logs shall be submitted with Plan and completed as maintenance is performed.
      e. Operation Outside of Normal Ranges: Systems and equipment shall not be operated outside the range of specified conditions. The Temporary Conditioning Plan shall address how the Contractor will ensure that operation will not harm the equipment.

2. Emergency Condition Identification and Response Protocols: The Temporary Conditioning Plan shall address protocols for responding to equipment malfunctions and or harmful operation. Automatic safeties and remote enunciation shall be in place to protect people and property. Temporary operation shall not be allowed until there is an automatic communication/enunciation medium such as a phone connection or an Internet connection. At a minimum, an alarm on the equipment used for temporary service shall be automatically sent to the Contractor¢s 24 hour monitoring service and to the Owner's help desk. The Contractor shall respond to and be responsible for securing conditions within the building.
3. Building Protection: Address how the system will be controlled to avoid humidity conditions that could either promote mold growth or cause corrosion.
4. Equipment Reconditioning: Address with specific means and methods how the equipment used for temporary conditioning will be reconditioned to like-new condition. Belts, seals, bearings, couplings, or other parts that wear more than 3% of their expected life shall be replaced.
5. Cleaning: Address how ducts, pipes, coils, converters, air handling equipment, terminal units, etc. shall be cleaned prior to Turn-Over.
6. Operations Log: Contractor responsible for operating the equipment shall maintain a log of all activities associated with operating and maintaining equipment. Log shall be submitted to Owner on a frequency specified by the Owner.
7. Operating System Alterations: The Temporary Conditioning Plan shall address specific protocol for doing work on the systems.
8. Damages: Any material, device, component, or equipment that is assessed as damaged or as having a substantially shortened life as a result of temporary conditioning operation shall be replaced by the Contractor at no cost to the Owner or to the project.
9. Segregation: Where only portions of a system are to be used, Contractor shall specifically indicate how the used portion will be isolated from the unused portion. The Temporary Conditioning Plan shall address how to ensure that the reduced operation condition will be maintained within acceptable ranges, and/or how capacity will be throttled to keep all operating parameters in recommended ranges.

1.7 QUALITY ASSURANCE

A. BAS Testing Technician Qualifications: Technicians performing BAS Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations are to have the following minimum qualifications:
   1. Journey level or equivalent skill level with knowledge of BAS, HVAC, electrical concepts, and building operations.
   2. Minimum **three years'** experience installing, servicing, and operating systems manufactured by approved manufacturer.
   3. International Society of Automation (ISA)-Certified Control Systems Technician (CCST) Level I.

B. HVAC Testing Technician Qualifications: Technicians to perform HVAC Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
   1. Journey level or equivalent skill level; vocational school four-year-program graduate or an Associate's degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC equipment, assemblies, and systems.
   2. Minimum **three years'** experience that is to include installing, servicing, and operating systems manufactured by approved manufacturer.

C. Testing Equipment and Instrumentation Quality and Calibration:
   1. Capable of testing and measuring performance within the specified acceptance criteria.
   2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
   3. Be maintained in good repair and operating condition throughout duration of use on Project.
   4. Be recalibrated/repaired if dropped or damaged in any way since last calibrated.

D. Proprietary Test Instrumentation and Tools:
   1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
      a. Be calibrated by manufacturer with current calibration tags permanently affixed.

b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.

2. HVAC proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS:

A. Perform Cx process in accordance with Section 019113 "General Commissioning Requirements" for **HVAC** and in accordance with the following:
1. **ASHRAE 202**.

3.2 CONSTRUCTION CHECKLISTS

A. Preliminary detailed construction checklists are to be prepared under Section 019113 "General Commissioning Requirements" for each **HVAC** system, assembly, subsystem, equipment, and component required to be commissioned, as detailed in ASHRAE 202. Contractor performs the following:
1. Review **HVAC** preliminary construction checklists and provide written comments on checklist items where appropriate.
2. Return preliminary Construction Checklist with review comments within **10** days of receipt.
3. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."
4. Use only construction checklists marked "Approved for Use, (date)" When performing tests. Mark construction checklists in the appropriate place as indicated Project events are completed, and provide pertinent details and other information.

B. Prepare preliminary detailed construction checklists for each **HVAC** system, assembly, subsystem, equipment, and component required to be commissioned, as detailed in **ASHRAE 202**.
1. Submit preliminary construction checklists to CxA and Designer for review.
2. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."
3. Use only construction checklists, marked "Approved for Use, (date)" when performing tests. Mark construction checklists in the appropriate place, as indicated Project events are completed and provide pertinent details and other information.

C. Systems required to be commissioned under IgCC:
1. Heating, ventilating, air-conditioning, and refrigeration systems (mechanical and/or passive) and associated controls.
2. Air-curtain systems.
3. Water-pumping and -mixing systems over 5 hp **(**4 kW**)** and purification systems.
4. Renewable energy systems and energy storage systems.
5. Energy and building management and demand-control systems.

D. Additional systems required to be commissioned:
1. Energy supply systems, including the following:
a. Fuel gas supply.
b. Central-plant hot-water supply.
2. Heat generation systems, including the following:
a. Boilers.
b. Auxiliary equipment.
3. Air-handling systems, including the following:
a. Supply, return, and exhaust air fans, motors, and drives.
b. Automatic and gravity dampers.
c. Heating and cooling devices.
d. Hangers and supports.
4. Air duct systems, including the following:
a. Duct systems.
b. Air-duct accessories, including volume dampers, fire and smoke dampers, turning vanes, sound attenuators, and flexible connectors.
c. Duct-mounted access doors and panels.
d. Hangers and supports.
5. Vibration isolation systems.

6. Controls and instrumentation, including the following:
   a. Controllers and sensors.
   b. Automatic control valves, dampers, and actuators.
   c. Control interface with fans, pumps, dampers, and other equipment and systems.
7. TAB Verification:
   a. Airflow.
   b. Water flow.
   c. Space pressurization.
8. Documentation:
   a. Mechanical systems manuals.
   b. Documentation of required commissioning.
9. Mechanical insulation, including the following:
   a. Duct and plenum insulation.
   b. HVAC piping insulation.

3.3 Cx TESTING PREPARATION

A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.

B. Certify that HVAC instrumentation and control systems have been completed and calibrated, point-to-point checkout has been successfully completed, and systems are operating in accordance with their design sequence of operation, Contract Documents, and approved submittals. Certify that all sensors are operating within specified accuracy and all systems are set to and maintaining set points as required by the design documents.

C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.4 Cx TEST CONDITIONS

A. Perform tests using design conditions, whenever possible.
   1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
   2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
   3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

B. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.

C. If seasonal testing is specified, complete appropriate initial performance tests and documentation, and schedule seasonal tests.

3.5 Cx TESTS COMMON TO HVAC SYSTEMS

A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.

B. Test systems, assemblies, subsystems, equipment, and components for operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response in accordance with acceptance criteria.

C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.

D. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance test requirements specified in Division 23 Sections specifying HVAC systems and equipment.

E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
   1. Cx Construction Checklist verification tests.

2. Cx Construction Checklist verification test demonstrations.

3.6 CONSTRUCTION CHECKLIST EXAMPLES

A. Vibration Isolation in HVAC Systems:
1. Prerequisites: Acceptance of results of construction checklists for vibration control devices specified in Section 230548.13 "Vibration Controls for HVAC Piping and Equipment".
2. Components to Be Tested:
   a. Vibration isolation control devices in HVAC systems.
   b. Support systems.
3. Test Purpose: Evaluate effectiveness of vibration isolation control devices.
4. Test Conditions, Constant Speed Equipment: Measure vibration of the facility structure at **three** locations designated by Owner's witness while the isolated equipment operates.
5. Test Conditions, Variable Speed Equipment: Measure vibration of the facility structure at **three** locations designated by Owner's witness at the following operating conditions:
   a. Maximum speed.
   b. Minimum speed.
   c. Critical speed.
6. Acceptance Criteria: Structure-borne vibration not to exceed specified performance.

3.7 TAB VERIFICATION

A. Prerequisites: Completion of "Examination" Article requirements and correction of deficiencies, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

B. Completion of "Preparation" Article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

C. Scope: HVAC air systems and hydronic piping systems.

D. Purpose: Differential flow relationships intended to maintain air and water pressurization differentials between the various areas of Project.

E. Conditions of the Test:
1. Cx Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
2. Systems operating in full heating mode **with minimum outside-air volume**.
3. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.

F. Acceptance Criteria:
1. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
2. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than the tolerances allowed.
3. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.8 HEATING CONTROL SYSTEM Cx TESTS

A. Test all sequences of operation as shown on the controls drawings.

3.9 CHILLER SYSTEM Cx TESTS

A. Test all sequences of operation as shown on the controls drawings.

3.10 TERMINAL UNIT EQUIPMENT Cx TESTS

A. Test all sequences of operation as shown on the controls drawings.

3.11 AIR-HANDLING SYSTEM Cx TESTS

A. Test all sequences of operation as shown on the controls drawings.

3.12 BUILDING AUTOMATION SYSTEM (BAS) COMMISSIONING

A. WORK INCLUDED
1. BAS Start-Up and Functional Performance Testing.
2. Validation of proper and thorough installation of BAS and associated equipment.
3. Generic Start-Up Documentation for BAS.

4. Development of final Start-Up Documentation for BAS.
5. Functional Performance Testing of BAS.
6. Coordination of BAS-related training.
7. Documentation of BAS Operation and Maintenance Documentation.

B. GENERAL DESCRIPTION
1. This section defines responsibilities of the Building Automation System Contractor to commission the BAS.
2. Commissioning (Cx) is the process of ensuring that (i) all building systems are installed and perform interactively according to the design intent; (ii) that systems are efficient and cost effective and meet the Owner's operational needs; (iii) that the installation is accurately documented; and (iv) that the Operators are adequately trained. Commissioning serves as a tool to minimize post-occupancy operational problems, and establishes testing and communication protocols to advance the building systems from installation to optimized, fully-dynamic operation.
3. Commissioning Authority (CxA) shall work with the Contractor and the design engineers to direct and oversee the Cx process and perform Functional Performance Testing.
4. The Commissioning Plan outlines the Cx process beyond the Construction Contract, including design phase activities and design team/owner responsibilities. The specification Sections dictate all requirements of the commissioning process relative to the construction contract. The Cx Plan is not part of the construction contract, although it is available for reference at the request of the Contractor.

C. SCOPE
1. The scope of Commissioning on this project shall include the entire BAS system.

D. DEFINITIONS AND ABBREVIATIONS
1. Refer to Section 019113 for a complete list of Definitions and Abbreviations.
2. POT (Portable Operators Terminal): Portable operator workstation (typically a laptop computer) that has BAS software loaded and the capability to access, program, and edit the BAS.
3. HHD (Hand-Held Device): Portable device (typically with limited functionality) that is used to access components of the BAS. May be a standard PDA or proprietary device/interface.

E. CONTRACTOR RESPONSIBILITIES
1. General responsibilities of the BAS Contractor (BAC) are specified in Section 019113. The following indicate additional specific responsibilities of the BAS Contractor.
2. Assist CxA in verification and Functional Performance Testing. Assistance will typically include the following:
    a. Establish trend logs of system operation as specified herein.
    b. Manipulate systems and equipment to facilitate Functional Performance Testing. Typically, this will only be for initial samples of like systems.
    c. Provide POTs or operator workstations in locations convenient to testing activities as specified below.
    d. Provide CxA with appropriate passwords, keys, and access to control panels and workstations.
    e. Where control systems do not allow a test mode or the overriding of physical input values for testing, program an interim virtual point for all inputs that can be used to represent the point and be overridden for testing.
3. Provide a control technician to work at the direction of the CxA for software optimization assistance for a minimum of 40 hours during the Acceptance Phase of the project.
4. Controls Parameter Matrix: Contractor shall provide a form summarizing all setpoints and alarm parameters and alarming strategies for the Owner to complete. Organize a meeting to discuss the desired initial setpoints and alarm parameters. Contractor shall enter the requested setpoints and alarm parameters at completion of start-up and record the applicable settings in the Start-Up Documentation.
5. Final Systems Operation Training: The BAC shall train the Owner and Operators on whole-building operation and use of the BAS. This training shall focus primarily on BAS control of building systems and operation and its impact on building performance, and shall be conducted after Functional Completion. Additional information is provided in Section 019113.

F. INSTRUMENTATION
1. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:
    a. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of +/- 0.1°F.

b. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
c. All equipment shall be calibrated according to the manufacturer¢s recommended intervals. Calibration tags shall be affixed or certificates readily available.

2. Standard Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems related to functional testing shall be provided by CxA.
3. Special Tools: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.

G. TAB & COMMISSIONING Portable operators terminal
1. Provide the CxA with all software, connection devices, licenses, passwords, etc. to facilitate connection to the BAS throughout the building. Provide a license to graphic software, and all operating software necessary for testing and configuration of all control elements at all levels. License may be a temporary license that will expire after the completion of the Warranty Period. Options include:
a. A laptop computer provided by BAS Contractor for dedicated use by the CxA throughout the Construction and Acceptance Phases. This would be turned over to the Owner at the end of the Acceptance Phase.
b. Browser access to the full graphic software: CxA will provide laptop, however BAS Contractor shall set up the laptop to successfully connect.
c. Licensed client software to be installed on CxA computer: BAS Contractor shall install the software and ensure it is functional.
d. Terminal Services session access to a graphic server with required CALs to allow use of all required software. BAS Contractor shall configure the CxA computer to connect to the terminal session.
2. Access to the BAS must be provided throughout the building as more fully defined as follows:
a. Full wireless connection to the graphic server throughout the building will be adequate.
b. Network connection for full access to the graphic server within 50¢ of any point in the building.
c. Exception to 1 and 2 above: An acceptable alternative to full building access to the graphic server relating to terminal controls shall be providing to the CxA the devices and software required to connect to local terminal controllers through a connection port in the space such as connection to a jack on the temperature sensor (basically what is required by TAB specified below). This does not apply to mechanical rooms as full graphic access is required in mechanical rooms.
3. Provide software required by TAB to calibrate all flow sensors. TAB will provide computer to be used as a portable operator¢s terminal. Any manufacturer specific hardware such as connection cables, converters, hand held devices, etc. shall be provided by the BAS Contractor.
4. Connections shall be provided local to the device being calibrated. For instance, for VAV boxes, connection of the operator¢s terminal shall be either at the sensor as well as at the box. Otherwise a wireless system shall be provided to facilitate this local functionality.

H. BAS Start-Up TESTING, ADJUSTING, CALIBRATION
1. BAS work and/or systems shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems under this contract, as described below:
a. Inspect the installation of all devices. Review the manufacturer¢s installation instructions and validate that the device is installed in accordance with them.
b. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
c. Verify integrity/safety of all electrical connections.
d. Coordinate with TAB Contractor to obtain and with CxA to fine tune control settings that are determined from balancing procedures. Record the following control settings as obtained from TAB Contractor, and note any TAB deficiencies in the BAS Start-Up Documentation:
1) Optimum duct static pressure setpoints for VAV air handling units.
2) Minimum outside air damper settings for air handling units.
3) Optimum differential pressure setpoints for variable speed pumping systems.

4) Calibration parameters for flow control devices such as VAV boxes and flow measuring stations. BAS Contractor shall provide hand held device as a minimum to the TAB and CxA to facilitate calibration. Connection for any given device shall be local to the device (i.e., at the VAV box or at the thermostat). HHD or POT shall allow querying and editing of parameters required for proper calibration and Start-Up.
5) Calibration parameters for fume hoods.

e. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BAS display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the BAS Start-Up Documentation.
f. Check and set zero and span adjustments for all transducers and transmitters.
g. For dampers and valves:
1) Check for adequate installation including free travel throughout range and adequate seal.
2) Where control loops are sequenced, check for proper control without overlap
h. For actuators:
1) Check to insure that device seals tightly when the appropriate signal is applied to the operator.
2) Check for appropriate fail position, and that the stroke and range is as required and coordinated with the programmed ranges when it is operating under normal conditions.
3) For pneumatic operators, adjust the operator spring compression as required to achieve close off. If positioner or volume booster is installed on the operator, calibrate per manufacturer¢s procedure to achieve spring range indicated. Check split range positioners to verify proper operation. Record settings for each device.
4) Check the stroke and range under actual loading conditions and validate that they correlate with programmed values.
5) For sequenced electronic actuators, calibrate per manufacturer¢s instructions to required ranges.
i. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device.
j. For outputs to reset other manufacturers devices (such as VSDs) and feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.
k. Verify proper sequences by using the approved Start-Up Documentation to record results. Verify proper sequence and operation of all specified functions.
l. Verify that all safety devices trip at appropriate conditions. Adjust setpoints accordingly.
m. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BAS Start-Up Documentation. Except from a start-up, maximum allowable variance from setpoint for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any step-change (for which the system has the capability to respond) in the control loop, the following tolerances shall be maintained (exceptions noted):
1) Duct air temperature: ±1 deg F
2) Zone temperature: ±3°F within 3 minutes and control within ±2 deg F
3) Chilled water temperatures: ±1 deg F
4) Hot water temperatures: ±2 deg F
5) Duct air pressure: ± 0.25 i.w.g
6) Water pressure: ±1 psig
n. For communication interfaces and BAS control panels:
1) Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the record drawings.
2) Ensure that terminations are safe, secure and labeled in accordance with the record drawings.
3) Check power supplies for proper voltage ranges and loading.

4) Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
5) Check for adequate signal strength and acceptable bandwidth utilization on communication networks.
6) Check for stand-alone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
7) Ensure that all outputs and devices fail to their proper positions/states.
8) Ensure that buffered and/or volatile information is retained through power outage.
9) With all system and communications operating normally and all trends functioning, sample and record update/annunciation times for critical alarms fed from the panel to the Operator Interface.
10) Check for adequate grounding of all BAS panels and devices.
11) Run self diagnostic routines and ensure they are functional.
12) Check the memory allocation and loading to ensure adequate and excess capacity is available and that it will not affect control functionality.

o. Coordinate desired initial alarm strategies with Owner's Operators. Set all required alarms and document the initial settings in the Start-Up Documentation.
p. Coordinate all initial setpoints with Owner's Operators. Ensure those setpoints are active.
q. For Operator Interfaces:
1) Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
2) Output all specified BAS reports for review and approval.
3) Verify that the alarm printing and logging is functional and per requirements.
4) Verify that trend archiving to disk and provide a sample to the CxA for review.
5) Verify alarm enunciation functionality. Time delay from actual occurrence to the time updated or enunciated on the screen. Ensure it is per the specified requirements.
6) Verify that real time and historical trends are accessible and viewable in graph format.
7) Verify that paging/dial out alarm annunciation is functional.
8) Verify the functionality of remote OIs and that a robust connection can be established consistently.
9) Verify that required third party software applications required with the bid are installed and are functional.
10) Demonstrate open protocol and custom third party interfaces reliably communicate and check response time.
11) Verify response times and screen update and refresh times are per the requirements.
12) Verify that all custom programs are editable from the OI. Check upload, download, back up and restore capabilities of system configuration information as well as custom programs.
13) Verify schedules are set up and working.
14) Verify Owner stipulated security and permissions is set up and functional.
15) In concert with the Building Power Outage test, validate that critical GUI installations are properly powered by UPS and emergency outlets to keep it functional during a power outage. Validate that the space has adequate lighting to manage the building in the event of an outage.

r. Start-up and check out control air compressors and air drying and filtering systems in accordance with the appropriate section and with manufacturer¢s instructions.
1) Validate adequate drying and pressures.
2) Validate adequate redundancy
3) Validate max run time and cycle time vs manufacturer¢s recommendations
4) Validate that routing of the compressed air does not result in condensation at any point in the system when used with the specified drier.
5) Check all PRVs both primary and back up to ensure adequate functionality and maintenance of downstream pressure.

s. Verify proper interface with Fire Alarm System.
t. Verify proper interface with control panels of equipment with self-contained controls that are being monitored by the BAS.

2. Submit Start-Up Documentation. This shall be completed, submitted, and approved prior to demonstration and Acceptance Phase.

I. SENSOR CHECKOUT AND CALIBRATION

1. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading of each other for pressure. Tolerances for critical applications may be tighter.
2. Calibration: Calibrate all sensors using one of the following procedures:
   a. Sensors Without Transmitters--Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gage or BAS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20% of the expected range.
   b. Sensors With Transmitters--Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer¢s resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or BAS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.
3. Sensor Tolerance: Sensors shall be within the tolerances specified for the device. Refer to Section 230900.

J. LOOP TUNING

1. For all control loops, Contractor shall tune the loops to ensure the fastest stable response without hunting, offset or overshoot with tolerances defined above. Contractor shall introduce upsets to the load when possible to affect response. Otherwise, setpoints can be changed to affect the response.
2. Generally tune loops during periods of high gain.
3. Document all parameters either by capturing text, short interval trends, or screen shots of trend graph documenting the final response.

K. COIL VALVE LEAK CHECK

1. Verify proper close off of the valves. Ensure the valve seats properly by simulating the maximum anticipated pressure difference across the circuit. Calibrate air temperature sensors on each side of coil to be within 0.5°F of each other. Via the OI, command the valve to close. Energize fans. After 5 minutes, observe air temperature difference across coil. If a temperature difference is indicated, and the piping surface temperature entering the coil is within 3°F of the water supply temp, leakage is probably occurring. If it appears that it is occurring, close the isolation valves to the coil to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.

L. VALVE STROKE SETUP AND CHECK

1. For all valve and actuator positions checked, verify the actual position against the OI readout.
2. Set pumps to normal operating mode. Command valve closed, verify that valve is closed, and adjust output zero signal as required. Command valve open, verify position is full open and adjust output signal as required. Command valve to a few intermediate positions. If actual valve position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

M. GRAPHIC COORDINATION

1. The Contractor shall prepare all graphics (only one example graphic is required for typical systems like terminal units) with points embedded for review of CxA and Owner. Owner shall use these graphics to provide direction to Contractor for the required final graphic. All final graphics must be complete and active before functional testing. Any deviation from the approved graphics will be considered a failure from the perspective of the functional test.

N. BAS DEMONSTRATION

1. Demonstrate the operation of the BAS hardware, software, and all related components and systems to the satisfaction of the CxA and Owner. Schedule the demonstration with the Owner's representative 1 week in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved.
2. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the job site.
3. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner and CxA.
4. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:
    a. Demonstrate that required software is installed on BAS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
    b. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
    c. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.
    d. Demonstrate correct calibration of input/output devices using the same methods specified for the start-Up tests. A maximum of 10 percent of I/O points shall be selected at random by CxA and/or Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by CxA for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
    e. Demonstrate that all BAS and other software programs exist at respective field panels. The BAS programming and point database shall be as submitted and approved.
    f. Demonstrate that all BAS programs accomplish the specified sequences of operation.
    g. Demonstrate that the panels automatically recover from power failures, as specified.
    h. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
    i. Identify access to equipment selected by CxA. Demonstrate that access is sufficient to perform required maintenance.
    j. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.
5. BAS Demonstration shall be completed and approved prior to Functional Performance Testing. CxA shall determine if the system is ready for Functional Performance Testing and document any problems requiring Contractor attention.
    a. If the systems are not ready for Functional Performance Testing, Contractor shall correct problems and provide notification to the Owner¢s representative that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time for an additional one week period. This process shall be repeated until CxA issues notice that the BAS is ready for Functional Performance Testing.
6. Any tests successfully completed during the BAS Demonstration will be recorded as ÜPassed¢ for the Functional Performance Testing and will not have to be re-accomplished.

O. FUNCTIONAL PERFORMANCE TESTING
1. Requirements for assistance with Functional Performance Testing are specified in the Section 019113, Section 230800 and Section 260800. Provide assistance during Functional Performance Testing per the Section 019113 and related Specifications.

P. BAS ACCEPTANCE PHASE AND OBSERVATION PERIOD
1. BAS Acceptance Phase: BAS Acceptance Phase consists of the Functional Performance Testing process of the BAS by the CxA and shall begin after approval of the BAS Demonstration and prior to issuance of Substantial Completion. Acceptance Phase for the BAS shall not be scheduled until all HVAC systems are in operation, the Start-Up Documentation has been reviewed, all required cleaning and lubrication has been completed (i.e., filters changed, piping flushed, strainers cleaned, etc.), and TAB report has been submitted and approved. Acceptance Phase and its approval to begin will be performed on a system-by-system basis if mutually agreed upon by Contractor and Owner.

2. BAS Observation Period: After Functional Performance Testing , the BAS shall be shown to operate properly for 2 weeks without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. At the end of the two weeks, BAS Contractor shall forward the trend logs to the CxA for review.
3. During the Acceptance Phase, the Contractor shall maintain a hard copy log of all alarms generated by the BAS. For each alarm received, Contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the Contractor¢s opinion, the cause of the alarm is not the responsibility of the Contractor, Contractor shall immediately notify the Owner's representative.
4. During the Acceptance Phase, the Contractor shall maintain all controller network and workstation hardware and software in a state that will allow remote access by CxA to trend logs as specified below.

Q. BAS TREND REQUIREMENTS
1. The BAS Contractor shall configure and analyze all trends required under this Section.
2. Trends are historical archives on computer disks that document the operation of the systems and equipment. Trends can be time-series (interval) recordings of system I/O parameters or change-of-value (COV) based trends that record when a system value changes by more than a specified threshold.
3. CxA will analyze trend logs of the system operating parameters to evaluate normal system functionality. The requirements of the trending are specified below. Contractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the CxA.
4. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field. Recorded parameters for a given piece of equipment or component shall be trended at the same time intervals and be presented in a maximum of two separate two dimensional formats with time being the vertical axis and field name being the horizontal axis.. Data shall be forwarded in one of the following formats.
   a. Microsoft Access Database (.mdb)
   b. Microsoft Excel Spreadsheet (.xls)
   c. Comma Separated Value (.csv or .txt), preferably with quotes delimiting text fields and # delimiting date/time fields.
5. Sample times indicated as COV (±) mean that the changed parameter only needs to be recorded whenever the value changes by the amount listed. When output to the trend file, the latest recorded value shall be listed along with the time increment record. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the time interval common to other point trends for the system.
6. Contractor shall provide the CxA with required passwords, phone numbers, etc. to allow the CxA access to the trend log data and allow downloading to a remote location. Contractor shall also provide step-by-step written instructions for accessing the data.
7. Trending Requirements: All I/O points on primary equipment shall be trended throughout the Cx process on 10 min. intervals for analog values and change-of-value for binary values. Trends shall include but are not necessarily limited to the following points:
   a. Outside air temperature
   b. Outside air relative humidity
   c. Outside air enthalpy
   d. Cooling tons
   e. All sensed hydronic temperatures
   f. All sensed air temperatures and relative humidity measurements on primary equipment
   g. All damper outputs on primary equipment
   h. All valve outputs on primary equipment
   i. All sensed fan volumes (flow) on primary equipment
   j. All inputs and outputs to Variable Speed Drives
   k. Return (or exhaust) air temperature on each air handler
   l. All safety indications
   m. Status on all primary equipment
   n. All air and water pressures on primary equipment or systems
   o. Zone temperatures
   p. Steam flow
   q. Electricity consumption where monitored.
   r. Natural gas flows
   s. Converter steam valves and hot water temperatures

t. Steam supply pressures and temperatures.
u. All points on primary equipment and selected sampling of terminal points unless approved otherwise.

R. TREND GRAPHS
1. Trend graphs shall be used during Functional Performance Testing to facilitate and document testing. Contractor shall prepare controller and workstation software to display graphical format trends throughout the Acceptance Phase. Trend graphs shall demonstrate compliance with contract documents. Trended values and intervals shall be the same as those specified for the Functional Performance Tests.
2. Lines shall be labeled and shall be distinguishable from each other by using either different line types or different line colors.
3. Indicate engineering units of the y-axis values; e.g. degrees F., inches w.c., Btu/lb, percent wide open, etc.
4. The y-axis scale shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.
5. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended.
6. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended simultaneously and on a common trend period.
7. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.
8. The format of all trend graphs must be provided as approved by the CxA.

S. WARRANTY PHASE - OPPOSITE SEASON TRENDING AND TESTING
1. Trending: Throughout the Warranty Phase, trend logs shall be maintained as required for the Acceptance Phase. BAS Contractor shall forward archived trend logs to the CxA for review upon CxA request. CxA will review these and notify BAS Contractor of any warranty work required.
2. Opposite Season Testing: Within 6 months of completion of the Acceptance Phase, CxA shall schedule and conduct Opposite Season Functional Performance Testing. The BAS Contractor shall support this testing and remedy any deficiencies identified.

T. SOFTWARE OPTIMIZATION ASSISTANCE
1. The Contractor shall provide the services of a BAS technician as specified above at the project site to be at the disposal of the CxA. The purpose of this requirement is to make changes, enhancements and additions to control unit and/or workstation software that have been identified by the CxA during the construction and commissioning of the project and that are beyond the specified Contract requirements. The cost for this service shall be included with the bid. Requests for assistance shall be for contiguous or non-contiguous 8-hour days, unless otherwise mutually agreed upon by Contractor, CxA, and Owner. The Owner's representative shall notify Contractor 2 days in advance of each day of requested assistance.
2. The BAS technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the BAS technician provided cannot perform every software task requested by the CxA in a timely fashion, Contractor shall provide additional qualified personnel at the project site as requested by the CxA to meet the total specified requirement on-site.

U. BAS OPERATOR TRAINING
1. Provide up to 6 complete sets of User Manuals (hard copy and one electronic copy) to be used for training.
2. BAS Contractor shall submit a Training Plan per the requirements of Div 01 to the CM who will forward it to the A/E and CxA for review.
3. On Site Training: Provide services of BAS Contractor's qualified technical personnel to instruct Owners personnel in operation and maintenance of the BAS. Instruction shall be in classroom setting at the project site for appropriate portions of the training. Training may be in non-contiguous days at the request of the Owner. The Owner's representative shall notify Contractor 1-week in advance of each day of requested training. The Contractor's designated training personnel shall meet with the A/E, CxA and Owner¢s representative for the purpose of discussing and fine-tuning the training agenda prior to the first training session. Training agenda shall be as follows:
a. Basic Operator Workstation Training:
1) Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of controller portable and built-in operator interface device display capabilities.

2) Brief overview of the various parts of the BAS O&M manuals, including hardware and software programming and operating publications, catalog data, controls installation drawings, and BAS programming documentation.
3) Demonstration of workstation login/logout procedures, password setup, and exception reporting.
4) Demonstration of workstation menu penetration and broad overview of the various workstation features.
5) Overview of systems installed.
6) Present all site-specific naming conventions and points lists, open protocol information, configuration databases, back up sequences, upload/download procedures etc.
7) Overview of scheduling procedures.
8) Overview of alarm features, including how to acknowledge, respond to, and archive alarms, and how to access further information from them.
9) Overview of trend features, including how to set up and view trends.
10) Overview of workstation reporting features and introductory level report generation and scheduling.

b. BAS Technician Training:
1) General review of sequence of operation and control logic for the project site, including standalone and fail safe modes of operation
2) Uploading/downloading and backing up controller configuration and application programs
3) Review of installed components including all communication devices, controllers, I/O, etc., and how to install/replace, maintain, commission, and diagnose them
4) Introduction to controller programming and overview of the programming application interface
5) Defining trends, generating graphs in real time; archiving trends, accessing historical archive and generating reports from them
6) Introductory network administration
7) Introduction to creating and editing graphics
8) Review of setpoint optimization and fine-tuning concepts
9) OI use and maintenance
10) Web page creation as applicable

c. System Administrator Training:
1) Overview of system architecture including all routers, bridges, repeaters, gateways, communications protocols, servers, controllers etc.
2) Overview of and recommendations for backing up and restoring the system configuration database
3) Server maintenance
4) Security Management: Assigning passwords and rights for various users on the server, workstations and GUI software

d. Final Systems Operation Training
1) The BAS Contractor shall conduct Final Systems Operation Training in accordance with Section 019113.
2) Final Systems Operation Training provides the Owner and Operators a training session on whole-building operation. It shall focus primarily on BAS control of building systems and operation and its impact on building performance. System interactions shall be presented and discussed (such as a combined air handler, chiller, boiler, and terminal unit system), along with a detailed presentation of the sequences of operation and their relationship to the BAS. This training shall be conducted by the BAC with assistance from the CxA, and shall be attended by the Owner, Operators, Contractor, Design Team, and by any other Cx Team members deemed necessary by the CxA or the Owner.
3) The Record BAS Shop Drawings shall be provided as a handout for the training.
4) Scheduling, attendees, and training methods shall be as specified in Section 019113.

END OF SECTION

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment, including but not limited to HVAC systems and components, control components for equipment not supplied with factory-wired controls

B. Direct-Digital Control (DDC) system description
   1. The Controls Contractor shall supply and install a complete Direct Digital Control (DDC) Building Automation System (BAS) as an extension of the existing BAS. as required to accomplish the Sequences of Control for heating, ventilating, air-conditioning and other building-level equipment and systems as described herein. The system shall be fully compatible with the existing Automated Logic system. Provide all necessary upgrades to the existing system to accomodate the new equipment.

C. Furnish all labor, materials, equipment and service necessary for a complete and operational DDC BAS pursuant with this specification and as shown on the associated contract drawings.

D. The system shall be fully compatible with the existing Automated Logic system. Provide all necessary upgrades to the existing system to accomodate the integration of the new equipment.

E. Provide all labor, material, equipment and service not specifically referred to in this specification or on associated drawings that are required to fulfill the functional intent of this specification at no additional cost to the Owner.

1.2 DEFINITIONS

A. B-AAC: Advanced Application Controllers

B. B-ASC: Application Specific Controllers

C. ATC: Automatic Temperature Control

D. BAS: Building Automation System

E. B-AWS: Advanced Workstation Software

F. B-OWS: Operator Workstation Software

G. B-BBC: Building Controllers

H. BLCN: Building Level Communication Network

I. BTN: BACnet Testing Laboratories

J. DDC: Direct digital control.

K. HLC: Heavy load conditions.

L. I/O: Input/output.

M. MS/TP: Master slave/token passing.

N. PC: Personal computer.

O. PID: Proportional plus integral plus derivative.

P. RTD: Resistance temperature detector.

1.3 DDC SYSTEM REQUIREMENTS

A. DDC Systems installed under this specification shall strictly adhere to the following characteristics:
   1. Building Automation System (BAS) Direct Digital Controls (DDC) shall consist of native BACnet, microprocessor-based, peer-to-peer, networked, distributed devices utilizing the BACnet communication protocol in an open, interoperable system. The BAS also includes operator interface devices, programming and configuration software applications, DDC input/output devices, non-DDC automatic temperature controls, enclosures and interconnecting conduit and wire.
      a. The BACnet operating stack must be embedded directly in every Device at the board level, and in all operator interface software packages.
      b. No Gateways, Communication Bridges, Protocol Translators or any other device that translates any proprietary or other communication protocol to the BACnet communication protocol shall be permitted as a part of the BAS installation pursuant with this specification section. Gateways may only be used as required for communication to existing systems or systems installed pursuant with other specification sections.

c. DDC controllers that are not BACnet compliant shall not be acceptable under this specification and are strictly prohibited.

2. The BAS shall be modular in nature and comprised of a network of stand-alone DDC devices. The System shall be designed and implemented in such a way that it may be expanded in both capacity and functionality through the addition of DDC Devices, sensors, actuators, etc.
3. All BAS controllers shall be tested, certified, clearly stamped and listed by the BACnet Testing Laboratories (BTL).
4. Program database, data acquisition, and all control sequence logic shall reside in each DDC Device. The Building Level Communication Network (BLCN) shall not be dependent upon connection to a Server or Master Controller for performance of the Sequence of Control as outlined in this specification. Each individual Device shall, to the greatest possible extent, perform its programmed sequence without reliance on the BLCN.
5. All BAS DDC Devices at all levels shall be fully custom-programmable in the field using the standard Operators Workstation Software. No configurable, canned program application specific controllers will be permitted.
6. All BAS DDC Devices shall be capable of updating firmware using software via internet without replacing any hardware, microprocessors or chips.
7. The BAS shall be capable of sending system alarms and Event Notifications to pagers, and email services.
8. Actuation of control devices shall be electronic. Spring return fail-safe actuation shall be provided when loss of property and/or property damage is possible and where specified.
9. DDC Automatic Temperature Control (ATC) System shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started; along with the time delay between starts shall be user-selectable.
10. All binary output points shall be protected from short cycling via output configuration and/or programming. This feature shall allow minimum on time and off-time to be configurable.
11. The DDC System Manufacturer product line selected shall be the most current and complete offering from the manufacturer and shall currently be actively manufactured and supported at the time that this project is bid.
12. This project shall not be used as a test site. First release and test version hardware, software and firmware shall not be implemented on this project under any circumstances.
13. DDC System devices and spare components or equivalent shall be readily available for a minimum of five (5) years after the completion and final acceptance of this project.

1.4 BASIC SYSTEM ARCHITECTURE

A. The DDC BAS as provided and installed under this specification shall be a complete system from a single manufacturer designed for use on intranets and the internet.

B. The primary BAS components shall include but not be limited to:
1. BACnet Advanced Operator Workstation Software (B-AWS)
2. Remote BACnet Advanced Operator Workstation Software (Remote B-AWS)
3. Portable Operator Workstation Software (Portable B-OWS)
4. Building Controllers (B-BC)
5. Advanced Application Controllers (B-AAC)
6. Application Specific Controllers (B-ASC)

C. Enterprise Level Communication Network (ELCN) shall consist of high-speed BACnet/IP Local Area Network (LAN) to host Advanced Operators Workstations (B-AWS), Building Controllers (B-BC), Building Level Communication Networks (BLCN) and Web-Enabled remote connectivity.

D. Building Level Communication Network (BLCN) shall consist of a BACnet internetwork to host field level DDC Controllers.

E. B-BCs shall automatically route BACnet communications to all configured available BACnet networks.

F. B-AWS shall be fully IT-compatible devices that communicate directly on a TCP/IP Local Area Network (LAN).
1. LAN shall be 10/100Mbps TCP/IP with the following minimum requirements:
a. Cable: 10 base-T, UTP-8 wire, category 5e or greater
b. Minimum throughput: 10Mbps with the ability to increase to 100Mbps
2. Enterprise Level Communication Network (ELCN) shall provide communication between BBCs, B-OWS, remote B-OWS and Web Server using a B/IP LAN backbone.
3. B-BCs shall connect directly to the LAN and communicate using B/IP without a TCP/IP Gateway or network server.

4. Coordinate implementation of the BAS on the Owner¢s LAN without disruption.

G. BAS Manufacturer must natively support the following BACnet data links as defined in the ANSI/ASHRAE Standard 135-2008, BACnet:
1. Point-to-Point (PTP)
2. Master Slave/Token Passing (MS/TP)
3. Ethernet (ISO 8802-3)
4. BACnet IP (B/IP)

H. Special Network Architecture Requirements:
1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to the controller that is controlling air-handling-system air-handling unit(s). Basically, create a DDC system LAN that aligns with the air-handling system being controlled.

I. Field sensors and control devices shall connect to peer-to-peer, fully programmable B-BC, B-AAC & B-ASC as required to achieve the point monitoring and Sequence of Control as specified herein. All devices are to be monitored by a B-AWS. Final control devices are to be electronic.

J. Each Mechanical System and/or major piece of Mechanical Equipment shall have one (1) dedicated B-BC controller with sufficient I/O capacity such that it shall be connected to ALL field devices and sensors associated with that system and/or piece of equipment. Distributed control of one (1) single piece of major mechanical equipment shall not be performed by multiple controllers.

K. All BAS controllers, sensors and devices shall be UL listed.
1. All BAS controllers and interface devices must be UL 916 Listed.

1.5 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
1. DDC System Speed:
a. Response Time of Connected I/O:
1) Update AI point values connected to DDC system every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
2) Update BI point values connected to DDC system every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
3) AO points connected to DDC system to begin to respond to controller output commands within two seconds. Global commands to also comply with this requirement.
4) BO point values connected to DDC system to respond to controller output commands within two seconds. Global commands to also comply with this requirement.
b. Display of Connected I/O:
1) Update and display analog point COV connected to DDC system every ten seconds for use by operator.
2) Update and display binary point COV connected to DDC system every ten seconds for use by operator.
3) Update graphic display refresh within 8 seconds.
4) Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.
2. Network Bandwidth: Design each network of DDC system to include spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions. Minimum spare bandwidth as follows:
a. ELCN Networks: 30 percent.
b. BLCN Networks: 30 percent.
3. DDC System Data Storage:
a. Include capability to archive not less than 48 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends, and other information indicated.
b. Local Storage:
1) Provide server with data storage indicated. Server(s) to use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

4. DDC Data Access:
   a. When logged into the system, operator able to also interact with any DDC controllers connected to DDC system as required for functional operation of DDC system.
   b. Use for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
5. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
6. B-BC, B-AAC, & B-ASC shall be able to execute control loops at a selectable frequency at least 1 time every second. The controller shall scan and update the process value and output generated by this calculation at this same frequency at a minimum.
7. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
8. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
9. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
10. 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 **(**0.5 deg C**)**.
    b. Water Flow: Plus or minus 5 percent of full scale.
    c. Water Pressure: Plus or minus 2 percent of full scale.
    d. Space Temperature: Plus or minus 1 deg F **(**0.5 deg C**)**.
    e. Ducted Air Temperature: Plus or minus 1 deg F **(**0.5 deg C**)**.
    f. Outside Air Temperature: Plus or minus 2 deg F **(**1.0 deg C**)**.
    g. Dew Point Temperature: Plus or minus 3 deg F **(**1.5 deg C**)**.
    h. Temperature Differential: Plus or minus 0.25 deg F **(**0.15 deg C**)**.
    i. Relative Humidity: Plus or minus 5 percent.
    j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
    k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
    l. Airflow (Terminal): Plus or minus 10 percent of full scale.
    m. Air Pressure (Space): Plus or minus 0.01-inch wg **(**2.5 Pa**)**.
    n. Air Pressure (Ducts): Plus or minus 0.1-inch wg **(**25 Pa**)**.
    o. Carbon Monoxide: Plus or minus 5 percent of reading.
    p. Carbon Dioxide: Plus or minus 50 ppm.
    q. Nitrogen Dioxide: Plus or minus 50 ppm.
    r. Electrical: Plus or minus 5 percent of reading.
11. Overall combined system repeatability of sensors, controllers and readout devices for a particular application shall be plus or minus 2% of full scale of the operating range. Repeatability of overall combined system of sensor, controller and readout device in a control loop application will be plus or minus 5% of full scale of the operating range.
12. Long-term electronic drift shall not exceed 0.4% per year.
13. All components provided as part of this system shall operate under ambient environmental conditions of 20F to 104F dry bulb and 10% to 90% relative humidity, noncondensing as a minimum. Sensors and control elements shall operate under the ambient environmental temperature, pressure, humidity, and vibration conditions encountered for the installed location. B-OWS equipment (hardware only), such as CRTs and printers, shall, unless designated otherwise, operate properly under ambient environmental conditions of 45F to 90F and a relative humidity of 10% to 90%.
14. Networked components of the system shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%.

1.6 SEQUENCE OF OPERATIONS

A. See the contract drawings for system sequence of operations for each system to be controlled.

1.7 ACTION SUBMITTALS

A. Submit in writing and so delineated at the beginning of each submittal, known substitutions and deviations from requirements of Contract Documents. Deviation from Contract Documents must be approved by the Engineer of record prior to submittal.

B. Sequence of Operations, Controls Diagram, BAS architecture, Bill of Materials, Controls Matrix and Points lists shall be a SEPARATE submittal (under separate cover) from all equipment product data associated with the controls system.

C. Complete BAS Engineering Design Submittal & Drawings shall be prepared pursuant with the following guidelines:
   1. Submittal documentation and drawings shall consistently use the same abbreviations, symbols, nomenclature and identifiers. Each control system element shall be assigned a unique identifier pursuant with the Contract Documents.
   2. Submittal documentation and drawings shall have at the beginning an Index and Design Drawing Legend.
      a. Index shall list all design drawings and elements including the drawing number, sheet number, drawing title, etc.
      b. Legend shall show and describe all symbols, abbreviations and acronyms used on the Design Drawings.

D. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
   1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
   2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
   3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

E. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
   2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
   3. Wiring Diagrams: Power, signal, and control wiring.
   4. Riser diagram of Building Level Communication Network (BLCN) and Enterprise Level Communication Network (ELCN) shall outline execution and details of all network cabling, BAS & Network Hardware including the following:
      a. All BAS/DDC Hardware with controller number, unique identifier/tag, location, equipment and service.
      b. All Network Hardware with unique identifier, location and service.
      c. Network cabling configuration and execution specification.
      d. Location of all cabling termination points and End of Line (EOL) terminators.
      e. Location of all network interface jacks.
      f. A separate riser diagram shall be provided for each network segment.
   5. Details of control panel faces, including controls, instruments, and labeling.
   6. A schedule of all control valves including the unique equipment identifier/tag, valve size, dimensions and installation/maintenance clearance, model number (including pattern and connections), close-off rating, flow, CV, pressure drop, pressure rating and location. The valve schedule shall also contain actuator selection data supported by calculations of the force required to move, close and seal the valve at design conditions.
   7. A schedule of all control dampers. This shall include the unique equipment identifier, unique damper identifier/tag, damper size, pressure drop, blade configuration, orientation and axis of frame, blade rotation, location and selection criteria of actuators, nominal and actual sizes, and manufacturer and model number. The Damper Schedule shall include the AMCA 500-D maximum leakage rate at the operating static-pressure differential.
   8. Sequence of Operation shall be submitted for every piece of equipment being controlled by and/or associated with the BAS. No operational deviation from specified Sequences of Operation as outlined in Contract Documents shall be permitted without prior written approval. Sequences of Operation shall include and conform to the following:
      a. Refer to equipment and control devices by their specific unique identifiers/tags pursuant with the Contract Documents and BAS Submittal package.

b. Clearly represent actual Application Programming methodology and functional control operation. Do not merely provide a copy of Contract Document specified Sequence of Control.
c. Include description of functional system operation under normal and failure conditions.

9. DDC System Hardware:
   a. Wiring diagrams for control units with termination numbers.
   b. Schematic diagrams and floor plans for field sensors and control hardware.
   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
10. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
11. Controlled Systems:
    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

1.8 INFORMATIONAL SUBMITTALS

A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

B. Qualification Data: For Installer and manufacturer.

C. Field quality-control test reports.

1.9 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1. Operator's Manual with Manufacturers complete operating instructions.
2. Programming Manual including:
   a. Documentation of all project specific Application and DDC programs.
   b. All necessary system Administrator-Level passwords and/or required access credentials.
   c. Information required for programming BAS.
   d. Complete Final Point Schedule including all hardware and software data points and documentation of calibration and configuration values for all Inputs, Outputs, Variables and PID Loops at the conclusion of systems commissioning and functional testing.
   e. Routine preventative maintenance procedures, corrective diagnostic troubleshooting procedures and calibration processes.
   f. Final Bill of Material with all installed parts, manufacturers, manufacturers¢ part numbers and ordering information.
   g. A schedule of recommended spare parts with part numbers and supplier.
3. Complete system database as functional at the conclusion of systems commissioning and functional testing including all graphics and images used by and/or created for BAS on electronic format as accepted by Owner.
4. Maintenance instructions and lists of recommended spare parts for each type of control device.
5. Interconnection wiring diagrams with identified and numbered system components and devices.
6. Keyboard illustrations and step-by-step procedures indexed for each operator function.
7. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
8. Calibration records and list of set points.

B. Software and Firmware Operational Documentation: Include the following:
1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens for all major equipment or systems, such as; chilled water plant including all components, typical air handling units, etc.
5. Software license required by and installed for DDC workstations and control systems.

C. Project Record Documents. Upon completion of installation and systems commissioning submit record documents for review. ÓAs-Built• Project Record Documents should include:

1. Project Record Application Engineering Drawings shall include all BAS System Engineering Design Submittal with Drawings updated to reflect actual field conditions, architecture and execution.

1.10 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish a recommended list of materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Two Relays each type.
2. Two Space sensors each type.
3. One Duct sensor each type.
4. One actuator each type.
5. One duct pressure DPT.
6. One transformer each type.
7. One controller each type.
8. One Supervisory controller each type.

1.11 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

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

C. Comply with ASHRAE 135 for DDC system components.

1.12 EXTENDED WARRANTIES

A. Warrant all DDC controllers to be free of defect in material and workmanship under normal operation and expected service as published by the manufacturer in the unit¢s performance specifications for a period of two (2) years at a minimum.

B. Warrant all other components of the BAS and installation to be free of defects in workmanship and material under normal expected service and use for a period of two (2) years from the date of final acceptance of the BAS by the Owner.

C. During the warranty period, provide all labor and materials required to repair or to replace all items or components that fail due to defects in workmanship or manufacture at no charge or reduction in service to the Owner.

D. Except in the event of property loss or damage, warranty service shall be provided during regular working hours Monday through Friday at no charge unless otherwise explicitly outlined in the Contract Documents. Warranty work outside these periods and associated charges shall be coordinated with Owner.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.14 COORDINATION

A. Coordinate location of all thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate with all related systems, subcontractors and the associated manufacturers responsible for the system to determine the points that are to be mapped from the third party system to the BAS. At a minimum, provide mapping, alarm configuration, and graphic creation for each system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Automated Logic / Albeiro Energy.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

D. Incorporate other monitored or controlled systems identified in paragraph 1.14.C above.

2.2 BUILDING LEVEL CONTROLLERS (B-BC)

A. All building level controllers shall comply with the minimum requirements of ANSI/ASHRAE Standard 135 Annex L for a BACnet Building Controllers (B-BCs) and shall be certified and listed by the BACnet esting Laboratories (BTL) as a B-BC.

B. Furnish B-BC(s) as necessary to control large point count major mechanical equipment, and execution of BAS global strategies, and as noted in the execution portion of this specification.
1. Each Mechanical System and/or major piece of Mechanical Equipment (e.g., Chilled Water, Heating Water, Large AHU, etc.) shall have one (1) dedicated DDC controller with sufficient I/O capacity such that it shall be connected to ALL field devices and sensors associated with that system and/or piece of equipment. Distributed control of one (1) single piece of major mechanical equipment shall not be performed by multiple controllers.
2. Each B-BC shall support local hardware Inputs and Outputs (I/O) by the use of on-board I/O and/or I/O expansion modules.

C. Building level controllers shall reside on the ELCN or BLCN using the BACnet/IP, BACnet/Ethernet or MS/TP data links as specified in ANSI/ASHRAE Standard 135.

D. B-BC shall be capable of locally executing global strategies for the BAS based on information from any object in the internetwork. Control Systems that require a higher-level host processor for update, time stamps, global point data, COS transfer, on-line control instruction, or communications control between B-BC panels shall not be acceptable.

E. BAS shall communicate with all B-AWS, B-BC, B-AAC & B-ASC on a peer-to-peer basis, and shall provide real-time clock functions for scheduling and network-wide time synchronization.

F. B-BC shall have sufficient memory to support its operating system, database, and programming requirements. Battery/capacitor shall retain static RAM memory and clock functions for a minimum of 72 hours.
1. B-BC operating system, field database, and application programs shall reside in EEPROM.
2. B-BC run-time field database and application programs shall reside in battery backed-up on-board memory of EEPROM.

G. B-BC shall comply with the following Hardware Configuration:
1. B-BC shall have integral power switch. If the device manufacturer provides no on-board switch then the System Contractor shall provide a separate dedicated transformer and switch within each enclosure for each controller present.
2. B-BC shall provide diagnostic LEDs for power, communications and processor status. The B-BC shall continually check the status of its processor and memory circuits.
3. Controller wiring terminals shall be removable terminal strips for ease of installation and service replacement.
4. All hardware inputs shall be Universal (i.e., binary or analog) configured on hardware and/or in software.
    a. Inputs shall accept dry-contact, thermistor, 4-20 mA, and 0-5VDC.
    b. Pulse accumulation shall accommodate a maximum frequency of 40Hz.
    c. Inputs shall have a minimum 10 Bit A/D conversion resolution.
    d. 24VAC over-voltage protection
    e. Status LED indicators for each input
5. All hardware outputs shall be Universal and configured on hardware and/or in software.
    a. Outputs shall provide configurable modulating voltage signal to industry standard 0-5VDC and 0-10VDC analog control devices and relays.
    b. Outputs shall be capable of sourcing 75mA at 12VDC.
    c. Outputs shall have a minimum 8 Bit D/A conversion resolution.
    d. 24VAC over-voltage and short protection

H. B-BC shall interact with the Control System Application Software in compliance with the following:

1. Database programming, configuration and modification shall be accomplished through the B-AWS online with the B-BC. The complete database and application program shall reside in the B-BC. The System Contractor shall configure the software to attain the proper sequence of control and to accomplish all other control system functions indicated in the Contract Documents. Provide a copy of all programming on disc to the Owner.
2. The B-BC shall function in a real-time, multi-tasking networked operating environment; able to display database values, programs, and control loops in real-time while functional and online using the B-AWS. The user shall be able to add, delete, or modify objects on-line as required without taking the B-BC offline. The programming shall provide all the necessary mathematics, logic, utility and control functions necessary to execute the specified sequence of control.
3. All required application programming shall be resident in the B-BC, B-AAC & B-ASC, and not in the B-AWS.
4. B-BC shall manage system-wide alarms by performing distributed, independent alarm analysis and filtering. At no time shall the B-BC panel's ability to report alarms be affected by either operator activity at a B-AWS or local I/O device, or communications with other B-BC on the network.
    a. B-BCs shall have capability to broadcast alarm conditions automatically across the BLCN or ELCN. Alarm Event notifications shall be sent to off-site computer or serial printer. A minimum of one B-BC per site shall be capable of sending SMTP email messages to an email server for configured alarm conditions.
    b. Active Alarm Events log shall be stored on the B-BC and may be viewed locally or remotely.
    c. All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.
    d. The user shall be able to define the specific system reaction for each point alarm and shall be able to customize reaction and filtering to minimize nuisance reporting. Each B-BC panel shall automatically inhibit the reporting of selected alarms during the standby power modes of operation, loss of power, fire alarm mode, and normal system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
    e. Alarm reports, messages, and files can be directed to a user-defined list of operator devices, or PCs used for archiving alarm information.
5. B-BC shall perform and manage historical data collection. Minimum sampling time shall be configurable with a minimum sample rate of once per second.
    a. B-BC panels shall store point history files for all analog and binary inputs and outputs.
    b. Measured and calculated analog and binary data shall also be assignable to user-definable trends.
    c. Trend data shall be stored at the stand-alone B-BC panels, and uploaded to hard disk storage automatically at preconfigured intervals when archival is desired.
6. Stand-alone B-BC panels shall automatically accumulate and store runtime hours for binary input and output points.
7. B-BC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.
8. B-BC panels shall have the ability to count and/or execute events on a daily, weekly, or monthly basis.

I. Communication and Protocols
1. The B-BC shall continuously scan the BACnet network and maintain a current database of field data in on board battery/capacitor backed RAM or EEPROM, including alarms, passwords, binding tables, device status, etc. The B-BC shall communicate with BACnet devices on the BLCN using the BACnet physical data link MS/TP at a baud rate of no less than 76.8 Kbps where not limited by third party BACnet devices such as variable frequency drives, utility meters, etc.
2. The B-BC shall provide a communications port for connection of the Portable Operators Terminal using Point-to-Point BACnet physical data link layer protocol or a connection to the network using BACnet/IP.
3. B-BC shall support and be capable of monitoring and controlling a network of communicating remote space sensors. These networked sensors shall occupy input/output hardware points in the B-BC.
4. B-BC shall support at a minimum of two (2) distinct dedicated BACnet/IP (B/IP) data link networks using TCP/IP and one (1) BACnet/Ethernet data link network simultaneously.
5. Building level controllers shall support the following communications requirements at a minimum:
    a. Client and Server BACnet Subscribe Change of Value (COV) Service.
    b. Client and Server BACnet Read Property Multiple (RPM) Service.
    c. BACnet®transmit and receive frame segmentation.

d. Post-installation, field-configurable maximum information frames, APDU frame timeout, APDU segment timeout and APDU retries.

6. Building level controllers shall support SMTP and provide stand-alone remote annunciation of alarms via e-mail without additional hardware, B-AWS or web-server.

2.3 APPLICATION SPECIFIC CONTROLLERS (B-ASC)

A. B-ASC shall comply with all aforementioned BAS System Requirements and shall comply with the BACnet profile for Application Specific Controllers (B-ASC).

B. B-ASC shall reside on the FLCN using the BACnet MS/TP data link as specified in ANSI/ASHRAE Standard 135 in compliance with the following requirements at a minimum:
1. Automatically detect the baud of the MS/TP network and then configure the device¢s communication baud to match that of the MS/TP network.

C. B-ASC shall support the following communications requirements at a minimum:
1. Client and Server BACnet Subscribe Change of Value (COV) Service.
2. Client and Server BACnet Read Property Multiple (RPM) Service.
3. BACnet transmit and receive frame segmentation.
4. Post-installation, field-configurable maximum information frames, APDU frame timeout, APDU segment timeout and APDU retries.

D. Provide one dedicated B-ASC for each Terminal Unit Mechanical Device on the project. Those include Variable Air Volume (VAV) Air Terminal Units (ATU), Serial and Parallel Fan-Powered (FP) VAV ATU¢s, Unit Heaters (UH), Unit Ventilators (UV), Fan Coil Units (FCU) and Individual Fans.

E. B-ASC shall provide microprocessor based self-contained stand-alone fully programmable operation of local process control loops. All local level application programs shall be installed on individual controllers in non-volatile memory.

F. Each B-ASC shall be capable of sharing point information with other B-BC, B-AAC, or B-ASC on a peer-to-peer basis via the BACnet BLCN.

G. Control systems that utilize canned programs or programmable read only memory (PROM) level application programming are not acceptable.

H. Once downloaded, a B-ASC shall not require further communication with the B-AWS except for data base changes, operator commands, and requests from the B-AWS for B-ASC data. Programming of B-ASCs shall be completely modifiable in the field, over installed BACnet Internetwork.
1. Each B-ASC shall be provided with the ability to prevent unauthorized access to its software program.
2. B-ASC shall have sufficient memory to support its operating system, database, and programming requirements.
3. B-ASC operating system, field database, and application programs shall reside in EEPROM.
4. B-ASC run-time field database and application programs shall reside in on-board non-volatile memory or EEPROM.

I. B-ASC shall perform and manage historical data collection. Minimum sampling time shall be configurable with a minimum sample rate of once per second.
1. B-ASC panels shall store point history files for all analog and binary inputs and outputs.
2. Measured and calculated analog and binary data shall also be assignable to user-definable trends.
3. Trend data shall be stored at the stand-alone B-ASC panels, and uploaded to hard disk storage automatically at pre-configured intervals when archival is desired.

J. Stand-alone B-ASC panels shall automatically accumulate and store runtime hours for binary input and output points.

K. B-ASC panels shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected analog and binary pulse input-type points.

L. B-ASC panels shall have the ability to count and/or execute events on a daily, weekly, or monthly basis.

M. B-ASC for VAV ATUs application shall comply with the following:
1. B-ASC shall be provided with integral damper actuator. Actuator shall feature the following at a minimum:
a. 35 in-lbs of torque.
b. Brushless DC Operator.

c. Actual damper position feedback. Drive time or other software calculated damper position shall not be accepted.
d. Damper End Switch using motor current sense or equivalent for positive feedback of both end stop positions.
e. Software selectable rotation.

2. Universal field device hardware inputs shall be provided and configured on hardware and/or in software and comply with the following:
   a. Inputs shall accept dry-contact, thermistor, 4-20 mA, and 0-5VDC.
   b. Pulse accumulation shall accommodate a minimum frequency of 40Hz.
   c. Inputs shall have a minimum 10 Bit A/D conversion resolution.
   d. 24VAC over-voltage protection.
3. Hardware Outputs shall be configured on hardware and/or in software and comply with the following:
   a. Universal Outputs shall provide configurable modulating voltage signal to industry 0-5VDC and 0-10VDC analog control devices and relays.
   b. Each TRIAC Output shall source 500 mA current, 24 VAC 0.5 ACA.
   c. Universal Output shall be capable of sourcing 75mA at 12VDC.
   d. Outputs shall have a minimum 8 Bit D/A conversion resolution.
   e. 24VAC over-voltage and short protection.
4. Airflow Calibration, Test and Air Balance, etc. shall be performed via dedicated handheld configuration tool connected directly to communication port located at ATU B-ASC sensor. Special proprietary software and/or applications loaded on a computer, tablet or other similar device shall not be acceptable to perform this function.
5. B-ASC shall provide diagnostic LEDs for power, communications and processor status. The B-ASC shall continually check the status of its processor and memory circuits.

N. B-ASC for unitary applications shall comply with the following:
1. B-ASC shall provide diagnostic LEDs for power, communications and processor status. The B-ASC shall continually check the status of its processor and memory circuits.
2. Controller wiring terminals shall be removable terminal strips for ease of installation and service replacement.
3. Universal field device hardware inputs shall be provided and configured on hardware and/or in software and comply with the following:
   a. Inputs shall accept dry-contact, thermistor, 4-20 mA, and 0-5VDC.
   b. Pulse accumulation shall accommodate a minimum frequency of 40Hz.
   c. Inputs shall have a minimum 10 Bit A/D conversion resolution.
   d. 24VAC over-voltage protection.
4. Hardware Outputs shall be configured on hardware and/or in software and comply with the following:
   a. Universal Outputs shall provide configurable modulating voltage signal to industry 0-5VDC and 0-10VDC analog control devices and relays.
   b. Each TRIAC Output shall source 500 mA current, 24 VAC 0.5 ACA.
   c. Universal Output shall be capable of sourcing 75mA at 12VDC.
   d. Outputs shall have a minimum 8 Bit D/A conversion resolution.
5. 24VAC over-voltage and short protection.

O. Control System Application Software:
1. The B-ASC application software shall be the same as and indistinguishable from the B-BC specified interaction with the Control System Application Software.
2. The controller software shall reside in a real time, multi-tasking, networking operating environment. Database definition shall be accomplished through the B-AWS online with the B-ASC. The complete database and application program shall reside in the B-ASC. Configure the software to attain the proper sequence of control and to accomplish all other control system functions indicated in the Contract Documents.
3. The user shall be able to add, delete, or modify objects on-line as required. The programming shall provide all the necessary mathematics, logic, utility and control functions necessary for proper sequence of control.

P. Communications and Protocols
1. The B-ASC shall communicate with field devices and controllers on the BLCN using the BACnet physical data link MS/TP at 76.8 Kbps where not limited by third party devices such as variable frequency drives, utility meters, etc.
2. The B-ASC shall provide a communications port for connection of the Portable Operators Terminal using Point-to-Point BACnet physical data link layer protocol or a connection to the inter-network.

3. B-ASC shall support, transmit, and receive of segmented messages.

Q. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

R. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

2.4 ENCLOSURES AND SUB-PANELS

A. Provide pedestal base or wall mounted local control enclosure to house all control components associated with each area, system or mechanical equipment room.
1. The enclosures shall be minimum 16 gauge steel or aluminum, totally enclosed on all sides and painted with a baked enamel finish. All enclosures must maintain a minimum separation of 1• from the back wall.
2. Enclosures located in wet indoor conditions or located outdoors shall meet NEMA 4X.
3. Penetrations are permitted on bottom of enclosure only. Do not make conduit penetrations in top or side of enclosure. Each enclosure shall be equipped with a wire gutter below with a minimum of six ¾•minimum conduit penetrations into the bottom of the enclosure to accommodate system wiring.
4. Where required by AHJ, enclosures located in mechanical or electrical rooms shall meet NEMA 2 requirements.
5. Enclosures located in all other locations including but not limited to mechanical or electrical rooms not requiring NEMA 2, occupied spaces, above ceilings and plenums shall be the same NEMA classification as all other enclosures located in the same environment, except if location requires additional protection due to potential vandalism or environmental conditions and shall at a minimum meet NEMA 1 requirements.
6. Enclosures provided as an integral (pre-packaged) part of another product and/or piece of equipment are acceptable.
7. Provide a continuous piano hinged door, keyed locking latch and removable sub-panel. A single key shall be common to all control enclosures.

B. Provide each DDC panel with a line filter, surge suppressor, electrical disconnect, control fuse, and control transformer.

C. Provide power supplies located inside control enclosures shall be fully enclosed with external 24 Vac terminals, on/off control, equipment overcurrent protection, power indication, high/low voltage separation, and convenience 120VAC outlets.

D. Provide insulated, modular, feed-through, clamp-style terminal blocks suitable for rail-mounting with end plates and partitions for the termination of all field wiring in control enclosures. Field wiring to equipment with integral terminals and/or unitary equipment (i.e., VAVs ATUs, EFs, &c.) shall not be required to have terminal blocks.

E. Rail mounted terminal blocks shall be color coded to match the associated conductor colors.

2.5 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
   a. Range: Minus 50 to 275 deg F **(**Minus 46 to 135 deg C**)**.
   b. Interchangeable Accuracy: At 32 deg F **(**zero deg C**)** within 0.5 deg F **(**0.3 deg C**)**.
   c. Repeatability: Within 0.5 deg F **(**0.3 deg C**)**.
   d. Self-Heating: Negligible.
4. Transmitter Requirements:
   a. Transmitter required for each 100-ohm RTD.
   b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

C. Platinum RTD, Single-Point Air Temperature Duct Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Minco; S400 Series PD or PF.
   b. BEC Controls Corporation.
   c. MAMAC Systems, Inc.
   d. RDF Corporation.
2. 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F ((Minus 45 to 135 deg C).)
4. Probe: Single-point sensor with a stainless-steel sheath.
5. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches ((450 mm) long).
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch ((16-mm) trade size.)

D. Platinum RTD, Air Temperature Averaging Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Minco; S400 Series PD or PF.
   b. BEC Controls Corporation.
   c. MAMAC Systems, Inc.
   d. RDF Corporation.
2. 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F **(**(Minus 45 to 135 deg C).**)**
4. Multiple sensors to provide average temperature across entire length of sensor.
5. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
6. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch **(**100-mm**)** radius.
7. Length: As required by application to cover entire cross section of air tunnel.
8. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
9. Gasket for attachment to duct or equipment to seal penetration airtight.
10. Conduit Connection: 1/2-inch **(**(16-mm) trade size.**)**

E. Platinum RTD Space Air Temperature Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Minco; S400 Series PD or PF.
   b. BEC Controls Corporation.
   c. MAMAC Systems, Inc.
   d. RDF Corporation.
2. 1000 ohms.
3. Temperature Range: Minus 50 to 212 deg F **(**(Minus 45 to 100 deg C).**)**
4. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
5. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
6. Concealed wiring connection.

F. Thermal Resistors (Thermistors): Common Requirements:
1. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

a. Range: Minus 50 to 275 deg F (Minus 46 to 135 deg C).
b. Interchangeable Accuracy: At 77 deg F (25 deg C) within 0.5 deg F (0.3 deg C).
c. Repeatability: Within 0.5 deg F (0.3 deg C).
d. Drift: Within 0.5 deg F (0.3 deg C) over 10 years.
e. Self-Heating: Negligible.

4. Transmitter optional, contingent on compliance with end-to-end control accuracy.

G. Thermistor, Single-Point Duct Air Temperature Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
a. Minco; TS400 Series TB.
b. BEC Controls Corporation.
c. Ebtron, Inc.
d. Heat-Timer Corporation.
e. I.T.M. Instruments Inc.
f. MAMAC Systems, Inc.
g. RDF Corporation.
2. Temperature Range: Minus 50 to 275 deg F ((Minus 45 to 135 deg C).)
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches ((450 mm) long).
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.
7. Conduit Connection: 1/2- inch (16-mm) trade size.

H. Thermistor Averaging Air Temperature Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
a. Minco; TS400 Series TB.
b. BEC Controls Corporation.
c. Ebtron, Inc.
d. Heat-Timer Corporation.
e. I.T.M. Instruments Inc.
f. MAMAC Systems, Inc.
g. RDF Corporation.
2. Temperature Range: Minus 50 to 275 deg F ((Minus 45 to 135 deg C).)
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch (16-mm) trade size.

I. Thermistor Outdoor Air Temperature Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
a. Minco; TS400 Series TB.
b. BEC Controls Corporation.
c. Ebtron, Inc.
d. Heat-Timer Corporation.
e. I.T.M. Instruments Inc.
f. MAMAC Systems, Inc.
g. RDF Corporation.
h. <Insert manufacturer's name; product name or designation>.
2. Temperature Range: Minus 50 to 275 deg F ((Minus 45 to 135 deg C).)
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch (16-mm) trade size.

J. Thermistor Space Air Temperature Sensors:

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Minco; TS400 Series TB.
   b. BEC Controls Corporation.
   c. Ebtron, Inc.
   d. Heat-Timer Corporation.
   e. I.T.M. Instruments Inc.
   f. MAMAC Systems, Inc.
   g. RDF Corporation.
2. Temperature Range: Minus 50 to 212 deg F **(**(Minus 45 to 100 deg C).**)**
3. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

K. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:
1. 1000-ohm platinum RTD or thermistor.
2. Thermistor:
   a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
   b. Thermistor drift shall be less than plus or minus 0.5 deg F **(**0.3 deg C**)** over 10 years.
3. Temperature Transmitter Requirements:
   a. Mating transmitter required with each 100-ohm RTD.
   b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.
4. Provide digital display of sensed temperature.
5. Provide sensor with local control.
   a. Local override to turn HVAC on.
   b. Local adjustment of temperature set point.
   c. Both features shall be capable of manual override through control system operator.

L. Humidity Sensors: Bulk polymer sensor element.
1. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
   a. BEC Controls Corporation.
   b. General Eastern Instruments.
   c. MAMAC Systems, Inc.
   d. ROTRONIC Instrument Corp.
   e. Vaisala.
2. Accuracy: 5 percent full range with linear output.
3. Room Sensor Range: 20 to 80 percent relative humidity.
4. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   a. Set-Point Adjustment: Concealed.
   b. Set-Point Indication: Concealed.
   c. Thermometer: Concealed.
   d. Color: White.
   e. Orientation: Vertical.
5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 40 to plus 170 deg F **(**minus 40 to plus 76 deg C**)**.
7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

M. Pressure Transmitters/Transducers:
1. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
   a. BEC Controls Corporation.
   b. General Eastern Instruments.
   c. MAMAC Systems, Inc.
   d. ROTRONIC Instrument Corp.
   e. Setra
   f. Vaisala.
2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
   a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   b. Output: 4 to 20 mA.

c. Building Static-Pressure Range: 0- to 0.25-inch wg (0 to 62 Pa).
d. Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240 Pa).

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure and tested to 300-psig (2070-kPa); linear output 4 to 20 mA.
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

N. Room sensor accessories include the following:
1. Insulating Bases: For sensors located on exterior walls.
2. Sensor Protective Guards: Locking; heavy-duty, transparent plastic; mounted on separate base.
3. Adjusting Key: As required for calibration and cover screws.

2.6 STATUS SENSORS

A. Status Inputs for Fans:
1. Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa).
2. Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

B. Status Inputs for Pumps:
1. Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.
2. Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
1. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
a. BEC Controls Corporation.
b. I.T.M. Instruments Inc.

2.7 WATER FLOW METERS

A. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
1. Onicon Incorporated
2. Approved performance equal.

B. Provide an ONICON F-3200 Series Electromagnetic Flow Meter complete with integral electronics module. The electronics module shall include a backlit graphic display and keypad. Connections to the piping shall be ANSI class 150 flanges (ANSI class 300 available where required). Provide suitable mating flanges. The flow tube shall be epoxy coated steel; the sensing electrodes shall be 316SS; the liner shall be polypropylene or ebonite for low temperature service, PFTE for hot water service. Each flow meter shall be individually wet-calibrated and accurate to within ±0.2% of reading from 1.6 to33 feet per second velocity. A certificate of calibration shall be provided with each flow meter. Output signals shall be 4-20 mA and programmable pulse. The flow meter shall be capable of measuring bi-directional flow. For installations in non-metallic pipe, install grounding rings between flanges. Each flow meter shall be factory programmed for its specific application, and shall be re-programmable using the integral keypad on the converter (no special interface device or computer required). Each flow meter shall be covered by the manufactures two-year warranty.

2.8 DUCT AIR FLOW MEASURING STATIONS

A. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
   1. EBTRON, Inc.
   2. Onicon Incorporated.
   3. Approved performance equal.

B. General:
   1. Provide an EBTRON, Inc. model GTx116-P+ duct airflow measuring station.
   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.
   3. Substitution requests for acceptance less than 60 days prior to bid date or products submitted in non-conformance with the requirements of this specification will not be considered.
      a. For any product to be considered for substitution, a written document shall be submitted to the engineer detailing exceptions and compliance, section-by-section with supporting documentation, before an approval will be considered.
      b. Any product submitted as an equal shall be expected to comply with all performance capabilities and functional aspects of this specification.
   4. Excluded devices
      a. Fan Inlet airflow measurement devices.
      b. Measurement technologies using chip-in-glass, chip-in-epoxy or other chip type thermistors for the heated sensor component are not acceptable.
      c. Pitot tubes, Pitot arrays, Piezo rings and other differential pressure based devices are not acceptable.
      d. Vortex shedding devices are not acceptable.

C. Required product performance:
   1. Airflow Measurement Devices (AMD) with Temperature Output and Airflow Alarming Capability
   2. 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 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 corrected by the transmitter for altitudes other than sea level.
      d. Temperature measurement shall be field configurable with velocity weighted average as the default, or manual selection of arithmetic average temperature.
   3. Sensor Probes
      a. Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube, 316 stainless steel tube are available when required.
      b. Sensor probe mounting brackets shall be constructed of 304 stainless steel.
      c. Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper.
         1) PVC jacketed internal wiring is not acceptable.

d. Probe internal wiring connections shall consist of solder joints and spot welds.
   1) Internal wiring connections shall be sealed and protected from the elements. They shall be capable of direct exposure to water without affecting instrument operation.
   2) Connectors of any type within the probe are not acceptable.
   3) Printed circuit boards within the probe are not acceptable.
e. 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 (-55°° C to 200°° C) and continuous and direct UV exposure.
   1) Plenum rated PVC jacket cables are not acceptable.
f. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
g. Each sensor probe shall contain one or more independently wired sensing nodes.
h. 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 in the field.
i. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Upon request, the manufacture shall provide a written independent laboratory test result of 100% survival rate in a 30 day saltwater and acid vapor test.
   1) Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
   2) Devices with exposed leads are not acceptable.
j. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
k. Each sensor node shall be individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard and have an accuracy of ±±2% of reading over the entire calibrated airflow range of 0 to 5,000 FPM **(**25.4 m/s**)**.
   1) Upon request the manufacture shall submit for AMD approval a copy of the NIST report of calibration used for the reference standard used.
      a) Devices claiming NIST traceability to third party laboratories and not directly to NIST are not acceptable.
      b) Devices calibrated against standards other than the NIST LDA are not acceptable.
l. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
m. The installed airflow accuracy shall be:
   1) Ducts - ±±3% of reading when installed in accordance with the manufactures recommended placement guidelines.
   2) Non-ducted Outdoor Air intakes ÓÓ better than or equal to ±±5% of reading when installed in accordance with the manufactures recommended placement guidelines.
n. 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.
o. Each sensing node shall have a temperature accuracy of ±±0.15°° F (0.08°° C) over an operating range of -20°° F to 160°° F. (-28.9°° C to 71.1°° C) and humidity range of 0 to 100% RH.

4. 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, receptacle plug pins and PCB test points shall be gold plated.
   d. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
   e. All integrated circuitry shall be temperature rated as ÜÜindustrial-grade¢¢. Submissions containing ÜÜcommercial-grade¢¢ integrated circuitry are not acceptable.
   f. The transmitter shall be capable of determining the airflow rate and temperature average of all connected sensor nodes in an array for a single location.
      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 be capable of providing a high and/or low airflow alarm with user-defined set point and % of set point tolerance. Alarm shall be capable of being manually or automatically reset and low-limit cutoff value may be selected to disable the alarm. An alarm delay function shall also be field defined.
h. 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.
i. The transmitter shall be capable of field configuration, diagnostics and include Field Output Adjustment Wizard that allows for a one or two point field adjustment to factory calibration for installations that require adjustment.
j. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.
k. 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 (AO1=airflow, AO2=temperature or alarm), in combination with either of the following:
1) one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection
2) one isolated Ethernet (simultaneously supported BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection
l. The analog signal capability shall include two output terminals: the first (AO1), shall provide the total airflow rate and the second output (AO2) shall be field configurable to provide temperature information.
m. The transmitter shall also be available with a single isolated LonWorks Free Topology network interface. Transmitters shall be available alternatively with one USB connection for thumb-drive data logging of sensor data. Neither of these options shall include analog output signals.
n. The network communications RS-485 (BACnet MS/TP or Modbus RTU) or Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) shall provide: the average airflow rate, temperature, hi and/or low airflow set point alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures. Individual node airflow rates and temperatures shall NOT be available via the network with Lon.
o. The transmitter shall have an on-off power switch. Isolation transformers shall not be required.
p. The transmitter shall be powered by 24 VAC (22.8 to 26.4 under load) @20 V-A maximum and use a switching power supply that is over-current and over-voltage protected.
q. The transmitter shall use a ÓÓwatchdog• • timer circuit to ensure automatic reset after power disruption, transients and brown-outs.
r. Each transmitter shall have an operating temperature range of -20°° F to 120°° F (-28.9°° C to 48.9°° C) and humidity range of 5 to 95% RH.

5. Listings and Certifications
a. The AMD shall be UL/cUL 873 Listed as an assembly.
1) Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.
b. All network-capable AMD models supplied with RS-485 interface and BACnet protocol shall be BTL Listed.
c. The AMD shall be tested for compliance with the EMC Directive¢¢s requirements and be certified to carry the CE Mark for European Union Shipments.

6. Installation
a. Install in accordance with manufacturer¢¢s placement guidelines. A written report shall be submitted to the consulting mechanical engineer if any discrepancies are found.

2.9 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Belimo Aircontrols (USA), Inc.
b. Siemens.
c. Johnson Controls.
2. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Spring-Return Motors for Valves Larger Than NPS 2-1/2 **(**DN 65**)**: Size for running and breakaway torque of 150 in. x lbf **(**16.9 N x m**)**.
4. Smoke Dampers:

a. Size for torque required for damper seal at load conditions with one actuator per damper section. Mechanically paralleled or 'piggybacked' actuators are not permitted.
b. Coupling: V-bolt dual nut clamp with a V-shaped toothed cradle. Aluminum clamps or set screws are not acceptable.
c. Overload Protection: Microprocessor or an electronic based motor controller providing burnout protection if stalled before full rotation is reached. The actuator shall be electronically cut off at full open to eliminate noise generation with the holding noise level to be inaudible.
d. Power Requirements: 0.23A (running) and 0.09A (holding) at 24V-ac or 27 VA (running) and 10 VA (holding) at 120V-ac.
e. Actuator timing shall be 15 seconds or as required by local codes, whichever is more stringent.
f. Temperature Rating: Actuator shall have a UL555S listing by the damper manufacturer for 350ºF
g. Proportional Smoke Damper Actuators shall meet all requirements specified above and shall modulate 0-100% open in response to a 2-10vdc or 4-20mA control signal. A 2-10vdc feedback output shall provide a 2-10vdc signal for position indication.
    1) Power Requirements (Proportional): Maximum (running) 12 VA at 24-V ac or 8 W at 24-V dc. Maximum (holding) 5VA at 24-V ac or 3 W at 24-V dc.
    2) A manual override winder and locking mechanism shall be provided for override operation of the actuator on a loss of power.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Belimo Aircontrols (USA), Inc.
    b. Honeywell Controls Inc.
2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. Dampers: Size for running torque calculated as follows:
    a. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. **(**62 kg-cm/sq. m**)** of damper.
4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24 or 120]-V ac.
8. Power Requirements (Modulating): Maximum 25 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 0- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: 40 to 104 deg F **(**5 to 40 deg C**)**.
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F **(**Minus 30 to plus 121 deg C**)**.
12. The manufacturer shall provide 5-year limited warranty from the date of sale covering defects in material or workmanship.
13. All actuators are to be delivered with a detailed written installation instruction.

2.10 CONTROL VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Belimo Aircontrols (USA), Inc.
2. VSI Series V, 1000-X

B. Control Valves: Factory fabricated, high performance segmented ball valve..

C. Hydronic System Characterized Ball valves shall have the following characteristics:
1. 1" through 12 inch• : Carbon Steel body, ASTM A216 WCC, stainless steel ball and blowout proof stem, flange to match ANSI 300 with a dual PTFE O-ring package design, PTFE seats, and a stainless steel flow characterizing disc.
2. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
3. Sizing: 3-psig **(**21-kPa**)** maximum pressure drop at design flow rate or the following:
    a. Two Position: Line size.
    b. Two-Way Modulating: Twice the load pressure drop, but not more than value specified above.
4. Valve assemblies shall be maintenance free.
5. 1-2 inch wafer flanged. 3 inch and larger double flanged.
6. Actuator to be Industrial electric type. Series 1000-X.

7. Provide manual overide power switch and allen handle.

D. Hydronic System Globe valves shall have the following characteristics:
1. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
2. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
3. Sizing: 5-psig (35-kPa) maximum pressure drop at design flow rate or the following:
a. Two Position: Line size.
b. Two-Way Modulating: Twice the load pressure drop, but not more than value specified above.
c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
5. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
6. Two- and three-way globe valves shall be used only if characterized control valves do not fit the sizing criteria or application.

E. Hydronic system Butterfly Valves - High Performance shall have the following characteristics:
1. Valve body shall be full lugged carbon steel ANSI Class 150 body with a 316 stainless steel disc without a nylon coating, RTFE seat, and be ANSI Class 150300 flange standards. Blowout-proof shaft shall be 17-4ph stainless steel and shall be supported at four locations by glass-backed TFE bushings. Valve packing shall be Chevron TFE and shall include fully adjustable packing flange and separable packing gland. Valve body shall have long stem design to allow for 2• insulation (minimum). Valve face-to-face dimensions shall comply with API 609 and MSS-SP-68. Valve assembly shall be completely assembled and tested, ready for installation.
2. Sizing: Two-Position (on/off) butterfly valves shall be sized using the 900 Cv rating. Modulating butterfly valves shall be sized using the 600 Cv rating.
a. Maximum pressure drop shall not exceed 5-psig at design flow rate.
3. Flow Characteristics: Modified equal percentage, full rated, bi-directional, dead end service with either flange removed.
4. Close-Off Pressure Rating: Bubble-tight shutoff (no leakage).
5. Media Temperature Range: ANSI Class 150 limitations.
6. Max Differential Pressure: 285 psi @ 100 deg F for ANSI 150.
7. The combination of two 2-way butterfly valves in a tee configuration cross-linked to ensure proper flow orientation shall be permitted. The tee should be constructed of cast iron/stainless steel.

2.11 DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Air Balance Inc.
2. TAMCO (T. A. Morrison & Co. Inc.).
3. Vent Products Company, Inc.

B. Dampers: AMCA-rated, opposed-blade design; 0.108-inch- (2.8-mm-) minimum thick, galvanized-steel or 0.125-inch- (3.2-mm-) minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- (1.6-mm-) thick galvanized steel with maximum blade width of 8 inches (200 mm) and length of 48 inches (1220 mm).
1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
3. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. (50 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (1000 Pa) when damper is held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

2.12 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Section 271500 "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

3.2 TEMPERATURE INSTRUMENT APPLICATIONS

A. Air Temperature Sensors:
   1. Duct, Supply air: 1000-ohm platinum RTD.
   2. Outdoor, air: 1000-ohm platinum RTD.
   3. Space: 1000-ohm platinum RTD.

B. Air Temperature Transmitters:
   1. Duct, : Air temperature RTD transmitter.
   2. Outdoor, : Air temperature RTD transmitter.
   3. Space, : Air temperature RTD transmitter.

C. Liquid Temperature Sensors:
   1. Hot water System, : Liquid temperature sensor, commercial grade.

3.3 GENERAL

A. All control system components shall be installed in locations as required to properly sense the controlled medium.

B. BAS Installation shall be performed by professionals in a workmanlike manner and in compliance with the Contract Documents,Division 26 Project Electrical System Specifications, the National Electric Code (NEC), and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ) and the following:
   1. Complete BAS installation including all DDC Devices, Enclosures, wiring, equipment, control devices and sensors shall be installed in accordance with the manufacturers¢¢ recommended installation procedures and as specified.
   2. All control devices are to be provided and installed with all required gaskets, seals, flanges, connection enclosures, thermal compounds, insulation, piping, fittings and valves as required for design operation, isolation, equalization, purging and calibration.
   3. Strap-on control devices shall not be permitted except as explicitly called out.
   4. All control devices mounted outdoors shall be protected by a weather-shield, integral outdoor enclosure, from ambient elements in such a manner as to not impede design functionality and/or sensing.
   5. BAS installation shall be such that it provides sufficient clearance for system maintenance by maintaining sufficient access for equipment, device and/or component service, calibration, removal, repair or replacement.
   6. BAS installation shall not interfere with required clearance for mechanical and/or electrical equipment maintenance.
   7. Penetrations through and mounting holes in the building exterior associated with the BAS installation shall be sealed and made water-tight.
   8. Dielectric isolation shall be provided where dissimilar metals are used in installation for connection and support.

C. Installation, wiring and material shall be protected from damage or theft before, during, and after installation. Any damaged or stolen installation, wiring, or material shall be repaired or replaced.

D. After completion of installation, calibrate and commission all components provided as part of the Control System and demonstrate proper sequence of operation in compliance with the specifications. BAS components not operating correctly shall be field corrected or replaced.

3.4 BAS APPLICATION SOFTWARE

A. At time of acceptance all operating system, Third party and Control System Application software shall be at least the latest official release version available.

B. Software programs are described to their general intent. It is recognized that Networked System manufacturer¢s software differ; however, the Application software provided shall incorporate the features described fully implemented and optimized to provide the sequences described, minimize energy consumption and prolong equipment life.

C. When programming the system BACnet addressing rules will be strictly adhered to. All addressing strategies will have to be approved by Owner and Engineer of Record prior to configuring any LAN types.

D. All analog and binary values shall be programmed with appropriate alarms.

E. Except as specified otherwise, throttling ranges, proportional bands, and switching differentials shall be centered on the associated set point.

F. All set points unless otherwise indicated are adjustable and shall be programmable for all control loops.

G. Each control loop and/or interlock(s) for all mechanical system including terminal unit systems shall be programmed with a control loop specific graphical trend to trend all values associated with each specific control loop or system interlock.

H. Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the system start commands shall be staggered by 15-second (adj.) intervals to minimize inrush current.

I. Scheduling shall be developed for each mechanical system. Final schedules shall be coordinated with the Owner and Engineer of Record prior to system commissioning.

J. Optimal start/stop programs shall be applied to all regularly scheduled mechanical and electrical systems.

K. At a minimum, trend log/historical data shall be implemented for every hardware point on the system. Additionally all software (virtual) points used as setpoints shall be trended. Point trends shall be grouped into logically interrelated points for individual mechanical and building systems. Initial set-up shall be to log values once every 5 minutes.

L. B-AWS Graphical User Interface (GUI) must be approved by the Owner and Engineer of Record and shall incorporate at a minimum the following:
   1. At a minimum, all physical hardware, sensors, control devices and set points shall be visible on a B-AWS in graphical form.
   2. All mechanical systems shall have a programmed real time color graphic for primary graphical user interface.
   3. Individual floor plan graphics will be programmed for each floor or area of the building. All space sensors shall be visible on floor plan graphics and system graphic.

3.5 B-AWS HARDWARE

A. Provide as specified for each PC-Based B-AWS.

B. Assemble server components in a configuration that allows easy operator access to all necessary components from one position.

C. Provide sufficient permanent and removable storage drives for 25% free memory after provision for all operating system, Third party and Control System Application software, all fully configured point databases, storage/back-up of all B-BC, B-AAC and B-ASC application programming, all graphic files, all user-defined reports and a three year archive of all trend and historical data described in this specification.

D. Provide sufficient RAM to meet system performance requirements.

3.6 BACnet PROTOCOL VERIFICATION SOFTWARE

A. Demonstrate exclusive communication utilizing the BACnet Protocol on all segments of the BACnet network.

3.7 BUILDING CONTROLLER (B-BC)

A. Provide as required to meet performance requirements of the system with a 10% increase in connected B-AAC and B-ASC on any individual network. Provide a dedicated B-BC for all project specific equipment requiring this controller type.

B. Locate strategically such that B-BC locations are as equally distributed throughout the project as possible.

3.8 ADVANCED APPLICATION CONTROLLERS (B-AAC)

A. Provide a dedicated B-AAC for each medium-sized mechanical system.

B. All points used for a single mechanical system shall be connected to the same B-AAC. Points used for control loop reset based on outside air, or space/zone temperature, or extremely remote differential pressure sensors on slow acting control loops are exempt from this requirement.

C. Provide spare additional I/O such that future use of spare capacity shall require providing only the field device, field wiring, point database definition and operational sequence programming changes as required. Additional point modules may be required to implement use of these spare points.
   1. Provide at least one (1) spare universal input and one (1) spare universal output or 5% spare I/O of the total capacity of each B-AAC whichever is greater.
   2. If B-AAC I/O is not universal then provide at least one (1) spare analog input, one (1) spare digital input, one (1) spare analog output and one (1) spare digital output or 5% spare I/O of the total capacity for each point type of each B-AAC whichever is greater.

3.9 APPLICATION SPECIFIC CONTROLLERS (B-ASC)

A. Provide a dedicated B-ASC for each Terminal Unit Mechanical Device on the project, including Individual Fans and hot water coils.

B. All points used for a single Terminal Unit Mechanical Device shall be connected to a dedicated B-ASC. Points used for control loop reset based on outside air, or space/zone temperature, or extremely remote differential pressure sensors on slow acting control loops are exempt from this requirement.

C. VAV ATU and FP-VAV ATU Controllers
   1. Provide networked B-ASC for each VAV ATU and FP-VAV ATU consisting of a controller, damper actuator, and velocity transducer.
   2. The ATU shall be provided with multi-point averaging type flow sensor factory piped to the velocity transducer.

3.10 LOCAL SYSTEM NETWORK INTERFACE

A. At a minimum the Portable B-AWS shall be able to connect to the BACnet Internetwork within each mechanical equipment space within the project.

3.11 ENCLOSURES & SUB-PANELS

A. All system components not designed for or required to be field installed shall be mounted in a control enclosure. Those components shall be sub panel mounted except components that are mounted on the panel face. Provide on/off power switch with over-current protection for control power sources in each local enclosure.

B. All control enclosures shall be located so that visual observation and adjustment can be accomplished while standing flatfooted on the floor in a convenient location adjacent to the equipment served. Install all equipment in readily accessible location as defined by Chapter1 Article 100 Part A of the NEC.

C. Label all control system components.

D. A copy of the As-built application engineering for the system served shall be laminated in clear plastic, shall be legible and suspended within enclosure.

E. All B-BC shall be mounted in an enclosure.

3.12 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches **(**1220 mm**)** above the floor.
   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install guards on thermostats in the following locations:
   1. Entrances.
   2. Public areas.
   3. Where indicated.

E. Install automatic dampers according to Section 233300 "Air Duct Accessories."

F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

G. Install labels and nameplates to identify control components according to Section 230553 "Identification for HVAC Piping and Equipment."

H. Install hydronic instrument wells, valves, and other accessories according to Section 232116 Hydronic Piping Specialties."

I. Install duct volume-control dampers according to Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts."

3.13 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. General
1. Provide all wiring required for a complete Control System.
2. Control system wiring and cabling installed for this project shall be performed by professionals in a workmanlike manner and in accordance with the Contract Documents, Division 26 Project Electrical System Specifications, the National Electric Code (NEC), and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ) and shall include but may not be limited to the following:
   a. All power wiring required not indicated on the electrical plans and specifications.
   b. Power to all actuators and sensors.
   c. Provide all wiring and cabling for network communications except for owner provided LANs/WANs.
   d. All sensor and control device input and output wiring.
   e. All interconnecting cabling between and amongst network devices, PCs printers, etc.
   f. Interlock wiring between devices, variable frequency drives and between motor starters.
   g. All other necessary wiring for fully complete and functional system as specified.
   h. Install piping, wiring/cabling routed parallel to or at right angles with the structure, properly supported every six (6) feet at a minimum and installed in a workmanlike manner.
3. Maximum allowable voltage for control wiring shall be 120-volts.
4. All wiring shall be installed as continuous links. Any required splices shall be made only within an approved junction box or other approved protective device with a maximum fill of 50%.
   a. BACnet network cabling shall not be field spliced.
5. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
6. Terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

B. Power Wiring and Cabling
1. Obtain power and provide wiring for all enclosures and controls equipment, including branch circuit wiring from circuit breaker panels unless specifically shown on the Plans or Specifications to be provided under Division 26.
2. All B-AWS equipment shall be served from isolated ground receptacles via UPS by dedicated branch circuits.
3. All other enclosures, sensor and control devices shall be fed from separate circuits in the electrical distribution panels and shall not be served from the typical floor receptacle or lighting circuits.

C. Network Wiring and Cabling
1. Network installation shall strictly adhere to the manufacturers networking installation instructions and procedures.
2. Network installation shall conform to standards for the LAN types and cabling types selected. Specific network rules inherent to the ANSI/AHRAE Standard 135-1995, BACnet shall be followed. Those include but are not limited to:
   a. Only one path can exist from any BACnet device to another.
   b. Each BACnet device connected to an internetwork LAN must have a unique device instance (0 - 4,194,303).
   c. Each internetwork LAN must have a unique Network Number (1 - 65,545).
3. Primary LAN Network wire and cable shall be run separately from all other wiring.
4. Other LAN Network wire and cabling shall be installed separate from any wiring over thirty (30) volts.
5. All communications shielding shall be grounded as per Networked System manufacturer¢s recommendations.

D. Installation
1. Install raceways, boxes, and cabinets according to Section 260533 "Raceways and Boxes for Electrical Systems."
2. Install building wire and cable according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3. Install signal and communication cable according to Section 271500 "Communications Horizontal Cabling."
    a. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
    b. Install exposed cable in raceway.
    c. Install concealed cable in raceway.
    d. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
    e. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
    f. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
    g. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
4. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
5. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.14 ANALOG SENSORS

A. Temperature
1. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor readings.
2. Install and properly support all enclosures and sensing elements as much as possible in the center of duct cross section and in straight duct runs. In condensing environments use stainless steel flanges to support sensing elements.
3. Sensors mounted on air ducts having exterior insulation shall be provided with handy-box mounting with insulating material firmly fitted around handy-box.
4. Averaging type sensors: provide a minimum of 1 linear foot of sensor per 4 square feet of duct/coil area or equal to duct/coil width where installed, whichever is longer. Averaging sensing tubing shall serpentine vertically across airstream and be supported firmly by mechanical clips.
5. Temperature sensors installed in piping or tanks shall be in separable thermowells. Sensors shall be inserted into thermowells with conductive paste. Assembly shall allow removal of sensor without loss of fluid.
6. At a minimum one outside air temperature sensor shall be installed. It shall be mounted outside on a northern exposure as high as serviceable on the building. The sensor shall be mounted within a ventilated enclosure to shield the sensor from the effects of the sun. The sensor location shall be selected such that it may not be affected by artificial and/or mechanical airstreams (i.e., building exhaust, building relief, etc.).
7. Terminal Unit Sensors shall be provided one per terminal unit device.
    a. They shall be wall mounted in the space served 60• above finished floor and located as shown on drawings.
    b. Provide a minimum of 16 feet of coiled temperature sensor control wiring for equipment with space sensor not located on the Drawings.
8. In all areas where terminal unit sensor locations are not known at the time of building startup, sensors shall be hung approximately 24 inches from the ceiling in the area of the controlled zone and connected. Control wiring shall be neatly coiled and attached to ceiling grid.

B. Wet Bulb
1. For outside air mount same as outside air temperature sensor.
2. For duct mounting execute same as duct mounted temperature sensor.

C. Pressure
1. Orient static pressure sensing taps faced directly down-stream in the airflow so as to eliminate velocity pressure effects. Locate pressure transducers within 10¢ of sensing point and use tubing sized such as to prevent signal phase lag.
    a. Final location of static/differential pressure sensing taps shall be pursuant with Contract Documents and as indicated on drawings. Where not explicitly indicated on drawings, pressure sensing taps shall be located as follows:
        1) Duct static pressure control sensor tap shall be located 2/3 distance from the Air Handling Unit of the total duct length in a straight section of ductwork with a minimum or four (4) duct diameters in both directions.

2) Positive static high-pressure safety cut-outs shall be located at Air Handling Unit immediately downstream of fan section.
3) Mixed-Air static and/or differential sensor tap shall be located in mixing box section.
4) Negative static pressure safety cut-outs shall be located immediately upstream of fan section.
5) Filter differential pressure taps shall be installed on both filter inlet and outlet.

b. Mount air differential pressure taps so that true differential is sensed.

2. Water gauge taps shall include snubbers and isolation valves.
3. Water differential pressure sensors shall be piped through a five-valve bypass assembly with snubbers.

3.15 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each system for compliance with sequence of operation.
5. Test software and hardware interlocks.

C. DDC Verification:
1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check DDC system as follows:
a. Verify that DDC controller power supply is from emergency power supply, if applicable.
b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
c. Verify that spare I/O capacity has been provided.
d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.16 CALIBRATION, COMMISSIONING. DEMONSTRATION AND ACCEPTANCE

A. Commissioning, Calibrating and Adjusting:
1. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated. Confirm in writing to the Owner and Architect the compliance with the field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components" .
2. Pretest Checklist and Test Plan
a. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.
b. After approval by Owner or Architect of the Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.
c. After testing is complete, submit completed Pretest Checklist.
d. Pretest Checklist: Submit the following list with items checked off once verified:
1) Detailed explanation for any items that are not completed or verified.
2) Required mechanical installation work is successfully completed and HVAC equipment is working correctly.

3) HVAC equipment motors operate below full-load amperage ratings.
4) Required DDC system components, wiring, and accessories are installed.
5) Installed DDC system architecture matches approved Drawings.
6) Control electric power circuits operate at proper voltage and are free from faults.
7) Required surge protection is installed.
8) DDC system network communications function properly, including uploading and downloading programming changes.
9) Using BACnet protocol analyzer, verify that communications are error free.
10) Each controller's programming is backed up.
11) Equipment, products, tubing, wiring cable, and conduits are properly labeled.
12) All I/O points are programmed into controllers.
13) Testing, adjusting, and balancing work affecting controls is complete.
14) Dampers and actuators zero and span adjustments are set properly.
15) Each control damper and actuator goes to failed position on loss of power and loss of signal.
16) Valves and actuators zero and span adjustments are set properly.
17) Each control valve and actuator goes to failed position on loss of power and loss of signal.
18) Meter, sensor, and transmitter readings are accurate and calibrated.
19) Control loops are tuned for smooth and stable operation.
20) View trend data where applicable.
21) Each controller works properly in standalone mode.
22) Safety controls and devices function properly.
23) Interfaces with fire-alarm system function properly.
24) Electrical interlocks function properly.
25) Operator workstations and other interfaces are delivered, all system and database software is installed, and graphics are created.
26) Record Drawings are completed.

e. Test Plan:
1) Prepare and submit validation Test Plan including test procedures for performance validation tests.
2) Address all specified functions of DDC system and sequences of operation in Test Plan.
3) Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4) Explain method for simulating necessary conditions of operation used to demonstrate performance.
5) Include Test Checklist to be used to check and initial that each test has been successfully completed.
6) Submit Test Plan documentation twenty business days before start of tests.

3. Fully commission the entire BAS. All commissioning shall be fully documented and all documentation shall be submitted prior to Demonstration and Acceptance testing.
a. Commissioning shall include a point-to-point • check-out of all I/O points in the DDC system.
b. Verify that all Temperature Control Panels (TCP), BAS equipment, controllers, devices and sensors are installed and operational according to the specifications, submittals and manufacturer¢s installation and application instructions.
c. Calibrate all inputs by comparing the actual site condition with the B-AWS point display.
d. Verify all outputs from B-AWS command to observed response of controlled device.
e. Verify failure response and fail-safe conditions of all devices and safeties.
f. Each control program shall be fully commissioned and tested for complete design intent compliance and functionality.
1) Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
g. Verify overall network performance of BAS for complete design intent compliance and functionality with all devices on-line, communicating and fully-operational.
h. Subsystems not directly controlled by the BAS but associated with the ATC shall also be fully tested and commissioned as to design intent compliance and functionality.
i. Validation Test:
1) Verify operating performance of each I/O point in DDC system.
a) Verify analog I/O points at operating value.
b) Make adjustments to out-of-tolerance I/O points.

c) Identify I/O points for future reference.
d) Simulate abnormal conditions to demonstrate proper function of safety devices.
e) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2) Simulate conditions to demonstrate proper sequence of control.
3) Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4) 24 hours after initial validation test, do as follows:
a) Re-check I/O points that required corrections during initial test.
b) Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
5) 24 Hours after second validation test, do as follows:
a) Re-check I/O points that required corrections during second test.
b) Continue validation testing until I/O point is normal on two consecutive tests.
6) Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7) After validation testing is complete, prepare and submit report indicating results of testing. For all I/O points that required correction, indicate how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

j. DDC System Response Time Test:
1) Simulate HLC.
a) Heavy load to be occurrence of 50 percent of total connected binary COV, one-half of which represents "alarm" condition, and 50 percent of total connected analog COV, one-half of which represents "alarm" condition, that are initiated simultaneously on a one-time basis.
2) Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3) Measure with timer having at least 0.1-second resolution and 0.01 percent accuracy.
4) Purpose of test is to demonstrate DDC system, as follows:
a) Reaction to COV and alarm conditions during HLC.
b) Ability to update DDC system database during HLC.
5) Passing test is contingent on the following:
a) Alarm reporting at printer beginning no more than two seconds after initiation (time zero) of HLC.
b) All alarms, both binary and analog, are reported and printed; none are lost.
c) Compliance with response times specified.
6) Prepare and submit report documenting HLC tested and results of test including time stamp and print out of all alarms.

k. DDC System Network Bandwidth Test:
1) Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2) To pass, none of DDC system networks are to use more than 70 percent of available bandwidth under normal and HLC operation.

4. Calibrate instruments.
a. Make three-point calibration test for both linearity and accuracy for each analog instrument.
5. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
6. Control System Inputs and Outputs:
a. Check analog inputs at 0, 50, and 100 percent of span.
b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
c. Check digital inputs using jumper wire.
d. Check digital outputs using ohmmeter to test for contact making or breaking.
e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
7. Flow:
a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
b. Manually operate flow switches to verify that they make or break contact.
8. Pressure:

a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

9. Temperature:
   a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
   b. Calibrate temperature switches to make or break contacts.
10. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
11. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
12. Provide diagnostic and test instruments for calibration and adjustment of system.
13. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

D. Demonstration and Acceptance
1. Demonstrate compliance of the BAS with the contract documents and operational functionality pursuant with the design Sequences of Operation. Using the documented calibration and commissioning test data the Owner and/or its representative shall select, at random, results to be demonstrated. At least 95% of the results demonstrated must perform as specified and documented on commissioning data sheets or the system must be re-calibrated and re-commissioned before being re-tested.
2. When the Calibration, Commissioning, Demonstration and Acceptance process has been completed and approved by Owner, obtain signed letter from Owner indicating Acceptance within thirty (30) days of approval.

3.17 TRAINING

A. Provide instruction on the adjustment, operation and maintenance of the BAS as installed including all hardware and software provided by a manufacturer-trained, competent application engineer and/or technician with sufficient experience in the installation, programming and operation of the BAS. Provide all training equipment and material.

B. Training Schedule:
1. Schedule training with Owner 20 business days before expected Substantial Completion.
2. Schedule training to provide Owner with at least 10 business days of notice in advance of training.
3. Training to occur within normal business hours at mutually agreed on time. Unless otherwise agreed to, training to occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session to be split in half with 15 -minute break between sessions. Morning and afternoon sessions to be separated by 30 -minute lunch period. Training, including breaks and excluding lunch period, are not to exceed eight hours per day.
4. Provide staggered training schedule as requested by Owner.

C. Training Attendee List and Sign-in Sheet:
1. Request from Owner in advance of training a proposed attendee list with name, phone number, and email address.
2. Provide preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Include preprinted sign-in sheet with training session number, date and time, instructor name, phone number, email address, and brief description of content to be covered during session. List attendees with columns for name, phone number, and email address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an email with attachment of scanned copy (PDF) of circulated sign-in sheet for each session. Indicate which attendees, if any, joined for only part of training sessions.

D. Attendee Training Manuals:

1. Provide each attendee with color hard copy of all training materials and visual presentations.
2. Organize hard-copy materials in three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes DVD or flash drive with PDF copy of all hard-copy materials.

E. Organization of Training Sessions:
1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
   a. Daily operators.
   b. Advanced operators.
   c. System managers and administrators.
2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions to ensure DDC system security.

F. Training Outline:
1. Submit training outline for Owner review at least ten business day before scheduling training.
2. Include in outline a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session, and synopses for each lesson planned.

G. On-Site Training:
1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
2. Provide training materials, projector, and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. Include on-site training with regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
5. Use operator workstation that is to be used with DDC system in the training. If operator workstations are unavailable, provide temporary workstation to convey training content.

H. Training Content for Daily Operators:
1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm, and each unique optimization routine.
5. Operating operator workstations, printers, and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports, and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.

25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
    a. Operation of HVAC equipment in normal-off, normal-on, and failed conditions while observing individual equipment, dampers, and valves for correct position under each condition.
    b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
    c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles, and other modes of operation indicated.
    d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
    e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
    f. Each control loop responds to set-point adjustment and stabilizes within time period indicated.
    g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

I. Training Content for Advanced Operators:
1. Making and changing workstation graphics.
2. Creating, deleting, and modifying alarms including annunciation and routing.
3. Creating, deleting, and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
4. Creating, deleting, and modifying reports.
5. Creating, deleting, and modifying points.
6. Creating, deleting, and modifying programming including ability to edit control programs offline.
7. Creating, deleting, and modifying system graphics and other types of displays.
8. Adding DDC controllers and other network communication devices such as gateways and routers.
9. Adding operator workstations.
10. Performing DDC system checkout and diagnostic procedures.
11. Performing DDC controllers operation and maintenance procedures.
12. Performing operator workstation operation and maintenance procedures.
13. Configuring DDC system hardware including controllers, workstations, communication devices, and I/O points.
14. Maintaining, calibrating, troubleshooting, diagnosing, and repairing hardware.
15. Adjusting, calibrating, and replacing DDC system components.

J. Training Content for System Managers and Administrators:
1. DDC system software maintenance and backups.
2. Uploading, downloading, and offline archiving of all DDC system software and databases.
3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.
6. Operator password assignments and modification.
7. Operator authority assignment and modification.
8. Workstation data segregation and modification.

K. Video of Training Sessions:
1. Provide digital video and audio recording of each training session. Create separate recording file for each session.
2. Stamp each recording file with training session number, session name, and date.
3. Provide Owner with two copies of digital files on cloud and flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION

SECTION 231123 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Joining materials.
4. Manual gas shutoff valves.
5. Pressure regulators.
6. Service meters.
7. Dielectric fittings.

B. Related Requirements:
1. Section 013573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. An example includes rooftop locations.

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

D. 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.

1.3 ACTION SUBMITTALS

A. Product Data:
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. Detail mounting, supports, and valve arrangements for pressure regulator assembly.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Welding certificates.

C. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

D. Field quality-control reports.

E. Qualification Statements: For professional engineer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For motorized gas valves pressure regulators service meters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with the ASME Boiler and Pressure Vessel Code.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping in accordance with requirements of authorities having jurisdiction.

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

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

1.8 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 in accordance with requirements indicated:
   1. Notify Owner no fewer than two 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.

1.9 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed and concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."

C. Coordinate requirements for piping identification for natural-gas piping. Comply with requirements in Section 220553 "Identification of Plumbing Piping and Equipment."

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each product type from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 54 the International Fuel Gas Code.

B. Minimum Operating-Pressure Ratings:
   1. Piping and Valves: 100 psig (690 kPa) minimum unless otherwise indicated.
   2. Service Regulators: 65 psig (450 kPa) minimum unless otherwise indicated.
   3. Minimum Operating Pressure of Service Meter: 5 psig (34.5 kPa) .

C. Natural-Gas System Pressure within Buildings:
   1. Single Pressure: More than 0.5 psig (3.45 kPa), but not more than 5 psig (13.8 kPa).
   2. Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa), but not more than 5 psig (13.8 kPa), and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, 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 A234/A234M 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.
6. Mechanical Couplings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Baker Hughes Company.
      2) Smith-Blair, a Xylem brand.
   b. Stainless steel flanges and tube with epoxy finish.
   c. NBR seals.
   d. Stainless steel bolts, washers, and nuts.
   e. Coupling is to be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
   f. Steel body couplings installed underground on plastic pipe are to be factory equipped with anode.

2.4 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
   1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
   2. Operating-Pressure Rating: 1 psig **(**3.45 kPa**)**.
   3. End Fittings: Zinc-coated steel.
   4. Threaded Ends: Comply with ASME B1.20.1.
   5. Maximum Length: 72 inches **(**1830 mm**)**.

B. Y-Pattern Strainers:
   1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
   2. End Connections: Threaded ends for NPS 2 **(**DN 50**)** and smaller; flanged ends for NPS 2-1/2 **(**DN 65**)** and larger.
   3. Strainer Screen: 40 60-mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
   4. CWP Rating: 125 psig **(**862 kPa**)**.

C. Weatherproof Vent Cap:
   1. 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.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.6 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 **(**DN 50**)** and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig **(**862 kPa**)**.
   2. Threaded Ends: Comply with ASME B1.20.1.
   3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   4. Tamperproof Feature: Locking feature for valves indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
   5. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch **(**25 mm**)** and smaller.

6. Service Mark: Valves NPS 1-1/4 to NPS 2 (DN 32 to DN 50) having initials "WOG" permanently marked on valve body.

B. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig (862 kPa).
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
4. Service Mark: Initials "WOG" permanently marked on valve body.

C. 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 Valves; a part of Aalberts Integrated Piping Systems.
   c. BrassCraft Manufacturing Co.; a Masco company.
2. Body: Bronze, complying with ASTM B584.
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. Listing: Valves NPS 1 (DN 25) and smaller are to 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.

D. 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 B584.
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 (862 kPa).
7. Listing: Valves NPS 1 (DN 25) and smaller are to 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.

E. Cast-Iron, Lubricated 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. Flowserve Corporation.
   c. Homestead Valve: a division of Olson Technologies, Inc.
   d. Milliken Valve Company; a Mueller brand.
   e. Mueller Co. LLC; Mueller Water Products, Inc.
   f. R & M Energy Systems; Robbins & Myers.
2. Body: Cast iron, complying with ASTM A126, 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 (862 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller are to 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.
    a. Honeywell Building Solutions; Honeywell International, Inc.
    b. Johnson Controls, Inc.

2.7 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 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80A.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Meter Company.
   b. Fischer; Emerson Electric Co., Automation Solutions.
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: NBR; resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: UV-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 regulator.
9. Pressure regulator is to maintain discharge pressure setting downstream and is to not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Maximum Inlet Pressure: Insert pressure.

C. Line Pressure Regulators: Comply with ANSI Z21.80A.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Actaris: a brand of ITT Controls.
   b. American Meter Company.
   c. Dormont; A Watts Water Technologies Company.
   d. Eclipse Innovative Thermal Technologies.
   e. Fischer; Emerson Electric Co., Automation Solutions.
   f. Itron Inc.
   g. Maxitrol Company.
   h. Richards Industrials.
   i. Schneider Electric USA, Inc.
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: NBR; resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: UV-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 regulator.
9. Pressure regulator is to maintain discharge pressure setting downstream and is to 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.
12. Maximum Inlet Pressure: 5 psig (34.5 kPa) .

D. 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. Maxitrol Company.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: NBR.
6. Seal Plug: UV-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 (6.9 kPa) .

2.8 SERVICE METERS

A. Turbine Meters: Comply with ASME MFC-4M.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Meter Company.
   b. Schneider Electric USA, Inc.
2. Housing: Cast iron or welded steel.
3. Connection Threads or Flanges: Steel.
4. Turbine: Aluminum or plastic.
5. Turbine Bearings: Self-lubricating.
6. Compensation: Continuous temperature and pressure.
7. Meter Index: Cubic feet.
8. Tamper resistant.
9. Remote meter reader compatible.
10. Maximum Inlet Pressure: 100 psig **(**690 kPa**)**.
11. Accuracy: Maximum plus or minus 2.0 percent.

B. Service-Meter Bars:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. A.Y. McDonald Mfg. Co.
   b. American Meter Company.
   c. Itron Inc.
   d. Mueller Co. LLC; Mueller Water Products, Inc.
2. Malleable- or cast-iron frame for supporting service meter.
3. Include offset swivel pipes, meter nuts with O-ring seal, and factory- or field-installed dielectric unions.
4. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.

C. Service-Meter Bypass Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. R.W. Lyall; brand of Hubbell Utility Solutions; Hubbell Incorporated.
   b. Williamson, T. D., Inc.
2. Ferrous, tee, pipe fitting with capped side inlet for temporary natural-gas supply.
3. Integral ball-check bypass valve.

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:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. A.Y. McDonald Mfg. Co.
   b. Jomar Valve.
   c. WATTS; A Watts Water Technologies Company.
   d. Wilkins.
   e. Zurn Industries, LLC.
2. Description:
   a. Standard: ASSE 1079.
   b. Pressure Rating: 125 psig **(**860 kPa**)** minimum at 180 deg F (82 deg C) .
   c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Capitol Manufacturing Company.
   b. WATTS; A Watts Water Technologies Company.
   c. Wilkins.
2. Description:
   a. Standard: ASSE 1079.
   b. Factory-fabricated, bolted, companion-flange assembly.
   c. Pressure Rating: 125 psig **(**860 kPa**)** minimum at 180 deg F (82 deg C) .
   d. 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, LLC.
   b. CALPICO, Inc.
2. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig **(**1035 kPa**)**.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

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 **(**150 mm**)** wide and 4 mils **(**0.1 mm**)** thick, continuously inscribed with a description and rated pressure 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 **(**750 mm**)** 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 in accordance with NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 requirements for preventing accidental ignition.

3.3 INSTALLATION OF OUTDOOR PIPING

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches **(**900 mm**)** below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
1. If natural-gas piping is installed less than 36 inches **(**900 mm**)** below finished grade, install it in containment conduit.

C. 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.
3. Replace pipe having damaged PE coating with new pipe.

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

E. Install pressure gauge upstream and downstream from each service regulator. Pressure gauges are specified in Section 230500 "Common Work Results for HVAC."

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 **(**75 mm**)** 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 **(**13.8 kPa**)** with valve and cap.

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 **(**DN 50**)** 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 230500 "Common Work Results for HVAC."

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

3.5 INSTALLATION OF SERVICE-METER ASSEMBLIES

A. Install service-meter assemblies aboveground, on concrete bases.

B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.

C. Install strainer on inlet of service-pressure regulator and meter set.

D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.

E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.

F. Install service meters downstream from pressure regulators.

G. Install metal bollards to protect meter assemblies. Comply with requirements in Section 055000 "Metal Fabrications" for pipe bollards.

3.6 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. Install anode for metallic valves in underground PE piping.

F. Do not install valves in return-air plenums.

3.7 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.

E. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

3.8 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC 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 **(**300 mm**)** 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.

3.9 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 **(**1800 mm**)** of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

3.10 LABELING AND IDENTIFICATION

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches **(**300 mm**)** below finished grade, except 6 inches **(**150 mm**)** below subgrade under pavements and slabs.

3.11 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Test, inspect, and purge natural gas in accordance with the International Fuel Gas Code and authorities having jurisdiction.
2. Natural-gas piping will be considered defective if it does not pass tests and inspections.

B. Prepare test and inspection reports.

3.12 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.13 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping is to be the following:
1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
2. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground natural-gas piping is to be one of the following:
1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa)

A. Aboveground, branch piping NPS 1 **(**DN 25**)** and smaller is to be one of the following:
1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping is to be one of the following:
1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

C. Underground, below building, piping is to be one of the following:
1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

3. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
4. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground portion of vent pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG (3.45 kPa) AND LESS THAN 5 PSIG (34.5 kPa)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller is to be the following:
1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping is to be one of the following:
1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with steel welding fittings and welded joints.

C. Underground, below building, piping is to be one of the following:
1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.
3. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.
4. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground portion of vent pipe and fittings with protective coating for steel piping.

3.16 UNDERGROUND, MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.

B. Underground:
1. NPS 2 (DN 50) and Smaller: Bronze plug valves.
2. NPS 2-1/2 (DN 65) and Larger: Cast-iron, lubricated plug valves.

3.17 ABOVEGROUND, MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter are to be one of the following:
1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full -port, bronze ball valves with bronze trim.
3. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 (DN 65) and larger at service meter are to be one of the following:
1. Two-piece, full -port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller are to be one of the following:
1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full -port, bronze ball valves with bronze trim.
3. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger are to be one of the following:
1. Two-piece, full regular-port, bronze ball valves with bronze trim.
2. Bronze plug valve.
3. Cast-iron, lubricated plug valve.

E. Valves in branch piping for single appliance are to be one of the following:
1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full -port, bronze ball valves with bronze trim.
3. Bronze plug valve.

END OF SECTION

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Stainless steel pipe and fittings.
4. Piping joining materials.
5. Transition fittings.
6. Dielectric fittings.

B. Related Requirements:
1. Section 013573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:
1. Pipe and tube.
2. Fittings.
3. Joining materials.
4. Transition fittings.

B. Delegated-Design Submittal: Refer to Section 013573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.
1. Provide delegated-design submittal for the following:
a. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
b. Locations of pipe anchors, alignment guides, and expansion joints and loops.
c. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
d. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, or BIM model, drawn to scale, indicating the items described in this Section, and coordinated with all building trades.

B. Qualification Data: For Installer.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Installer Qualifications:
1. Installers of Pressure-Sealed Joints: Installers are to be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP are to be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

B. Steel Support Welding: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.

C. Pipe Welding: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code: Section IX.
1. Comply with ASME B31.9 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 are to be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
   1. Hot-Water Heating Piping: 200 psig (689 kPa) at 200 deg F (93 deg C).
   2. Makeup-Water Piping: 150 psig (1034 kPa) at 73 deg F (22 deg C).
   3. Air-Vent Piping: 180 deg F (82 deg C).
   4. Pressure-Relief-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: [ASTM B88, Type K (ASTM B88M, Type A)] [and] [ASTM B88, Type L (ASTM B88M, Type B)].

B. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4 (DN 100).

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M black steel with plain ends; welded and seamless, Grade B, and schedule number as indicated in Part 3,"Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3, "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3, "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3, "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A234/A234M; wall thickness to match adjoining pipe.

G. 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.

H. Grooved Mechanical-Joint Fittings and Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
      b. Star Pipe Products.
      c. Victaulic Company.
   2. Source Limitations: Obtain grooved mechanical-joint fittings and couplings from single manufacturer.
   3. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, 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.
   4. 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.

2.4 PIPING 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 (3.2-mm) maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face, Class 300, cast-iron and cast-bronze flanges.

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

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

2.5 DIELECTRIC FITTINGS

A. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. A.Y. McDonald Mfg. Co.
   b. WATTS.
   c. Wilkins.
   d. Zurn Industries, LLC.
2. Description:
   a. Standard: ASSE 1079.
   b. Pressure Rating: 250 psig **(**1725 kPa**)**.
   c. End Connections: Solder-joint copper alloy and threaded ferrous. Solder joints are not to be used on pipe sizes greater than NPS 4 **(**DN 100**)**.

B. 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. Description:
   a. Standard: ASSE 1079.
   b. Factory-fabricated, bolted, companion-flange assembly.
   c. Pressure Rating: 300 psig **(**2070 kPa**)**.
   d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-Water Heating Piping, Aboveground, NPS 2 **(**DN 50**)** and Smaller, to Be Any of the Following:
1. Type K **(**Type A**)**, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40, Grade B, steel pipe; Class 300, malleable-iron fittings; and threaded joints.

B. Hot-Water Heating Piping, Aboveground, NPS 2-1/2 **(**DN 65**)** and Larger, to Be Any of the Following:
1. Schedule 40, Grade B, steel pipe; Class 300 malleable-iron fittings; welded joints, cast-iron flanges, flange-fittings, and flanged joints.

C. Chilled-Water Piping, Aboveground, NPS 2 **(**DN 50**)** and Smaller, to be Any of the Following:
1. Schedule 40, Grade B steel pipe; Class 300, malleable-iron fittings; and threadedor grooved mechanical joints.

D. Chilled-Water Piping, Aboveground, NPS 2-1/2 **(**DN 65**)** and Larger, to Be Any of the Following:
1. Schedule 40, Grade B, steel pipe; grooved mechanical joint coupling and fittings; and grooved mechanical joints.
2. Schedule 40, Grade B, steel pipe, plain-end mechanical joint coupling and fittings; and plain-end mechanical joints.

E. Condenser-Water Piping, Aboveground, NPS 2-1/2 **(**DN 65**)** and Larger, to Be Any of the Following:
1. Schedule 40, Grade B, steel pipe; grooved, mechanical joint coupling and fittings; and grooved mechanical joints.
2. Schedule 40, steel pipe, plain-end mechanical joint coupling and fittings; and plain-end mechanical joints.

F. Makeup-Water Piping Installed Aboveground to Be Any of the Following:
1. Type K **(**Type A**)**, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

G. 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 **(**Type A**)**, annealed-temper copper tubing with soldered or flared joints.

H. Pressure-Relief-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed, with metal-to-plastic transition fittings for plastic piping systems, according to piping manufacturer's written instructions.

3.2 INSTALLATION OF PIPING

A. 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.

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 **(**DN 20**)** ball valve, and short NPS 3/4 **(**DN 20**)** threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

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

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

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to the following:
1. SECTION **230523** - **GENERAL-DUTY VALVES FOR HVAC PIPING**

Q. Install air vents and pressure-relief valves in accordance with Section 232116 "Hydronic Piping Specialties."

R. Install unions in piping, NPS 2 **(**DN 50**)** and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

S. Install flanges in piping, NPS 2-1/2 **(**DN 65**)** and larger, at final connections of equipment and elsewhere as indicated.

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

U. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

V. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 JOINT CONSTRUCTION

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

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

C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

D. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

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

F. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators in accordance with "Quality Assurance" Article.

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

3.4 INSTALLATION OF DIELECTRIC FITTINGS

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

B. Dielectric Fittings for NPS 2 **(**DN 50**)** and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4 **(**DN 65 to DN 100**)**: Use dielectric flanges .

D. Dielectric Fittings for NPS 5 **(**DN 125**)** and Larger: Use dielectric flange kits.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

C. Install hangers for copper tubing and 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 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. Install hangers for fiberglass 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.

F. Support horizontal piping within 12 inches **(**300 mm**)** of each fitting and coupling.

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

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections are to be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gauges for HVAC Piping."

3.7 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

3.8 SYSTEM STARTUP

A. Perform the following before operating the system:
1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.9 FIELD QUALITY CONTROL

A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure is to be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install pressure-relief valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
1. Use ambient-temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure is not to exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9.
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

END OF SECTION

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Hydronic specialty valves.
2. Air vents.
3. Expansion tanks and fittings.
4. Air/dirt separators and purgers.
5. Strainers.
6. Flexible connectors.

B. Related Requirements:
1. Section 230500 "Common Work Results for HVAC" for expansion fittings and loops.
2. Section 230523 "General-Duty Valves for HVAC Piping" for specification and installation requirements for general-duty valves common to most piping systems.

1.2 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.

1.3 CLOSEOUT SUBMITTALS

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

1.4 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators in accordance with ASME BPVC, Section IX.

B. Pressure-relief and safety-relief valves and pressure vessels bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC, Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Armstrong Fluid Technology.
b. Bell & Gossett; a Xylem brand.
c. Flamco; a division of AALBERTS Ind.
d. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
e. NIBCO INC.
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 Gauge 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 **(**860 kPa**)**.
10. Maximum Operating Temperature: 250 deg F (121 deg C).

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Armstrong Fluid Technology.
b. Bell & Gossett; a Xylem brand.
c. Flamco; a division of AALBERTS Ind.
d. IMI Flow Design, Inc.
e. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
2. Body: Cast-iron or steel body, ball, butterfly, 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 Gauge 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 **(**860 kPa**)**.
11. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Automatic Flow-Control Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil; an ASC Engineered Solution.
   b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   c. Bell & Gossett; a Xylem brand.
   d. Caleffi North America.
   e. Flowcon Americas LLC.
   f. Griswold Controls, LLC.
   g. Hays Fluid Controls.
   h. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
   i. NIBCO INC.
   j. NuTech Hydronic Specialty Products.
   k. Oventrop Corporation.
   l. Spence Engineering Company, Inc.
   m. Tunstall Corporation.
   n. Victaulic Company.
   o. WATTS; A Watts Water Technologies Company.
2. Body: Brass or ferrous metal.
3. Combination Assemblies: Include bronze or brass-alloy ball valve.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Size and Capacity: For each application, provide a valve with rated capacity equal to or greater than capacity of device being served.
6. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
7. Minimum CWP Rating: [175 psig **(**1207 kPa**)**] [300 psig **(**2070 kPa**)**].
8. Maximum Operating Temperature: [200 deg F (93 deg C)] [250 deg F (121 deg C)].

2.2 AIR VENTS

A. Manual Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   b. Bell & Gossett; a Xylem brand.
   c. HCI; Hydronics Components Inc.
   d. Taco Comfort Solutions.
   e. WATTS; A Watts Water Technologies Company.
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/8 (DN 6).
7. CWP Rating: 150 psig **(**1035 kPa**)**.
8. Maximum Operating Temperature: 225 deg F (107 deg C).

B. Automatic Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   b. Bell & Gossett; a Xylem brand.
   c. Caleffi North America.
   d. Flo Fab Inc.
   e. Metraflex Company (The).
   f. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
   g. NuTech Hydronic Specialty Products.
   h. Oventrop Corporation.

i. Taco Comfort Solutions.
j. WATTS; A Watts Water Technologies Company.

2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/4 (DN 8).
7. CWP Rating: 150 psig **(**1035 kPa**)**.
8. Maximum Operating Temperature: 240 deg F (116 deg C).

2.3 EXPANSION TANKS AND FITTINGS

A. Diaphragm-Type ASME Expansion Tanks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. AMTROL, Inc.
b. Armstrong Fluid Technology.
c. Bell & Gossett; a Xylem brand.
d. Taco Comfort Solutions.
2. Tank: Welded steel, rated for 125 psig **(**860 kPa**)** working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
3. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

B. Bladder-Type ASME Expansion Tanks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Armstrong Fluid Technology.
b. Bell & Gossett; a Xylem brand.
c. Flo Fab Inc.
d. Taco Comfort Solutions.
e. WATTS; A Watts Water Technologies Company.
2. Tank: Welded steel, rated for 125 psig **(**860 kPa**)** working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity. Field-replaceable bladder.
4. Sight glass.
5. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.4 AIR/DIRT SEPARATORS AND PURGERS

A. Tangential-Type Air Separators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. AMTROL, Inc.
b. Armstrong Fluid Technology.
c. Bell & Gossett; a Xylem brand.
d. Spirotherm, Inc.
2. Tank: Welded steel; ASME constructed and labeled for 125 psig **(**860 kPa**)** minimum working pressure and 375 deg F (191 deg C) maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 **(**DN 50**)** and smaller; flanged connections for NPS 2-1/2 **(**DN 65**)** and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

B. In-Line Air Separators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Armstrong Fluid Technology.
b. Bell & Gossett; a Xylem brand.
c. Caleffi North America.
d. Flo Fab Inc.
e. Taco Comfort Solutions.
f. WATTS; A Watts Water Technologies Company.

2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
3. Maximum Working Pressure: Up to 175 psig (1207 kPa).
4. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

C. Air Purgers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bell & Gossett; a Xylem brand.
   b. Griswold Controls, LLC.
   c. Taco Comfort Solutions.
   d. WATTS; A Watts Water Technologies Company.
2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig (1035 kPa).
4. Maximum Operating Temperature: 250 deg F (121 deg C).

2.5 STRAINERS

A. Y-Pattern Strainers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. FNW; Ferguson Enterprises, Inc.
   b. Metraflex Company (The).
   c. WATTS; A Watts Water Technologies Company.
   d. Zurn Industries, LLC.
2. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
3. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
4. Strainer Screen: Stainless steel, 20-mesh strainer, or perforated stainless steel basket.
5. CWP Rating: 125 psig (860 kPa).

2.6 FLEXIBLE CONNECTORS

A. Stainless Steel Bellows, Flexible Connectors:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flexicraft Industries.
   b. Flo Fab Inc.
   c. Metraflex Company (The).
2. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
3. End Connections: Threaded or flanged to match equipment connected.
4. Performance: Capable of 3/4-inch (20-mm) misalignment.
5. CWP Rating: 150 psig (1035 kPa).
6. Maximum Operating Temperature: 250 deg F (121 deg C).

B. Spherical, Rubber, Flexible Connectors:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flexicraft Industries.
   b. Flo Fab Inc.
   c. Metraflex Company (The).
2. Body: Fiber-reinforced rubber body.
3. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
4. Performance: Capable of misalignment.
5. CWP Rating: 150 psig (1035 kPa).
6. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine all piping specialties 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. Examine threads on all devices for form and cleanliness.

C. 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.

D. Do not attempt to repair defective piping specialties; replace with new devices. Remove defective piping specialties from site.

3.2 INSTALLATION OF VALVES

A. Install calibrated-orifice balancing valve at each branch connection to return main.

B. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.

C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

D. Install pressure-relief and safety-relief valves at hot-water generators and elsewhere as required by ASME BPVC. Pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME BPVC, Section VIII, Division 1, for installation requirements.

3.3 HYDRONIC SPECIALTIES INSTALLATION

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

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.
   1. Provide air outlet drain line full size of air outlet to floor drain or to other point indicated on Drawings.

C. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 **(**DN 50**)** and larger.

E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve full size of separator outlet; extend full size to nearest floor drain.

F. Install expansion tanks having direct air/water interface above the air separator or air purger. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
   1. Install tank fittings that are shipped loose.
   2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, and fittings, plus tank full of water. Do not overload building components and structural members.
   3. Install piping from air separator or air purger to expansion tank with a 2 percent upward slope toward tank to avoid air entrapment.

G. Install diaphragm- or bladder-type expansion tanks on the floor.

H. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Separately coupled, base-mounted, end-suction centrifugal pumps.

1.2 DEFINITIONS

A. ECM: Electronically commutated motor.

B. EPDM: Ethylene propylene diene monomer.

C. EPR: Ethylene propylene rubber.

D. FKM: Fluoroelastomer polymer.

E. HI: Hydraulic Institute.

F. NBR: Nitrile rubber or Buna-N.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pump.
   1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
   2. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.
   1. Show pump layout and connections.
   2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates for pumps, 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.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ITT Corporation.
   2. Taco Comfort Solutions.

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump with flexible shaft coupling as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

D. Pump Construction:
1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring realignment of pump and motor shaft.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Type 316 stainless steel.
4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and EPDM bellows and gasket.
5. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

E. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor.

F. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

G. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

H. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
1. Enclosure: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Variable-speed motor.
6. Provide integral pump motor variable-speed controller.

2.3 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:
1. Angle pattern.
2. 300-psig **(**2060-kPa**)** pressure rating, [cast] [ductile]-iron body and end cap, pump-inlet fitting.
3. Bronze 16-mesh wire startup and [bronze] [Type 304 stainless steel] permanent strainers with 3/16-inch **(**4.8-mm**)** perforations and 51 percent open area).
4. Type 304 stainless steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

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

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

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Equipment Mounting:
1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.

C. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

D. Comply with pump and coupling manufacturers' written instructions.

E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

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

E. Install triple-duty valve on discharge side of pumps.

F. Install suction diffuser and shutoff valve on suction side of pumps.
1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

I. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

3.5 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch **(**13 mm**)** high.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping. Use startup strainer for initial startup.
4. Perform the following startup checks for each pump before starting:
   a. Verify bearing lubrication.
   b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   c. Verify that pump is rotating in correct direction.
5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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

C. Perform tests and inspections[with the assistance of a factory-authorized service representative].

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

E. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION

SECTION 232213 - STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Steel pipe and fittings.
   2. Joining materials.

B. Related Requirements:
   1. Section 013573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.
   2. Section 232216 "Steam and Condensate Heating Piping Specialties" for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Steel pipe and fittings.
   2. Stainless steel pipe and fittings.
   3. Fiberglass pipe and fittings.
   4. Joining materials.

B. Delegated-Design Submittal: Refer to Section 013573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.
   1. Provide delegated-design submittal including the following:
      a. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
      b. Locations of pipe anchors and alignment guides and expansion joints and loops.
      c. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
      d. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Other building services.
   3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Fiberglass Pipe and Fitting Installers: Installers of fiberglass pipe and fittings shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

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

C. Pipe Welding: Qualify procedures and operators according to the following:
   1. ASME Compliance: Comply with ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," for materials, products, and installation.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a registered design professional, as defined in Section 013573 "Delegated Design Requirements and Procedures" to design steam and condensate heating piping.
   1. Material properties indicated in this Section shall be considered as minimum properties.

B. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
   1. HP Steam Piping:**100** psig **(**kPa**)**.
   2. LP Steam Piping: **15** psig **(**kPa**)**.
   3. Condensate Piping: **5** psig **(**kPa**)** at 250 deg F (121 deg C).

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 300 as indicated in piping applications articles.

C. Malleable-Iron Unions: ASME B16.39; Classes 300 as indicated in piping applications articles.

D. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   1. Material Group: 1.1.
   2. End Connections: Butt welding.
   3. Facings: Raised face.

E. Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch **(**3.2-mm**)** maximum thickness unless otherwise indicated.
      a. Full-Face Type: For flat-face flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel of type to match pipe unless otherwise indicated.

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

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

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 300 cast-iron fittings; and threaded joints.

B. LP Steam Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 40, Type E, Grade B, steel pipe; Class 300 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 (DN 50) and smaller, shall be the following:
   1. Schedule 80, Type S, Grade B, steel pipe; Class 300 cast-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 (DN 65) and larger, shall be the following:
   1. Schedule 80, Type E, Grade B, steel pipe; Class 300 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
   2. Schedule 80, Type S, Grade B, steel pipe; Class 300 cast-iron fittings; and threaded joints.
   3. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

3.2 HP STEAM PIPING APPLICATIONS

A. HP Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 300 cast-iron fittings; and threaded joints.

B. HP Steam Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 80, Type E, Grade B, steel pipe; Class 300 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 (DN 50) and smaller, shall be the following:
   1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 (DN 65) and larger, shall be the following:
   1. Schedule 80, Type E, Grade B, steel pipe; Class 300 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.3 ANCILLARY PIPING APPLICATIONS

A. Vacuum-Breaker Piping: Outlet, same as service where installed.

3.4 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

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

H. Install piping to allow application of insulation.

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

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

K. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) full port-ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install valves according to the following Sections or other Sections as needed:
   1. Section 230523.12 "Ball Valves for HVAC Piping."
   2. Section 230523.13 "Butterfly Valves for HVAC Piping."

P. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

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

S. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and full port ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.
1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet (90 m).
2. Size drip legs same size as main. In steam mains NPS 6 (DN 150) and larger, drip leg size can be reduced, but to no less than NPS 4 (DN 100).

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

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 STEAM AND CONDENSATE PIPING SPECIALTIES

A. Comply with requirements in Section 232216 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic restraints in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers, supports, and anchor devices.

C. Install the following pipe attachments:
1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

D. Install hangers for steel steam supply piping and steel steam condensate 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.

E. Install hangers for fiberglass 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.

F. Support horizontal piping within [12 inches **(**300 mm**)**] <Insert dimension> of each fitting.

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

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

3.7 PIPE JOINT CONSTRUCTION

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

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

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

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

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

3.8 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.9 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

D. Prepare test and inspection reports.

END OF SECTION

SECTION 232216 - STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Steam traps.

B. Related Requirements:
   1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
   2. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
   3. Section 230523 "General Duty Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Strainer.
   2. Flash tank.
   3. Valve.
   4. Steam trap.
   5. Air vent and vacuum breaker.
   6. Connector.
   7. Meter.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to the following:
   1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
   1. HP Steam Piping: 100 psig **(**kPa**)**.
   2. LP Steam Piping: 15 psig **(**kPa**)**.
   3. Condensate Piping: 5 psig **(**kPa**)** at 250 deg F (121 deg C).

2.2 STEAM TRAPS

A. Float and Thermostatic Steam Traps, Cast Iron:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Armstrong International, Inc.
      b. Hoffman Specialty.
      c. Spirax Sarco Limited.
   2. Body and Bolted Cap: ASTM A126 cast iron.
   3. End Connections: Threaded.
   4. Float Mechanism: Replaceable, stainless steel.
   5. Seat: Hardened stainless steel.
   6. Trap Type: Balanced pressure.
   7. Thermostatic Bellows: Stainless steel or monel.
   8. Thermostatic air vent capable of withstanding 45 deg F (25 deg C) of superheat and resisting water hammer without sustaining damage.
   9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless steel cage, valve, and seat.
   10. Maximum Operating Pressure: 125 psig **(**860 kPa**)**.

B. Inverted Bucket Steam Traps, Cast Iron:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Armstrong International, Inc.
b. Hoffman Specialty.
c. Spirax Sarco Limited.
2. Body and Cap: Cast iron.
3. End Connections: Threaded.
4. Head and Seat: Stainless steel.
5. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
6. Bucket: Brass or stainless steel.
7. Strainer: Integral stainless steel inlet strainer within the trap body.
8. Air Vent: Stainless steel thermostatic vent.
9. Pressure Rating: 250 psig **(**1725 kPa**)**.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 INSTALLATION OF PIPING

A. Install piping to permit valve servicing.

B. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) full-port ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Install valves according to Section 230523 "General Duty Valves for HVAC Piping".

D. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.

E. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

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

G. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and full-port ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

H. Flash Tank:
1. Pitch condensate piping down toward flash tank.
2. If more than one condensate pipe discharges into flash tank, install a check valve in each line.
3. Install thermostatic air vent at tank top.
4. Install safety valve at tank top.
5. Install full-port ball valve, and swing check valve on condensate outlet.
6. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for 3 times the calculated heat load.
7. Install pressure gage on low-pressure steam outlet according to Section 230519 "Meters and Gages for HVAC Piping."

3.3 INSTALLATION OF STEAM TRAPS

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.4 INSTALLATION OF SAFETY VALVES

A. Install safety valves according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping."

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2 (DN 65).

3.5 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION

SECTION 232513 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Water treatment for closed-loop hydronic systems.
   2. Manual chemical-feed equipment.
   3. Chemicals.

B. Related Requirements:
   1. Section 232533 "HVAC Makeup-Water Filtration Equipment" for water treatment of water softeners, RO equipment, and filtration equipment.
   2. Section 013573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 DEFINITIONS

A. RO: Reverse osmosis.

B. TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.

C. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
   1. Bypass feeders.

B. Shop Drawings: Pretreatment and chemical-treatment equipment, showing tanks, maintenance space required, and piping connections to hydronic systems.
   1. Include plans, elevations, sections, and attachment details.
   2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

B. Field quality-control reports.

C. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.

D. Water Analysis: Illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aqua-Chem, Inc.
   2. Barclay Water Management, Inc.
   3. Boland Trane Services.
   4. Cascade Water Services, Inc.
   5. Earthwise Environmental Inc.

6. Metro Group, Inc. (The).
7. Nalco; an Ecolab company.
8. Sonitec-Vortisand Inc.
9. Insert manufacturer's name.

2.2 PERFORMANCE REQUIREMENTS

A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including hot-water heating below 250 deg F (120 deg C) shall have the following water qualities:
1. pH: Maintain a value within 8.5-10.5.
2. Steel Corrosion Inhibiters: Provide sufficient inhibitors to limit mild steel corrosion to 2 mils per year. Maintain soluble iron concentrations at or below mg/L.
3. Scale Control: Provide softened water for initial fill and makeup.
4. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Provide steel feeders with corrosion-resistant exterior coating, minimum 3-1/2-inch **(**89-mm**)** fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Provide quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
1. Capacity: 5 gal. **(**19 L**)**.
2. Minimum Working Pressure: 175 psig **(**1210 kPa**)**.

2.4 CHEMICAL-TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounted cabinet for testing pH, corrosion inhibitors, alkalinity, hardness, and other properties recommended by manufacturer.

B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
1. Two -station rack for closed-loop systems.

2.5 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer, compatible with piping system components and connected equipment, and able to attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drain.

B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install water-testing equipment on wall near water-chemical-application equipment.

D. Install interconnecting control wiring for chemical-treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Install automatic fluid make-up equipment for glycol water system, and include the following:
1. Chemical solution tanks.
2. Chemical solution injection pumps.
3. Water meter in makeup supply to system.
4. Pressure switch to operate injection pump as necessary to maintain glycol system pressure.

3.3 PIPING CONNECTIONS

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

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

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General-Duty Valves for HVAC Piping."

E. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

3.4 FIELD QUALITY CONTROL

A. Testing Agency:
1. Engage a qualified testing agency to perform tests and inspections.

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

C. Perform tests and inspections[with the assistance of a factory-authorized service representative].

D. Tests and Inspections:
1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig **(**345 kPa**)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials, and retest piping until no leaks exist.

E. Equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. At four -week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis, advising Owner of changes necessary to adhere to "Performance Requirements" Article.

H. Comply with ASTM D3370 and with the following standards:
1. Silica: ASTM D859.
2. Acidity and Alkalinity: ASTM D1067.
3. Iron: ASTM D1068.
4. Water Hardness: ASTM D1126.

3.5 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:
   1. Initial water analysis and HVAC water-treatment recommendations.
   2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
   3. Periodic field service and consultation.
   4. Customer report charts and log sheets.
   5. Laboratory technical analysis.
   6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION

SECTION 232533 - HVAC MAKEUP-WATER FILTRATION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following HVAC water filtration equipment:
   1. HVAC makeup-water softeners.
   2. Centrifugal separators.
   3. Water-softener chemicals.

B. Related Requirements:
   1. Section 013573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 DEFINITIONS

A. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
   1. Water softeners.
   2. Centrifugal separators.

B. Shop Drawings: Softeners and filtration equipment, maintenance space required, and piping connections to HVAC systems.
   1. Include plans, elevations, sections, and attachment details.
   2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, water softeners, and controllers to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 HVAC MAKEUP-WATER SOFTENER

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   1. Culligan International Company.
   2. Marlo Incorporated.
   3. Pentair, Inc.

C. Description: Twin mineral tanks and one brine tank, factory mounted on skid.

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. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.

F. Mineral Tanks:
   1. Fabricate and label fiber-reinforced plastic (FRP) filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
   2. Pressure Rating: 100 psig **(**690 kPa**)** minimum.
   3. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F **(**5 to at least 38 deg C**)**.

4. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
5. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
6. Upper Distribution System: Single-point type, fabricated from galvanized-steel pipe and fittings.
7. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging polyethylene strainers; arranged for even-flow distribution through resin bed.

G. Controls: Automatic; factory mounted on mineral tanks and factory wired.
1. Adjustable duration of regeneration steps.
2. Push-button start and complete manual operation override.
3. Pointer on pilot-control valve shall indicate cycle of operation.
4. Means of manual operation of pilot-control valve if power fails.
5. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
   a. Slow opening and closing, nonslam operation.
   b. Diaphragm guiding on full perimeter from fully open to fully closed.
   c. Isolated dissimilar metals within valve.
   d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
   e. Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
   f. Sampling cocks for soft water.
6. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons **(**liters**)** and that automatically resets after regeneration to preset total in gallons **(**liters**)** for next service run. Include alternator to regenerate one mineral tank with the other in service.

H. Brine Tank: Combination measuring and wet-salt storing system.
1. Tank and Cover Material: Fiberglass a minimum of 3/16 inch **(**4.8 mm**)** thick; or molded polyethylene a minimum of 3/8 inch **(**9.5 mm**)** thick.
2. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
3. Size: Large enough for at least four regenerations at full salting.

I. Factory-Installed Accessories:
1. Piping, valves, tubing, and drains.
2. Sampling cocks.
3. Main-operating-valve position indicators.
4. Water meters.

J. Water Test Kit: Include in wall-mounting enclosure for water softener.

K. Capacities and Characteristics: As scheduled on the Drawings.

2.2 CENTRIFUGAL SEPARATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. LAKOS; Claude Laval Corporation.
2. PEP Filters, Inc.

B. Description: Simplex separator housing with baffles and chambers for removing particles from water by centrifugal action and gravity.

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.

D. Housing: With manufacturer's proprietary system of baffles and chambers.
1. Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
3. Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
4. Collection Chamber: Designed to hold separated particles.
5. Outlet: Near top of unit.
6. Purge: At bottom of collection chamber.
7. Pipe Connections NPS 2 **(**DN 50**)** and Smaller: Threaded according to ASME B1.20.1.

8. Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if tank is stainless steel.

E. Motorized Purge Valve: Gate or plug pattern valve.
1. Motorized Valves: Butterfly-type, flanged or grooved-end, ductile-iron body, with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.

F. Strainer: Stainless-steel basket type mounted on pump suction.

G. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.

H. Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.

I. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
1. Casing: Radially split, cast iron.
2. Pressure Rating: 125 psig (860 kPa) minimum.
3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
4. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
5. Seal: Mechanical.
6. Motor: Open, dripproof motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

J. Controls: Automatic control of circulating pump and separator purge; factory wired for single electrical connection.
1. Panel: NEMA 250, Type 4 enclosure.
2. Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
3. Separator Purge: Automatic and manual.
4. TSS Controller Interlock: Open separator purge valve with bleed-off control.

K. Support: Skid mounting. Fabricate supports and base and attachment to separator housing with reinforcement strong enough to resist separator movement during a seismic event when separator base is anchored to building structure.

L. Capacities and Characteristics:
1. Separator Performance: As scheudled on the Drawing.
2. Housing:
a. Material: Stainless steel.
b. Pressure Rating: 80 psig.

2.3 WATER-SOFTENER CHEMICALS

A. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. (69 kg/cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.

B. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Equipment Mounting:
1. Install water-softener equipment on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 WATER-SOFTENER INSTALLATION

A. Install water-softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.

C. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

D. Install water-testing sets on wall adjacent to water softeners.

3.4 CONNECTIONS

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

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

C. Make piping connections between HVAC water-softener equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC water-softener equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

E. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

F. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

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

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing.
   3. Place HVAC water-softener and water filtration system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
   4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
   5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
   7. Cap and subject piping to static water pressure of 50 psig **(**345 kPa**)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
   8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Prepare test and inspection reports.

3.6 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:
   1. Periodic field service and consultation.
   2. Customer report charts and log sheets.
   3. Laboratory technical analysis.
   4. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

END OF SECTION

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Single-wall rectangular ducts and fittings.
2. Sheet metal materials.
3. Duct liner.
4. Sealants and gaskets.
5. Hangers and supports.

B. Related Requirements:
1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 DEFINITIONS

A. OSHPD: Office of Statewide Health Planning and Development (State of California).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
1. Sealants and gaskets.
2. Ducts and fittings.

B. Shop Drawings:
1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top [and bottom]of ducts.
5. Dimensions of [main] [all] duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment[, seismic restraints,] and vibration isolation.

C. Delegated Design Submittals:
1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations[, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation] for selecting hangers and supports[and seismic restraints].

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Welding certificates.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
1. [AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.]
2.
3.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports are to 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 airstream comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
   1. Construct ducts of galvanized sheet steel unless otherwise indicated.
   2. For ducts exposed to weather, construct of [Type 304] [Type 316] stainless steel indicated by manufacturer to be suitable for outdoor installation.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. For ducts with longest side less than 36 inches **(**914 mm**)**, select joint types in accordance with Figure 2-1.
   2. For ducts with longest side 36 inches **(**914 mm**)** or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
   3. [Where specified for specific applications, all joints are to be welded.]

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."[All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.]
   1. [Where specified for specific applications, all joints are to be welded.]

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
   1. Galvanized Coating Designation: G90 **(**Z275**)**.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A36/A36M, 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.

D. Tie Rods: Galvanized steel, 1/4-inch- (6-mm-) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch- (10-mm-) minimum diameter for lengths longer than 36 inches (900 mm).

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
   1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   2. Tape Width: [3 inches (76 mm)] [4 inches (102 mm)] [6 inches (152 mm)].
   3. Sealant: Modified styrene acrylic.
   4. Water resistant.
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10 inch wg (2500 Pa), positive and negative.
   7. Service: Indoor and outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
   10. Sealant shall have a VOC content of 420 g/L or less.

C. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   3. Shore A Hardness: Minimum 20.
   4. Water resistant.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10 inch wg (2500 Pa), positive and negative.
   8. Service: Indoor or outdoor.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C920.
   1. General: Single-component, acid-curing, silicone, elastomeric.
   2. Type: S.
   3. Grade: NS.
   4. Class: 25.
   5. Use: O.
   6. Sealant shall have a VOC content of 420 g/L or less.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:
   1. Seal is to provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and is to be rated for10-inch wg (2500-Pa) static-pressure class, positive or negative.
   2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
   3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "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 A603.

E. Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch **(**25 mm**)**, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches **(**38 mm**)**.

J. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

L. Elbows: Use long-radius elbows wherever they fit.
1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches **(**300 mm**)** and smaller and a minimum of five segments for 14 inches **(**350 mm**)** and larger.

M. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
4. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
5. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
6. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "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 (610 mm) of each elbow and within 48 inches (1220 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 DUCTWORK 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.

3.6 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Duct System Cleanliness Tests:
   1. Visually inspect duct system to ensure that no visible contaminants are present.
   2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.8 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."

C. Use duct cleaning methodology as indicated in NADCA ACR.

D. Use service openings for entry and inspection.
   1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
   2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
   3. Remove and reinstall ceiling to gain access during the cleaning process.

E. Particulate Collection and Odor Control:
   1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
   2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

F. Clean the following components by removing surface contaminants and deposits:
   1. Air outlets and inlets (registers, grilles, and diffusers).
   2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
   4. Coils and related components.
   5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
   6. Supply-air ducts, dampers, actuators, and turning vanes.
   7. Dedicated exhaust and ventilation components and makeup air systems.

G. Mechanical Cleaning Methodology:
   1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
   2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
   3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.9 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
   1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

B. Supply Ducts:
   1. Ducts Connected to Equipment Not Listed Above:
      a. Pressure Class: Positive 4- (1000) inch wg **(**Pa**)**.
      b. Minimum SMACNA Seal Class: **B**.
      c. SMACNA Leakage Class for Rectangular: 4.
      d. SMACNA Leakage Class for Round and Flat Oval: **4**.
   2. Ducts Connected to Equipment Not Listed above:
      a. Pressure Class: Positive or negative 4- (1000) inch wg **(**Pa**)**.
      b. Minimum SMACNA Seal Class: **B** if negative pressure; A if positive pressure.
      c. SMACNA Leakage Class for Rectangular: **4**.
      d. SMACNA Leakage Class for Round and Flat Oval: **4**.

C. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
   1. Ducts Connected to Equipment Not Listed Above:
      a. Pressure Class: Positive or negative 4- (1000) inch wg **(**Pa**)**.
      b. Minimum SMACNA Seal Class: **B**.
      c. SMACNA Leakage Class for Rectangular: **4**.
      d. SMACNA Leakage Class for Round and Flat Oval: **4**.

D. Intermediate Reinforcement:
   1. Galvanized-Steel Ducts: Galvanized steel.

E. Elbow Configuration:
   1. Rectangular Duct - Requirements for Different Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
      a. Velocity 1000 fpm **(**5 m/s**)** or Lower:
         1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
         2) Mitered Type RE 4 without vanes.
      b. Velocity 1000 to 1500 fpm **(**5 to 7.6 m/s**)**:
         1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
         2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
         3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
      c. Velocity 1500 fpm **(**7.6 m/s**)** or Higher:
         1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
         2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
         3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
   2. Rectangular Duct - Requirements for All Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
      a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      4) Radius-to Diameter Ratio: 1.5.
   b. Round Elbows, 12 (305) Inches (mm) and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 (356) Inches (mm) and Larger in Diameter: Standing seam.

F. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Conical spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
   a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
   c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Manual volume dampers.
2. Control dampers.
3. Turning vanes.
4. Duct-mounted access doors.
5. Duct accessory hardware.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.
1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Duct security bars.
f. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fusible Links: Furnish quantity equal to [10] <Insert number> percent of amount installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MANUAL VOLUME DAMPERS

A. Low-Leakage, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
a. Air Balance; a division of MESTEK, Inc.
b. Cesco Products; a division of MESTEK, Inc.
c. Greenheck Fan Corporation.

d. Lloyd Industries, Inc.
e. Nailor Industries Inc.
f. Ruskin Company.

2. Performance:
   a. [AMCA Certification: Test and rate in accordance with AMCA 511.]
   b. Leakage:
      1) Class II: Leakage shall not exceed 10 cfm/sq. ft. (51 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
3. Construction:
   a. Linkage: Out of airstream.
   b. Suitable for horizontal or vertical airflow applications.
4. Locking device to hold damper blades in a fixed position without vibration.

B. Jackshaft:
1. Size: 0.5-inch (13-mm) 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- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.3 CONTROL DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Ruskin Company.

B. General Requirements:
1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.

C. Performance:
1. AMCA Certification: Test and rate in accordance with AMCA 511.
2. Pressure Drop: 0.05 inch wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested in accordance with AMCA 500-D, Figure 5.3.
3. Velocity: Up to 3000 fpm (15 m/s).
4. Temperature: Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C).
5. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

2.4 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
1. Aero-Dyne Sound Control Co.
2. CL WARD & Family Inc.
3. Ductmate Industries, Inc.
4. Duro Dyne Inc.
5. Ward Industries; a brand of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply 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."

2.5 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
   1. Cesco Products; a division of MESTEK, Inc.
   2. CL WARD & Family Inc.
   3. Ductmate Industries, Inc.
   4. Duro Dyne Inc.
   5. McGill AirFlow LLC.
   6. Ruskin Company.

B. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 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. [24-gauge- **(**0.70-mm-**) thick galvanized steel**] [or] [0.032-inch **(**0.81-mm**) thick aluminum**] [or] [24-gauge- **(**0.70-mm-**) thick stainless steel**] <Insert value> door panel.
      d. Vision panel.
      e. Hinges and Latches: 1-by-1-inch **(**25-by-25-mm**)** butt or piano hinge and cam latches.
      f. Fabricate doors airtight and suitable for duct pressure class.
   2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
      a. 24-gauge- **(**0.70-mm-**)** thick galvanized steel or 0.032-inch- **(**0.81-mm-**)** thick aluminum frame.
   3. Number of Hinges and Locks:
      a. Access Doors Less Than 12 Inches **(**300 mm**)** Square: No hinges and two sash locks.
      b. Access Doors up to [18 Inches **(**460 mm**)**] Square: Continuous and two sash locks.
      c. Access Doors up to 24 by 48 Inches **(**600 by 1200 mm**)**: Continuous and two compression latches.
      d. Access Doors Larger Than 24 by 48 Inches **(**600 by 1200 mm**)**: Continuous and two compression latches with outside and inside handles.

2.6 DUCT ACCESSORY HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CL WARD & Family Inc.
   2. Ductmate Industries, Inc.
   3. Duro Dyne Inc.
   4. Ward Industries; a brand of Hart & Cooley, Inc.

B. 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.

C. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.7 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
   1. Galvanized Coating Designation: G90 **(**Z275**)**.
   2. Exposed-Surface Finish: Mill phosphatized.

B. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

C. Tie Rods: Galvanized steel, 1/4-inch **(**6-mm**)** minimum diameter for lengths 36 inches **(**900 mm**)** or less; 3/8-inch **(**10-mm**)** minimum diameter for lengths longer than 36 inches **(**900 mm**)**.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. 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.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
1. On both sides of duct coils.
2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-ft. (15-m) spacing.
8. Upstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. For grease ducts, install at locations and spacing as required by NFPA 96.
11. Control devices requiring inspection.
12. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:
1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5 inches wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Install duct test holes where required for testing and balancing purposes.

O. 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 **(**6-mm**)** 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 size and location of access doors are adequate to perform required operation.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

SECTION 233400 - HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Fans, mixed flow.
2. Ventilators, centrifugal - roof-mounted upblast and sidewall mounted.

1.2 ACTION SUBMITTALS

A. Product Data:
1. For each type of product.
a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
b. Rated capacities, furnished specialties, and accessories for each fan.
c. Fans:
1) Certified fan performance curves with system operating conditions indicated.
2) Certified fan sound-power ratings.
3) Fan construction and accessories.
4) Motor ratings and electrical characteristics, plus motor and electrical accessories.
5) Fan speed controllers.
d. Material thickness and finishes, including color charts.
e. Dampers, including housings, linkages, and operators.

B. Shop Drawings:
1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators [and seismic restraints]and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Sustainable Design Submittals:
1. Product data showing compliance with ASHRAE 62.1.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans showing fan rooms and fan system layouts, reflected ceiling plans, and other drawings required to illustrate relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Startup service reports.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.2 FANS, MIXED FLOW

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

B. Source Limitations: Obtain mixed-flow fans from single manufacturer.

C. Standards: Comply with UL 705.

D. Housings: Galvanized steel.
1. Inlet and Outlet Connections: Outer mounting frame and companion flanges.
2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
3. Mixed-Flow Outlet Connection: Two flanged discharge(s) perpendicular to fan inlet.

E. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

F. Accessories:
1. Mounting Clips: Horizontal ceiling clips welded to fan housing, of same material as housing.
2. Inlet and Outlet Screens: On unducted fan inlet and outlet - wire-mesh screen, of same material as housing.
3. Backdraft Dampers: Butterfly style, for mounting with flexible connection to fan discharge or direct mounted to discharge diffuser section, of same material as housing.
4. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
5. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
6. Inlet Cones: Round-to-round transition, of same material as housing.
7. Outlet Cones: Round-to-round transition, of same material as housing.
8. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
9. Belt Guard: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
10. Direct-Driven Units: Encase motor in housing outside of airstream.
11. Factory-wired motor disconnect switch located on outside of fan housing.

G. Factory Finishes:
1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: Epoxy; .
   a. Apply to finished housings.
   b. Apply to fan wheels.

2.3 MANUFACTURER, CHIMNEY AUTOMATION SYSTEM

A. A. Furnish ENERVEX Chimney Automation System(s) or equal by US Draft with design volume and design pressure as scheduled on the drawings and specified. The entire system must conform to UL378, Standard for Draft Equipment, UL705, Standard for Power Ventilators and UL60947, Standard for Low-Voltage Switchgear and Controlgear and bear a certification mark from UL, ETL or other nationally recognized testing laboratory.

2.4 DESCRIPTION, CHIMNEY AUTOMATION SYSTEM

A. The chimney fan design must be a Type B, Spark Resistant Construction in compliance with AMCA Standard 99-0401. The chimney fan shall be of a clamshell design with vertical discharge and manufactured in a heat and corrosion resistant material rated for an operating temperature up to 575°F (302°C) measured at the chimney termination point. It must be listed for use with condensing heating appliances which should be acknowledged in the installation manual.

B. The backward inclined impeller shall be made of cast aluminum material to eliminate the possibility of sparks and the potential of igniting unburned fuel and/or explosive gases. It must be balanced statically and dynamically with balancing weights being an integral and non-removable part of the impeller.

C. The motor must be a maintenance-free, variable speed motor with pre-lubricated and sealed ball bearings. The motor shall be factory warranted by the chimney fan manufacturer to operate at frequencies as low as 8Hz for three-phase motors. The bearings must be of a high temperature type with a minimum rating of 320°F (160°C). The motor shall be Class H insulated with a temperature rating of min. 356°F (180°C) and rated as shown on schedule (if 3 phase). The motor must be a totally enclosed, fan-cooled (TEFC) motor that does not need an exterior cooling fan. To assure motor longevity the motor shall be inverter-duty rated and not operate at speeds above 1740 RPM.

D. The modulating fan control, EBC31, must be a true PID-based control with infinitely variable speed settings and in a NEMA 1 rated enclosure. It shall interfere with the operation of the heating appliances by preventing burner operation during emergencies where a mechanical or electrical problem occurs. The features must be part of the compliance with UL378, Standard for Draft Equipment, UL705 Standard for Power Ventilators and UL60947, Standard for Low-Voltage Switchgear and Controlgear:
   1. 128 x 64 pixel LCD screen
   2. 32-Bit microcontroller with internal 512 kB FLASH-memory, 32 MB External SPI FLASH
   3. Two RS485 ports for expandable functionality and connectivity
   4. Able to control three functions (Exhaust Fan, Supply Fan, and Overdraft Damper) simultaneously via a single control.
   5. Integrated BUS interface to allow for future expansion.
   6. Programmable microprocessor for selective programming of, but not limited to, draft, intermittent vs. continuous fan operation, purge times, sensor sensitivity, alarm limits and delays, manual overrides, low/high limit fan speeds via the operating panel.
   7. A standard board that interlocks with up to 6 boilers/appliances so a call for heat activates the power venter and releases the individual burner once the pre-set draft has been established.
   8. “Plug-and-Play” self-check that detects connections, setting requirements and accessories during each start-up.
   9. An integrated and programmable proven draft function that can be set for automatic and manual reset.
   10. An integrated Operating Priority option, which allows one or more appliances to operate during electrical or mechanical failure of the fan, provided the draft requirement can be met and safe operation assured. Set up of a default Operating Priority must be possible, so the most important appliance(s) have highest priority during calls for heat. It must automatically check for fan operation every two hours and go back to normal operation if appropriate.
   11. Bearing cycle activation every 7 days if the power venter has not been operating during the past 7 day period.
   12. A normally open (NO) contact is available within the control to activate a visual or audible alarm (by others), or to interlock with a Building Management System.
   13. An alarm function that will display the fault code on the LCD display and signal an audible alarm (by others). The control shall log the last 10 fault codes.
   14. Ethernet port for TCP/IP networking
      a. Graphical web interface for monitoring the 0-10V in/outputs, alarms, and set points.
      b. Upgrade of firmware can be done via the web interface to ensure controller is always up to date.
      c. Remote monitoring and management capabilities standard, including the ability to adjust system configuration remotely.
      d. Ability to upload or download configuration file via web interface or USB.
   15. (Relay board for additional appliances in system. Board will fit inside control housing and interlock appliances with safety features of control)
   16. (Triac board for single phase. Board will fit inside control housing.)
   17. (Expansion board for MODS Damper System)
   18. Adjustable pre-purge, so the control will allow the power venter to prime the mechanical room prior to appliance startup.
   19. Adjustable post-purge, so the control will allow the power venter to operate for up to 3 minutes after the burner has shut down.
   20. English, Spanish, and French Language display options
   21. USB port for firmware upgrade and data logging
   22. (Optional) BACnet interface through RS485 module

E. The pressure sensor, XTP, shall be certified for use with oil- or gas-fired appliances and shall include a chimney probe along with tubing for installation in the chimney or stack as shown on the manufacturer’s submittal and feature:
   a. The range of operation shall be -1.0 - +1.0 inWC, with a minimum accuracy of +/-0.25% of span.
   b. The pressure drift shall be less than +/- 0.25% full scale, the offset longtime drift (1 year) shall not exceed +/- 0.005 inWC and the sensor response time shall be less than 0.25 seconds.

F. Motor speed controller (MSC), ENERVEX EDrive, must be factory programmed and provide the following specifications:
   1. All features shall be included in the motor controller enclosure, which shall be NEMA 1 rated.

2. Sensorless Vector Control type that is suitable for all types of high-efficiency Permanent Magnet Motors as well as standard induction motors.
3. Internal Category C1 EMC filter and brake chopper and have flying start capability.
4. Analog inpuit
5. Built-in keyboard and Bluetooth connectivity. Programmable via PC with OptiTools Studio.
6. Able to operate in environments of up to (50°C)
7. Rated for 150% overload for 60 secs and 175% for 2 secs.
8. Able to communicate via Modbus RTU (EIA-485)
9. Optional control of single phase motors.

2.5 PERFORMANCE, CHIMNEY AUTOMATION SYSTEM

A. The Chimney Automation System will ensure that the draft set-point (in. W.C.) is reached and maintained within 20 seconds of burner light-off. This can be measured with an external manometer at the appliance outlet.

B. Ramp-up and ramp-down time of the fan will be no more than 20 seconds.

C. The Chimney Automation System will maintain the draft set-point to within +/- 0.01” W.C.

D. The control will shut down the appliance(s) within 15 seconds if draft is not maintained as stated above.

2.6 SEQUENCE OF OPERATION

A. Each heating appliance must be interlocked with the control. Upon a call for heat, the control will activate the chimney fan to establish draft in the chimney system. Once the draft set-point is reached, the control will enable the appliance(s) calling for heat to fire. This sequence is repeated every time an appliance calls for heat without the control interrupting the sequencing of the heating appliances.

B. When an appliance shuts down, the chimney fan will adjust its speed to satisfy the draft set-point. Once the last appliance has shut down, the chimney fan will continue to run in post-purge mode for a set period of time to remove residual flue gases.

C. If proper draft cannot be maintained because of a mechanical or electrical failure, the control will go into alarm mode and the integrated proven draft function will shut down all appliances within 15 seconds. While in alarm mode, the control constantly monitors the draft. If the failure corrects itself or is corrected via intervention, the system will restart automatically. If the failure is not corrected, the control will utilize the integrated Operating Priority function. During a following call for heat, the control determines if one or more appliances can operate safely at the given draft conditions. If so, the heating appliance(s) will be able to operate without chimney fan operation. After two (2) hours, the control verifies chimney fan operation and, if present, the control will go back to normal operation. Otherwise, the control will continue to operate in Operating Priority mode. The self-check is repeated every two (2) hours infinitely. During a period without chimney fan operation, the control is in alarm mode to notify the Building Management System.

D. If the chimney fan is out of commission for seven (7) consecutive days, the Bearing Cycle Activation function will allow the fan to operate at a low speed for a short time. This is automatically repeated every seven (7) consecutive days the chimney fan does not operate.

2.7 STACK CONNECTION

A. Furnish a plenum box to mount the fans as shown on drawings.

2.8 RELAY BOARD FOR EBC31 CONTROL (For 7 boilers or more only)

A. Furnish an internal relay to interlock multiple boilers with the EBC31’s safety functions or external relay if single phase fans.

2.9 BALANCING BAFFLES
(FOR POSITIVE PRESSURE STACK)

A. Furnish balancing baffles, type BBF is constructed of 316 stainless steel housing, for positive pressure stack for each boiler and water heater where specified by manufacturer if applicable. The BBF is UL listed for UL 378 Draft Equipment and in Canada for ULC/ORD-C378 Draft Equipment. Any alternate baffles shall carry the same listings.

2.10 ELECTRICAL REQUIREMENTS

A. Power supply shall be:
1. To the EBC31 control: 1x120V AC, 60 Hz.
2. To the motor speed controller: As shown on schedule.

B. All wiring shall be in accordance with the National Electrical Code.

2.11 Alternate Manufacturers

A. All product substitution proposals on the basis of alternative mechanical draft system manufacturers must include detailed information regarding product performance and include a listing report by a nationally recognized testing laboratory that verifies that the entire system is in compliance with UL378, Standard for Draft Equipment, UL705, Standard for Power Ventialtors and UL60947, Standard for Low-Voltage Switchgear and Controlgear and meets all the specifications listed. It is the Contractor's responsibility to assure that a substituted system meets the complete detailed functions specified herein. If a substituted system does not provide all these functions, the Contractor will be fully liable for bringing the installed system into compliance or replacing it with the originally specified manufacturer's system.

2.12 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.13 SOURCE QUALITY CONTROL

A. [AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.]

B. [AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.]

C. [AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.]

D. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, in accordance with manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:
1. Install floor-mounted fans on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Install roof-mounted fans on roof curbs or support steel. See Drawings for specific requirements.
3. Unit Support: Install fans level on structural curbs. Coordinate with duct connections. [Coordinate wall penetrations and flashing with wall construction.] [Secure units to structural support with anchor bolts.]
4. Support duct-mounted and other hanging fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
5. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
6. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Curb Support, Prefabricated: Rail-type wood support provided by fan manufacturer.

F. Install units with adequate clearances for service and maintenance.

G. Label fans in accordance with requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK 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. Where installing ducts adjacent to fans, allow space for service and maintenance.

3.3 PIPING CONNECTIONS

A. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

B. Install heat tracing on all drain piping subject to freezing temperature and as indicated on Drawings. Furnish and install heat tracing in accordance with Section 230533 "Heat Tracing for HVAC Piping."

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch **(**13 mm**)** high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.6 STARTUP SERVICE:

A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
6. For belt-drive fans, 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.
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. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
12. Shut unit down and reconnect automatic temperature-control operators.
13. Remove and replace malfunctioning units and retest as specified above.

3.7 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.8 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC fans.

END OF SECTION

SECTION 233713.23 - AIR REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Adjustable blade face .
   2. Fixed face registers and grilles.
   3. Linear bar grilles.

PART 2 - PRODUCTS

2.1 REGISTERS

A. Fixed Face Register :
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Hart & Cooley Inc.
      b. Nailor Industries Inc.
      c. Titus.
   3. Material: Steel.
   4. Finish: Baked enamel, white.
   5. Face Arrangement: Perforated core.

2.2 GRILLES

A. Fixed Face Grille:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Nailor Industries Inc.
      b. Price Industries.
      c. Titus.
   3. Material: Steel.
   4. Finish: Baked enamel, white.
   5. Face Arrangement: Perforated core.
   6. Accessory: Filter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where registers and grilles 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 registers and grilles level and plumb.

B. Outlets and Inlets Locations: 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 registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 235113.11 - DRAFT CONTROL FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Draft inducer fans.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of product.
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. Detail fabrication and assembly of hangers and seismic restraints.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For draft control fans to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of draft inducer fans that fail in materials or workmanship within specified warranty period.
1. Failure includes failure of the fan due to corrosion.
2. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DRAFT INDUCER FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ENERVEX Inc.
2. US Draft Co.

B. CHIMNEY AUTOMATION SYSTEM
1. Furnish Chimney Automation System(s) with design volume and design pressure as scheduled on the drawings and specified. The entire system must conform to UL378, Standard for Draft Equipment, UL705, Standard for Power Ventilators and UL60947, Standard for Low-Voltage Switchgear and Controlgear and bear a certification mark from UL, ETL or other nationally recognized testing laboratory.

C. DESCRIPTION
1. The chimney fan design must be a Type B, Spark Resistant Construction in compliance with AMCA Standard 99-0401. The chimney fan shall be of a clamshell design with vertical discharge and manufactured in a heat and corrosion resistant material rated for an operating temperature up to 575°F (302°C) measured at the chimney termination point. It must be listed for use with condensing heating appliances which should be acknowledged in the installation manual.
2. The backward inclined impeller shall be made of cast aluminum material to eliminate the possibility of sparks and the potential of igniting unburned fuel and/or explosive gases. It must be balanced statically and dynamically with balancing weights being an integral and non-removable part of the impeller.
3. The motor must be a maintenance-free, variable speed motor with pre-lubricated and sealed ball bearings. The motor shall be factory warranted by the chimney fan manufacturer to operate at frequencies as low as 8Hz for three-phase motors. The bearings must be of a high temperature type with a minimum rating of 320°F (160°C). The motor shall be Class H insulated with a temperature rating of min. 356°F (180°C) and rated as shown on schedule (if 3 phase). The motor must be a totally enclosed, fan-cooled (TEFC) motor that does not need an exterior cooling fan. To assure motor longevity the motor shall be inverter-duty rated and not operate at speeds above 1740 RPM.

4. The modulating fan control, EBC31, must be a true PID-based control with infinitely variable speed settings and in a NEMA 1 rated enclosure. It shall interfere with the operation of the heating appliances by preventing burner operation during emergencies where a mechanical or electrical problem occurs. The features must be part of the compliance with UL378, Standard for Draft Equipment, UL705 Standard for Power Ventilators and UL60947, Standard for Low-Voltage Switchgear and Controlgear:
    a. 128 x 64 pixel LCD screen
    b. 32-Bit microcontroller with internal 512 kB FLASH-memory, 32 MB External SPI FLASH
    c. Two RS485 ports for expandable functionality and connectivity
    d. Able to control three functions (Exhaust Fan, Supply Fan, and Overdraft Damper) simultaneously via a single control.
    e. Integrated BUS interface to allow for future expansion.
    f. Programmable microprocessor for selective programming of, but not limited to, draft, intermittent vs. continuous fan operation, purge times, sensor sensitivity, alarm limits and delays, manual overrides, low/high limit fan speeds via the operating panel.
    g. A standard board that interlocks with up to 6 boilers/appliances so a call for heat activates the power venter and releases the individual burner once the pre-set draft has been established.
    h. “Plug-and-Play” self-check that detects connections, setting requirements and accessories during each start-up.
    i. An integrated and programmable proven draft function that can be set for automatic and manual reset.
    j. An integrated Operating Priority option, which allows one or more appliances to operate during electrical or mechanical failure of the fan, provided the draft requirement can be met and safe operation assured. Set up of a default Operating Priority must be possible, so the most important appliance(s) have highest priority during calls for heat. It must automatically check for fan operation every two hours and go back to normal operation if appropriate.
    k. Bearing cycle activation every 7 days if the power venter has not been operating during the past 7 day period.
    l. A normally open (NO) contact is available within the control to activate a visual or audible alarm (by others), or to interlock with a Building Management System.
    m. An alarm function that will display the fault code on the LCD display and signal an audible alarm (by others). The control shall log the last 10 fault codes.
    n. Ethernet port for TCP/IP networking
        1) Graphical web interface for monitoring the 0-10V in/outputs, alarms, and set points.
        2) Upgrade of firmware can be done via the web interface to ensure controller is always up to date.
        3) Remote monitoring and management capabilities standard, including the ability to adjust system configuration remotely.
        4) Ability to upload or download configuration file via web interface or USB.
    o. (Relay board for additional appliances in system. Board will fit inside control housing and interlock appliances with safety features of control)
    p. (Triac board for single phase. Board will fit inside control housing.)
    q. (Expansion board for MODS Damper System)
    r. Adjustable pre-purge, so the control will allow the power venter to prime the mechanical room prior to appliance startup.
    s. Adjustable post-purge, so the control will allow the power venter to operate for up to 3 minutes after the burner has shut down.
    t. English, Spanish, and French Language display options
    u. USB port for firmware upgrade and data logging
    v. (Optional) BACnet interface through RS485 module
5. The pressure sensor, XTP, shall be certified for use with oil- or gas-fired appliances and shall include a chimney probe along with tubing for installation in the chimney or stack as shown on the manufacturer’s submittal and feature:
    a. The range of operation shall be -1.0 - +1.0 inWC, with a minimum accuracy of +/-0.25% of span.
    b. The pressure drift shall be less than +/- 0.25% full scale, the offset longtime drift (1 year) shall not exceed +/- 0.005 inWC and the sensor response time shall be less than 0.25 seconds.
6. Motor speed controller (MSC), ENERVEX EDrive, must be factory programmed and provide the following specifications:

a. All features shall be included in the motor controller enclosure, which shall be NEMA 1 rated.
b. Sensorless Vector Control type that is suitable for all types of high-efficiency Permanent Magnet Motors as well as standard induction motors.
c. Internal Category C1 EMC filter and brake chopper and have flying start capability.
d. Analog inpuit
e. Built-in keyboard and Bluetooth connectivity. Programmable via PC with OptiTools Studio.
f. Able to operate in environments of up to (50°C)
g. Rated for 150% overload for 60 secs and 175% for 2 secs.
h. Able to communicate via Modbus RTU (EIA-485)
i. Optional control of single phase motors.

D. PERFORMANCE, CHIMNEY AUTOMATION SYSTEM
1. The Chimney Automation System will ensure that the draft set-point (in. W.C.) is reached and maintained within 20 seconds of burner light-off. This can be measured with an external manometer at the appliance outlet.
2. Ramp-up and ramp-down time of the fan will be no more than 20 seconds.
3. The Chimney Automation System will maintain the draft set-point to within +/- 0.01” W.C.
4. The control will shut down the appliance(s) within 15 seconds if draft is not maintained as stated above.

E. SEQUENCE OF OPERATION
1. Each heating appliance must be interlocked with the control. Upon a call for heat, the control will activate the chimney fan to establish draft in the chimney system. Once the draft set-point is reached, the control will enable the appliance(s) calling for heat to fire. This sequence is repeated every time an appliance calls for heat without the control interrupting the sequencing of the heating appliances.
2. When an appliance shuts down, the chimney fan will adjust its speed to satisfy the draft set-point. Once the last appliance has shut down, the chimney fan will continue to run in post-purge mode for a set period of time to remove residual flue gases.
3. If proper draft cannot be maintained because of a mechanical or electrical failure, the control will go into alarm mode and the integrated proven draft function will shut down all appliances within 15 seconds. While in alarm mode, the control constantly monitors the draft. If the failure corrects itself or is corrected via intervention, the system will restart automatically. If the failure is not corrected, the control will utilize the integrated Operating Priority function. During a following call for heat, the control determines if one or more appliances can operate safely at the given draft conditions. If so, the heating appliance(s) will be able to operate without chimney fan operation. After two (2) hours, the control verifies chimney fan operation and, if present, the control will go back to normal operation. Otherwise, the control will continue to operate in Operating Priority mode. The self-check is repeated every two (2) hours infinitely. During a period without chimney fan operation, the control is in alarm mode to notify the Building Management System.
4. If the chimney fan is out of commission for seven (7) consecutive days, the Bearing Cycle Activation function will allow the fan to operate at a low speed for a short time. This is automatically repeated every seven (7) consecutive days the chimney fan does not operate.

F. STACK CONNECTION
1. Furnish a plenum box to mount the fans as shown on drawings.

G. RELAY BOARD FOR EBC31 CONTROL (For 7 boilers or more only)
1. Furnish an internal relay to interlock multiple boilers with the EBC31’s safety functions or external relay if single phase fans.

H. BALANCING BAFFLES
(FOR POSITIVE PRESSURE STACK)
1. Furnish balancing baffles, type BBF is constructed of 316 stainless steel housing, for positive pressure stack for each boiler and water heater where specified by manufacturer if applicable. The BBF is UL listed for UL 378 Draft Equipment and in Canada for ULC/ORD-C378 Draft Equipment. Any alternate baffles shall carry the same listings.

I. ELECTRICAL REQUIREMENTS
1. Power supply shall be:
a. To the EBC31 control: 1x120V AC, 60 Hz.
b. To the motor speed controller: As shown on schedule.
2. All wiring shall be in accordance with the National Electrical Code.

J. MOTORS
1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
2. Variable-frequency drive for variable-speed fans is specified in Section 262923 "Variable-Frequency Motor Controllers."
3. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install listed components in a manner complying with the listing.

B. Install draft inducer fans in double-wall vent section that is designed to couple with other vent materials.

C. Secure draft inducer fans to appliances, breechings, or stacks with hardware compatible with connected materials.

D. Install draft inducer fans with clearances for service and maintenance.

E. Breeching and vent sections, when installed according to manufacturer's instructions, shall comply with national safety standards and building codes. Stacks terminating above a roof must terminate as required by code or NFPA 211. Locate to comply with minimum clearances from combustibles.

F. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using factory-applied gasket recommended by manufacturer.

G. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

H. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

I. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION

SECTION 235123 - GAS VENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Listed double-wall vents.

1.2 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 product.

B. Shop Drawings: For vents.
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. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.4 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 D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENTS

2.2 LISTED SPECIAL GAS VENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Schebler eVent with Dual Seal (basis of design)
2. Metal-Fab, Inc.

B. Selkirk Corporation; Selkirk Metalbestos and Air Mate.Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
1. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

C. Description: The factory built double wall modular chimney shall be laboratory tested and listed with Underwriters Laboratories Standard UL 1738 for use with category II, III, & IV appliances with a maximum flue gas temperature of 550°F and ULC-S636-95 for gas vent "" BH, Class I/Class II 245°C. Product must have UL pressure rating of 40" w.c. Product to have leak free guarantee for three (3) years and lifetime product warranty backed by the manufacturer.

D. Construction: Between the inner and outer shells there shall be a minimum of a 1" air gap. Stainless steel centering clips shall be welded to the outer shell to maintain the 1" spacing and ensure concentricity of the shells. Vent sections shall be sealed by use of a ½flange to flange with a factory applied gasket including an inner collar on one of the flanges. Flanges to be coupled using RapidLock¢¢ band system. No sealant is allowed for the entire system allowing immediate start-up of appliance.

E. Inner Shell: Inner liner material shall be type AL29-4C® or 316L stainless steel. Inner shell thickness shall be .024" (24 ga. eVent) and .036" (20 ga. eVent Plus) for 5 to 48 diameter systems. All inner shell seams shall be full penetration welded the entire length of the pipe section. Riveted, tack or spot-welded seams are not permitted on any part or fitting.

F. Outer Jacket: Outer shell material shall be 430 stainless steel with a thickness of .028• • for 5• • to 48• • diameter systems. Optional outer shell material can be aluminized steel or 304 or 316 stainless steel. All outer shell seams shall be full penetration welded the entire length of the pipe section. Riveted, tack or spot-welded seams are not permitted.

G. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

H. Engineered system design performance for boiler room with factory provided comprehensive stack sizing analysis for natural gas fired or liquid propane gas fired category II negative pressure or category IV positive pressure condensing appliances to validate full load with the boiler or all boilers firing at high fire and part load firing rate performance. This analysis must review each boiler or water heater performance independently within the group at varying stack temperatures and outside air temperatures to confirm proper combustion and firebox performance positive or negative draft ranges are in full accordance with applicable manufacturer design and combustion criteria requirements for varying lead boiler rotation sequence and the proximity to the common stack. Stack sizing analysis must be done with outside air temperature ranges of 65-degrees F. and average low temperature at site location. Each stack sizing analysis report shall also include a formal factory provided itemized CAD drawing detail with applied design layout details and all dimensions utilized for the formal stack sizing analysis including the boiler riser dimensional details, the horizontal breeching dimensional details, and the common vertical stack dimensional details. Any additional field provided or necessitated dimensional or routing changes or bill of material changes must have an updated factory provided stack sizing analysis and CAD drawing detail provided to validate any potential impact that the routing change may have had on the condensing high performance boilers operational, combustion and firebox ranges.

2.3 MANUFACTURERS, SEALED MODULATING DAMPER SYSTEM

A. Furnish ENERVEX Sealed Modulating Damper System (s) (SMDS) with design diameter as scheduled on the drawings and specified. The damper and control shall be listed to UL378, Standard for Draft Equipment and UL 17, Standard for Vent or Chimney Connector Dampers for Oil-Fired Appliances, ULC/ORD-C378, Standard for Draft Equipment, ANSI Z21.66-1996, Standard for Automatic Vent Damper Devices for Use With Gas-fired Appliances, and UL60947, Standard for Low-Voltage Switchgear and Controlgear

B. AUTOMATIC DRAFT CONTROL SYSTEM DESIGN
1. The single-blade damper shall be constructed of 316L stainless steel with a minimum of .036 inches.
2. The damper shall have a permanently mounted graphite gasket mounted on the damper blade and shall have graphite shaft seals. Silicone based gaskets and seals shall not be accepted due to the lack of resistance to acidic condensate.
3. The damper actuator must be microprocessor based.
4. The rotation time from 0° through 90°shall not exceed 50 seconds, and the operating torque should not be less than 360 in.lb (40Nm).
5. The damper shall be listed to UL378 Standard for Draft Equipment at 1400°F (760°C)
6. The modulating damper control, EBC24, must be a true PID-based control with infinitely variable speed settings and in a NEMA 4X rated enclosure. It shall interfere with the operation of the heating appliances by preventing burner operation during emergencies where a mechanical or electrical problem occurs.
7. The features must be part of the compliance with UL378, Standard for Draft Equipment and UL60947 Standard for Low-Voltage Switchgear and Control gear:
    a. 128 x 64 pixel LCD screen
    b. 32-Bit microcontroller with internal 512 kB FLASH-memory, 32 MB External SPI FLASH
    c. Two RS485 ports for expandable functionality and connectivity
    d. Integrated BUS interface to allow for future expansion.
    e. Programmable microprocessor for selective programming of, but not limited to, draft, intermittent vs. continuous damper operation, purge times, sensor sensitivity, alarm limits and delays, manual overrides, low/high limit damper positioning via the operating panel.
    f. A standard board that interlocks with up to 2 boilers/appliances so a call for heat activates the damper actuator and releases the individual burner once the pre-set draft has been established.

g. “Plug-and-Play” self-check that detects connections, setting requirements and accessories during each start-up.
h. An integrated and programmable proven draft function that can be set for automatic and manual reset.
i. An integrated Operating Priority option, which allows one or more appliances to operate during electrical or mechanical failure of the damper or any of its components, provided the draft requirement can be met and safe operation assured. Set up of a default Operating Priority must be possible, so the most important appliance(s) have highest priority during calls for heat. It must automatically check for damper operation every two hours and go back to normal operation if appropriate.
j. A normally open (NO) contact is available within the control to activate a visual or audible alarm (by others), or to interlock with a Building Management System.
k. An alarm function that will display the fault code on the LCD display and signal an audible alarm (by others). The control shall log the last 10 fault codes.
l. A field adjustable minimum pressure and maximum pressure alarm set points with independent alarm delay adjustments.
m. Ethernet port for TCP/IP networking
n. Graphical web interface for monitoring the 0-10V in/outputs, alarms, and set points.
o. Upgrade of firmware can be done via the web interface to ensure controller is always up to date.
p. Remote monitoring and management capabilities standard, including the ability to adjust system configuration remotely.
q. Ability to upload or download configuration file via web interface or USB.
r. Adjustable pre-purge, so the control will allow the appliance to prime
s. Adjustable post-purge, so the control will allow the damper to remain fully open for up to 3 minutes after the burner has shut down.
t. English, Spanish, and French Language display options
u. USB port for firmware upgrade and data logging
v. Modbus interface through RS485 module

8. The pressure sensor, XTP, shall be certified for use with oil- or gas-fired appliances and shall include a chimney probe along with tubing for installation in the chimney or stack as shown on the manufacturer’s submittal and feature:
   a. The range of operation shall be -1.0 - +1.0 inWC, with a minimum accuracy of +/-0.25% of span.
   b. The pressure drift shall be less than +/- 0.25% full scale, the offset longtime drift (1 year) shall not exceed +/- 0.005 inWC and the sensor response time shall be less than 0.25 seconds.

C. ELECTRICAL REQUIREMENTS
1. Power supply shall be:
   a. To the EBC24 control: 1x120V AC, 60 Hz.
   b. . To the damper actuator: 24 VAC, 22VA

2. All wiring shall be in accordance with the National Electrical Code.

D. SEQUENCE OF OPERATION
1. Upon call for heat, the draft system goes through a time adjustable pre-purge cycle (45 seconds recommended with standard damper/actuator). This will allow the damper to move to its fully-open position.
2. After pre-purge, the ‘‘boiler out’’ contacts on the draft control close and allow the burner to sequence through its pre-purge and firing cycles. During this time, the draft controller should be in its ““Prime Cycle””. The prime cycle is time adjustable and should be set for the total time required to establish draft in the venting system (usually a total of around two minutes). During the prime cycle, the standard alarm limits are inactive to allow time for draft to develop naturally.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

3.2 APPLICATION

A. Listed Type B and BW Vents: Vents for certified gas appliances.

3.3 INSTALLATION OF LISTED VENTS

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

D. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

E. Lap joints in direction of flow.

3.4 INSTALLATION, OPERATING TESTS, START-UP, AND ON-SITE SERVICES FOR SMDS

A. System vendor’s service organization shall employ senior service technicians having experience in all aspects of trouble shooting, corrective service, and preventive maintenance O&M reporting.

B. After installation is completed:
   1. Test the operation of the Sealed Modulating Damper System and:
      a. Increase and decrease draft setting.
      b. Increase and decrease firing rate.
   2. Test safety control by firing boiler and:
      a. Shut off power to the actuator
      b. Shut off power to the control.
      c. Increase boiler outlet pressure to exceed the maximum pressure alarm set point
   3. Provide services of factory representative of chimney automation system manufacturer to:
      a. Confirm proper installation of damper and draft controls.
      b. Test individual controls for proper operation.
      c. Test safety system.

C. Submit a written report signed by manufacturer’s authorized representative, confirming that safety and operating controls have been properly installed.

3.5 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION

SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes gas-fired, fire-tube condensing boilers, trim, and accessories for generating hot water.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
   2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:
   1. Product Data: For energy performance.

C. Shop Drawings: For boilers, boiler trim, and accessories.
   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For boiler, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

E. Other Informational Submittals:
   1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
   2. CSA B51 pressure vessel Canadian Registration Number (CRN).

1.4 CLOSEOUT SUBMITTALS

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

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Pulse-Combustion Boilers:
      a. Heat Exchanger Damaged by Thermal Shock: 10 years from date of Substantial Completion.
      b. Heat-Exchanger Corrosion: Nonprorated for five years from date of Substantial Completion.
   2. Warranty Period for Fire-Tube Condensing Boilers:
      a. Leakage and Materials: 10 years from date of Substantial Completion.
      b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Nonprorated for five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.

E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

F. CSA Compliance: Test boilers for compliance with CSA B51.

G. Mounting Base: For securing boiler to concrete base.
1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

2.2 FORCED-DRAFT, FIRE-TUBE CONDENSING BOILERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Fulton.
2. AERCO International, Inc.
3. Cleaver-Brooks.

B. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; ; water supply, return, and condensate drain connections; and controls. Water-heating service only. Medium mass design suitable for low flow/variable flow pumping systems.

C. Heat Exchanger:Stainless steel, corrosion-resistant combustion chamber.

D. Pressure Vessel: Stainless steel with welded heads and tube connections.

E. Burner: Natural gas, forced draft, low NOx, minimum 4-to1 turn down.

F. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

G. Gas Train: Combination gas valve with manual shutoff and pressure regulator in compliance with CSD-1.

H. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

I. Casing:
1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Baked-enamel or Powder-coated protective finish.
4. Insulation: Minimum R 12.5.
5. Combustion-Air Connections: Inlet and vent duct collars.

J. Capacities and Characteristics: As scheduled on the Drawings.

2.3 TRIM

A. Include devices sized to comply with ASME B31.9. Comply with ASME B31.1 if boiler operating pressures exceed 160 psig (1100 kPa) or if boiler temperature exceeds 250 deg F (121 deg C).

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic.

F. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

2.4 BOILER CONTROLS

A. Boiler operating controls shall include the following devices and features:
1. Digital Control panel.
2. Control transformer.
3. Local operator display/interface device.
4. Set-Point Adjust: Set points shall be manually adjustable through the operator interface device.
5. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.

B. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
1. High Cutoff: Automatic reset stops burner if operating conditions rise above maximum boiler design temperature (hot water boilers) .
2. Low-Water Cutoff Switch: Probe shall prevent burner operation on low water. Cutoff switch shall be manual -reset type.
3. Blocked Inlet Air Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

C. MODULAR BOILER PLANT SEQUENCING CONTROL: For multiple boilers installed in a common system, a standalone boiler plant sequencing control system shall be provided to monitor, enable/disable and command the firing rate of each boiler. To ensure accurate temperature control and optimized boiler operating efficiencies, a Fulton ModSync SE or PLC with equivalent functionality shall be used.
1. The control panel shall be listed and labeled to UL508A and include the following hardware:
2. A microprocessor-based process controller with a real-time clock, assignable I/O, and a graphical user interface (GUI). The display shall be minimum 5.7” color touchscreen LCD. Alpha-numeric displays have inherent flexibility limitations and are not accepted.
3. The enclosure shall be wall mountable, suitable for installation in indoor or outdoor environments and carry a NEMA 4X rating.
4. Electrical requirement shall be 120/60/1.
5. Field configurable assignable I/O shall be provided:
    a. 16 Digital Inputs (24 VDC)
        1) Individual Boiler Isolation Valve Interlock
        2) Individual Boiler Dedicated (Primary) Pump Interlock
        3) E-Stop Status Monitoring
        4) Individual Boiler Remote Mode Selected
        5) Individual Boiler Main Burner On Status
        6) Individual Boiler Alarm Status
        7) Individual System (Secondary) Pump Status
        8) Individual System (Secondary) Pump Alarm
        9) Primary Low Water
        10) Secondary Low Water
    b. 14 Digital Outputs (24 VDC)
        1) Individual Boiler Isolation Valve Control
        2) Individual Boiler (Primary) Pump Enable Control
        3) Individual Boiler Alarm Output
        4) Individual Boiler Status Output
        5) General Heat Demand Status Output
        6) Individual Boiler Heat Demand Status Output
        7) Individual System (Secondary) Pump Enable Control
    c. 3 Analog Inputs (4-20 mA)
        1) Supply Header Pressure
        2) Return Header Pressure
        3) Differential Pressure
        4) Temperature Retransmission

d. 4 Analog Outputs (4-20 mA)
1) An expansion shall be provided for an additional 6 analog outputs.
2) Dedicated Boiler (Primary) Pump Speed
3) System (Secondary) Pump Speed
4) Individual Boiler Firing Rate

D. Instrumentation: Shall be field installed and wired back to the boiler plant sequencing panel. Sensors shall be PT100 type with tolerance according to IEC 60751.
1. A supply header temperature sensor shall measure the common supply water temperature for use as the process variable.
a. Return header water temperature sensor for monitoring purposes.
b. Outdoor air temperature sensor.

E. Temperature Control Features:
1. Proportional Integral Derivative (PID) load control
a. A control variable (CV) is calculated using PID settings and the difference between process variable (PV) and setpoint (SP). The CV is used to determine response.
2. To satisfy flexible control configurations, multiple setpoint modes shall be provided. The mode shall be field configurable through the touchscreen GUI.
a. Outdoor Air Temperature (OAT) Reset
1) The control shall monitor OAT and calculate a hydronic setpoint temperature. As OAT increases, the setpoint shall decrease, thereby significantly reducing fuel costs and emissions while continuing to satisfy building load requirements.
2) OAT reset parameters shall be user configurable. Minimum and maximum setpoint parameters shall be provided to prevent the reset schedule from operating outside of a configured temperature range.
b. 4-20mA Remote Setpoint
c. BMS Communication
d. Manual (Static, Local)
3. An Outdoor Temperature Disable warm weather shutdown function shall be provided to disable the boiler plant upon reaching a configurable OAT. A hysteresis variable will prevent the plant from re-enabling until the OAT decreases by a configurable amount.
4. Setback functionality shall be provided to adjust the temperature setpoint.
5. Multiple setback schedules shall be provided based on whether the building is in Occupied or Unoccupied mode as determined by configurable Time of Day or Day of Week parameters or manual selection.
6. An Anticipation Mode function shall be provided to automatically switch to Occupied Mode a configurable number of hours earlier than scheduled if OAT drops below a configurable temperature during Unoccupied Mode.
7. Cold Start:
a. A low fire hold function shall be provided to command a boiler to maintain a configurable low modulation rate for a configurable timer upon a new heat demand.
8. Warm Standby:
a. To ensure boilers are prepared to respond to rapid heating demands, the control shall enable any boiler which has remained idle for a configurable amount of time and command the burner to low fire.

F. Lead/Lag Control of Modular (Multiple) Boiler Plants: Lead/Lag capabilities shall be provided for up to 8 boilers installed in the same process.
1. The boiler plant sequencing control shall communicate with the boilers through Modbus RTU or hardwire I/O.
2. Sequence of Operation:
a. Upon a heat demand, the lead boiler is enabled and firing rate commanded to low fire.
b. In accordance with PID settings the CV parameter shall determine boiler firing rate.
c. A configurable Lag Boiler Start Delay timer shall be provided to prevent short cycling.
d. The control shall enable a lag boiler when the Lag Boiler Start CV value has been reached and the Lag Boiler Start Delay has expired. The lead and lag boiler firing rates shall modulate in parallel at the lowest possible firing rate necessary to satisfy the load.
e. Where additional capacity is required, the control shall enable additional lag boiler stages in accordance with configurable settings until all available boilers in the plant are enabled.
f. The boiler plant shall be commanded to modulate in parallel as a single cohesive unit to maintain the system load at the lowest possible firing rate, minimizing cycling and maximizing the boiler plant thermal efficiency.

g. As the load is satisfied, boiler firing rate(s) shall decrease in parallel. As boilers reach low fire and the CV decreases, lag boiler stages shall be disabled.
h. The lead boiler shall be disabled when the process variable reaches a configurable stop parameter relative to the setpoint.

3. Automatic Boiler Rotation:
   a. Automatic rotation of the boiler Lead and Lag positions shall be determined using configurable operating history cycle count or run hours. Sequencing systems that rotate the lead position to the next boiler in the sequence are not accepted due to their inability to maintain balanced boiler usage.
4. Forced Rotation:
   a. When enabled, the control shall rotate the boilers at a configurable time or day of the week and shall not wait for the next heat demand to rotate Lead and Lag positions.
5. Transition Delay:
   a. Running transition functionality shall be provided to allow for more seamless transition when a Lead/Lag rotation is triggered. The running boiler(s) shall remain enabled until the next boiler is firing, or the demand is satisfied.
6. Boiler Outlet Monitoring:
   a. Monitoring of the individual boiler pressure vessel outlet temperature shall be provided. Should the outlet temperature exceed setpoint by a configurable amount, the firing rate of that boiler shall be lowered to a configurable rate to prevent nuisance Manual Reset High Limit (MRHL) lockouts. Upon dropping to a configurable outlet temperature, the firing rate override shall be lifted.

G. Ancillary Device Control Functions:
1. Dedicated Boiler Motorized Isolation Valve Control:
   a. Upon a heat demand for the boiler, the contact shall be enabled.
   b. After the burner is disabled and upon reaching a configurable time delay, the contact will be disabled.
   c. The control shall enable lead boiler isolation valve contact at all times.

H. Graphical User Interface:
1. The following screens or menus shall be provided for intuitive overview and configuration of the multiple boiler system.
   a. Outdoor Reset Configuration
   b. Setback Schedule
   c. Lead/Lag Configuration
   d. Boiler Configuration
      1) Shall include for each boiler: Status, cycles, run hours, cycles per run hour ratio, outlet temperature, automatic modulation, and manual firing rate control.
      2) Functionality shall be provided to enable/disable each boiler through the operator interface. Disabled boilers are excluded from the sequencing logic.
   e. System Status
      1) Detail current outdoor, system and control variable values. The status screen will also display enable/disable and firing rate information for each of the boilers.
   f. Alarm Status
      1) Provides a text description of any current alarm conditions. Boiler sequencing systems that use codes or symbols to detail alarm conditions will not be acceptable.
   g. Alarm History
      1) Records the last 100 alarm conditions. A Date/Time stamp and text description of each alarm condition in the history shall be available.
   h. Trending Data
      1) Trending of the supply temperature, system setpoint and outdoor temperature will be displayed to provide system operational history for tuning of the PID and lead/lag parameters.
2. Password requirements will prevent access to any of the screens where parameters may be adjusted, while maintaining the ability of viewing the system status and performance.

I. Alarm Handling:
1. The control shall start a timer when each boiler stage is enabled to run. If the main gas valves do not energize within the user-defined timeframe then a local limit is preventing the boiler from operating. The boiler shall be removed from the lead/lag sequence and a local boiler error alarm should be annunciated. An automatic reset option shall allow the boiler to be re-enabled after a configurable timer has elapsed.

2. The control shall automatically remove the boiler from the sequencing rotation if an alarm occurs and adjust lead/lag positions. The boiler shall be automatically added back into rotation upon detecting the alarm has been cleared.
3. The control shall monitor the status of all connected instrumentation and boilers. An alarm shall be annunciated for an instrumentation error.
4. Should an outdoor temperature sensor error occur, the control will automatically switch to manual (static) setpoint mode.

J. Building Automation System Interface: Hardware and software to enable building automation system (BAS) to monitor, control, and display boiler status and alarms.
1. Fixed Hardwired Contacts:
   a. Monitoring: General Alarm.
   b. Control: Remote Enable, DHW Aquastat.
   c. Remote Setpoint Signal: 4-20 mA.
2. Communication Protocol: A communication interface with BAS shall enable BAS operator to remotely enable and monitor the boiler plant from an operator workstation.
   a. The boiler plant sequencing control will communicate to the Building Automation System via a daisy chain addressed Modbus RTU network.
   b. The boiler plant sequencing control shall have the ability to receive temperature values from the BAS through the communication protocol.
   c. A BACnet MSTP and IP protocol communication gateway shall be provided. A communication point mapping list shall be provided.
3. .

2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall be to circuit breaker.
5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
6. Provide each motor with overcurrent protection.

2.6 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.
1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.2 BOILER INSTALLATION

A. Equipment Mounting:
   1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
   2. Comply with requirements for vibration isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
   3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

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

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

I. Boiler Venting:
   1. Install flue venting kit and combustion-air intake.
   2. Connect full size to boiler connections. Comply with requirements in Section 235123 "Gas Vents."

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Perform installation and startup checks according to manufacturer's written instructions.
   2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
   3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
      a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature or steam pressure.
      b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

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

C. Prepare test and inspection reports.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

E. Performance Tests:
1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.
   a. Test for full capacity.
   b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, percent of full capacity. Determine efficiency at each test point.
4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
7. Notify Architect 24 hours minimum in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION

SECTION 260400 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Design Intent:
1. The Contract Documents indicate and specify the electrical design intent. The Contract Drawings are schematic and diagrammatic and are not intended to indicate construction details and routing unless specifically indicated. The specifications establish minimum performance, product and installation requirements.
2. In addition to the specified and indicated performance and quality requirements, furnish products and perform installation work consistent with the design intent, industry standards and as necessary to the provision of complete operating electrical systems.
3. Install electrical work in accordance with the National Electrical Code and all applicable local codes in a neat and workmanlike manner.
4. This Section specifies basic electrical requirements applicable to all Divisions unless explicitly excepted.
5. If there is a conflict between applicable documents, then the more stringent requirement shall apply. All documents listed are believed to be the most current releases of the documents. The Contractor has the responsibility to determine and adhere to the most recent release when developing the proposal for installation.
6. Contractor shall thoroughly review entire set of Contract Documents, including all discipline drawings and specifications prior to bidding and include all required electrical work in bid, even if not explicitly shown on electrical Drawings and Specifications.

1.2 REFERENCES

A. American National Standards Institute (ANSI) C2 - National Electrical Safety Code.

B. City of Washington Ordinances.

C. District of Columbia Codes.

D. National Electrical Contractors Association (NECA).
1. 1 - Standard for Good Workmanship in Electrical Construction.
2. 500 - Recommended Practice for Installing Indoor Commercial Lighting Systems.

E. National Fire Protection Association (NFPA).
1. 70 - National Electrical Code (NEC).
2. 70E - Standard for Electrical Safety in the Workplace.
3. 72 - National Fire Alarm and Signaling Code.
4. 101 - Life Safety Code.
5. 111 - Standard for Stored Electrical Energy Emergency and Standby Power Systems.

F. InterNational Electrical Testing Association (NETA).
1. MTS - Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems.
2. **ATS - Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.**

1.3 Submittals

A. General
1. Submit Shop Drawings, Product Data, Samples and other specified submittals on a "system" basis. Retain, and assemble drawings and data from manufacturer or component manufacturers such that each submittal is for a complete system.
2. Refer to Divison 01 for basic definitions and requirements for submittals.
3. Refer to Division 01 for submittal compliance form.

B. Quality Control Submittals
1. Submit results of factory tests two weeks prior to product shipment from factory.
2. Submit results of field tests immediately upon completion of the field test.

C. Contract Closeout Submittals
1. Refer to Division 01 for basic definitions and requirements for record documents.

a. Submit, at the completion of the work, record drawings per Division 01 and in an approved electronic format matching the electronic format in which the construction documents were produced. Indicate the actual electrical installation, size and construction details. Include the following information: Power distribution system, including distribution equipment and each conduit and wire size installed.
b. Layout and circuiting for wiring devices, surface raceways and related equipment, including location of all outlets, junction boxes, and conduit runs, including conduit size, circuit numbers, and number of wires in each run.
c. Layout and circuitry for power circuits to mechanical equipment and other electrified building equipment, including each conduit and wire size.
d. Supporting and mounting details.
e. Panel schedule drawings consisting of each panelboard. Schedules shall indicate the as-built circuiting with loads and room numbers identified. Room numbers on schedules shall include the architectural room number indicated on the Drawings and the signage room numbers from the signage schedules. Each circuit in the panel schedules shall be uniquely identified, regardless of how they are indicated on the construction documents.
f. Layout and location of above ceiling devices, including, but not limited to: controllers, control panels, emergency load transfer devices, power supplies, relays, battery packs and all other electrical equipment and products requiring maintenance, service, adjustment or replacement in the future.

1.4 Quality Assurance

A. Owner Construction Design Standards
1. Provide an electrical installation in accordance with the Owner's construction design standards and specifications, unless specific written waivers are provided by the Owner.

B. Regulatory Requirements
1. Comply with the applicable requirements of ANSI C2 and the latest NFPA 70.
a. Requirements of ANSI C2 and NFPA 70 shall be minimum standards of products and installation work. Furnish products and perform installation work which exceed the standards of ANSI C2 and NFPA 70 when specified or indicated.
2. Comply with applicable requirements of city, county, and state laws, ordinances and regulations including modifications and supplements to ANSI C2 and NFPA 70.
3. Comply with the applicable requirements of U.S.Department of Labor, Occupational Safety and Health Administration Standards (OSHA).
4. All materials shall conform with the standards of the Underwriter's Laboratories in every case where such standards have been established for the particular type of material or assembly .
5. All material and equipment shall be UL listed and bear the UL label where such listing and labeling exists.
6. In the case where two or more Codes conflict or contradict each other, comply with the more stringent Code or standard.

C. Contractor Qualifications and Character of Work
1. Contractor personnel must be knowledgeable in local, state and national codes and regulations. Contractor shall have been in the business of installing electrical systems for a minimum of ten (10) years.
2. Contractor shall be **licensed and bonded**, and have working experience in the District of Columbia.
3. Contractor must possess and maintain current liability insurance certificates.
4. Contractor shall obtain and pay for all permits and inspections required by laws, local ordinances, rules, and regulations having jurisdiction for the work. Permits shall be readily available and posted in a prominent place at building site and protected from weather and physical damage.
5. The installation shall be executed in a workmanlike manner and shall present a neat physical appearance when completed.

D. Coordination
1. Utilities.
a. Coordinate work related to utility services with the appropriate utility companies. Comply with the requirements of the following companies:
1) Electrical power: Potomac Electric Power Company (PEPCO).

1.5 PROJECT/SITE CONDITIONS

A. Environmental Requirements
1. Provide products suitable for operation under the following environmental conditions:

a. Temperature: -18 to 38 degrees C (0 to 100 degrees F).
b. Humidity: 0 to 95 relative percent, non-condensing.
c. Altitude: 2010 meters (6600 feet) above sea level.
d. Outdoor: Products that are UL listed for wet locations.

1.6 WARRANTIES

A. Refer to the Conditions of the Contract for provisions concerning Contract general warranty, Statements of Compliance, correction of Work period, and form of Special Warranty.

B. All electrical systems, equipment and installations shall be provided with a one-year minimum Warranty starting from the date of substantial completion.

C. During the warranty period, and for non-conformities the contractor shall take all necessary and appropriate action; free of charge, to correct any non-conformity with the warranties contained in the manufacturer agreement. During the warranty period, contractor shall provide to Owner, free of costs and charges, all support necessary to ensure that the installation meets the requirements specified in the Contract Documents and performance guarantees provided by the contractors. During the warranty period, contractors shall furnish, or cause to be furnished, all maintenance, service, parts and replacements necessary to maintain the installation in good working condition, at no cost to Owner.

1.7 CONDUCTOR SIZING

A. Feeder and Branch Circuit Sizing
1. Provide feeder and branch circuits per the circuit sizing schedules indicated on Drawings. Where schedules are not indicated, provide conductors which are sized as required per the NEC for the indicated overcurrent protective device rating. Circuit sizing and installation shall consider the field routing and anticipated voltage drop. Upsize wire, as necessary, to compensate for voltage drop and/or other forms of derating required in accordance with the NEC.
2. Derate conductor ampacities per the NEC for field conditions including but not limited to conduits exposed to sunlight, elevated ambient temperature, and/or more than 3 current carrying conductors in a raceway.

1.8 SYSTEMS INTEGRATION

A. Coordinate with equipment suppliers and ensure integration of systems comprised of disparate equipment which work together to form a complete system.

B. Provide all miscellaneous components, wiring, hardware, etc. required for complete and operational equipment and systems whether or not these items are explicitly shown in the Contract Documents.

C. Provide systems which maintain the UL rating of the individual pieces of equipment.

D. Submit system integration wiring diagrams, control diagrams and sequence of operation, as needed.

1.9 COORDINATION

A. Contractor shall participate in the project scheduling, coordination meetings and coordination drawing/modeling activities as specified in Division 01.

B. All potential coordination issues shall be brought to the attention of the Construction Manager immediately before proceeding with the installation.

C. Contractor shall be responsible for all cross connecting and coordination with vendors and other trade contractors to provide complete operational systems.

D. For purpose of clarify and legibility, drawings are diagrammatic. Locate equipment as close as practical to the locations shown on the drawings. Should field conditions prevent the installation of equipment or materials as indicated on the drawings, make deviations only with the prior approval of the Owner's representative.

E. Coordinate arrangement, mounting, and support of electrical equipment:
1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping at required slope.
4. To allow connecting raceways, cables, wireways, cable trays, and busways to be clear of obstructions and of the working and access space of other equipment.

F. Coordinate work with other trades to ensure completion is consistent with the project schedule. Ensure the NEC-required working space and dedicated electrical space about electrical equipment is provided. Foreign systems shall not be located within these dedicated zones. Any work that encroaches on the working space or dedicated electrical space shall be relocated at the Contractor's expense.

G. Equipment and device mounting heights and alignment shall adhere to architectural drawings, rules and requirements. Devices of all trades within the same general area shall be coordinated prior to construction. Care shall be taken to align devices horizontally and vertically. Devices that are not aligned properly shall be relocated at the Contractor's expense.

H. Coordinate exact conduit routing in the field with other trades and with building elements such as structural steel members. Conduit and raceways are not explicitly shown. Conduit routing where shown on drawings shall be considered approximate. Contractor shall be responsible for final routing in the field and shall be responsible for complete coordination with all other trades.

I. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

J. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.

K. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07.

PART 2 - PRODUCTS

2.1 Manufacturers

A. General
1. Furnish products by one of the equipment manufacturers listed under the heading "Manufacturers" within the applicable sections. When given, furnish the specified product model or brand for the selected manufacturer.
2. Provide products, for which quantities of two or more are to be furnished, from the same manufacturer and of the same product or model series.
3. Furnish product components designed to be used together and which are physically and electrically compatible.

B. Comparable Products
1. Comparable products may be proposed when the "or as approved" clause is specified under the heading "Manufacturers". Submit such products substitutions for approval per Division 01.• •

C. Product Substitutions
1. Product substitutions may be requested under the conditions specified in Division 1. Submit product substitutions for consideration per Division 01.

2.2 Products

A. Product Listing and Labeling
1. Provide listed and labeled product for which listings and labels exist by Underwriters Laboratories Inc. (UL), Factory Mutual (FM), or similar independent testing organizations recognized by the authorities having jurisdiction. For products for which there are no such listings and labels, provide listed and labeled components of those products, for which component listing and labels exist.

B. PCB Content Prohibited
1. Provide products which do not contain any amounts of polychlorinated biphenyl (PCB) compounds.

C. Asbestos Content Prohibited
1. Provide products which do not contain any amounts of asbestos.

D. Access Doors
1. Provide access doors necessary to access devices, whether for control or maintenance, governed by these Basic Electrical Materials and Methods. Access doors are not explicitly shown on the Drawings.
2. Access doors shall be coordinated with other trades and final locations shall be approved by Architect. Access doors not approved by Architect shall be removed or relocated at the Contractor's expense.
3. Access doors installed in fire rated floors, walls or ceilings shall be sufficiently rated to maintain the rating of the surface where installed.

2.3 Source Quality Control

A. Factory Tests
1. Permit Architect and Owner to observe factory tests. Provide minimum five working days notice of factory tests.
2. Schedule no more than one equipment or system factory test per week.

PART 3 - EXECUTION

3.1 CONSTRUCTION PHASING

A. The project will utilize phased construction. Contractor shall account for any and all costs associated with a phased construction schedule in bid. Refer to drawings for specific phased approach.

3.2 SHUTDOWNS

A. Interruption of Existing Service: Do not interrupt electric, communications or fire alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Architect, Construction Manager and Owner no fewer than seven days in advance of proposed interruption of service.
2. Indicate method of providing temporary service.
3. Do not proceed with interruption of service without Architect's, Construction Manager's and Owner’s written permission.
4. Comply with NFPA 70E.

B. Coordinate all service interruptions with other disciplines and Owner's representative. Shutdowns shall be performed during off hours, which may include weekends or holidays. This premium time cost shall be included in the Contractor's base bid.

C. Maintain Owner communications and network services operations during construction. Coordinate all service interruptions with other disciplines and Owner's representative.

D. Maintain Owner fire alarm systems and services operations during construction. Coordinate all service interruptions with other disciplines and Owner's representative.

3.3 DEMOLITION

A. **All power/circuit wiring including conduits shall be removed back to the upstream source. If needed, outages shall be coordinated to perform the removal.**

B. Protect adjacent building services and materials indicated to remain. Install and maintain barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition is complete.

C. “Carefully remove, clean and restore and reinstall items that are relocated during construction to a "like new" condition.

D. Building elements such as walls, partitions, floors and ceilings affected by electrical construction such as conduit penetrations shall be repaired, patched, painted and otherwise restored to a "like new" condition.

E. Lamp and Ballast Recycling.
1. Recycle lamps, ballasts and drivers containing hazardous materials such as mercury during construction. These shall include tubular fluorescent, compact fluorescent, HID, LED, induction and cold cathode lamps. These lamp types, ballasts and drivers associated with these lamps shall not be disposed of as solid municipal waste.

F. Equipment Protection and Cleanup.
1. Protect equipment and materials during shipment, storage and construction against damage, dust and contamination. Items that become damaged, dirty or contaminated during construction shall be restored to a "like new" condition or replaced at the Contractor's expense.
2. Remove and legally dispose of demolished items, rubbish, debris and construction waste from the construction site daily, and at the completion of the work. The contractor shall maintain a "clean" work site. Failure to do so may result in the cleanup being performed by others and all costs thereof being deducted from the Contractor’s final payment.

3.4 TEMPORARY SERVICE

A. The facility will remain operational during construction. Provide equipment, hardware, wiring, etc. to maintain systems scheduled to remain operational during construction. Coordinate detailed work phasing plans with the Construction Manager, Architect and Owner prior to commencing work.

B. Provide, maintain and remove all temporary lighting, power and communications required to complete the project.
   1. Coordinate temporary service installation with the local utility companies and building landlord prior to construction.
   2. **Provide overcurrent devices to all power panels and circuits to prevent inadvertent tripping of existing DC Courts equipment.**

C. In addition to NEC ground fault protection requirements, provide ground fault protection on temporary feeders 200 amps and greater.

D. Temporary feeders shall be limited to the following types:
   1. Conductors installed in raceways.
   2. Type MC cable.
   3. Multi-conductor cable with an overall protective outer jacket (where inaccessible to the public and not subject to physical damage or abuse).
   4. NEC recognized hard usage cord (where inaccessible to the public and not subject to physical damage or abuse).
   5. Label temporary feeders every 25 feet maximum.

3.5 INSTALLATION

A. General
   1. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items, unless otherwise indicated.
   2. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
   3. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
   4. Right of Way: Give to piping systems installed at a required slope.

B. Wiring Installation
   1. Install wiring for control systems, power feeder and branch circuits, lighting branch circuits, communication and auxiliary systems, such as fire alarm and security, in separate raceways unless otherwise indicated.
   2. For healthcare projects select the first sentence below; for all other projects select the second sentence.Install wiring and devices and make connections for Owner furnished equipment and furnished under other sections of the specifications. Refer to the specific sections for electrical requirements. Coordinate installation with the equipment supplier and the approved shop drawings.
   3. Prior to rough-in of electrical and telecommunications devices, verify locations with the owner's final furniture plans and the system supplier's approved installation drawings. Adjust locations of devices to coordinate with furniture and equipment layouts.

C. Device Location
   1. Allow for relocation prior to installation of wiring devices and other control devices, for example, receptacles, switches, occupancy sensors, fire alarm devices and access control devices, within a 10-foot radius of indicated location without additional cost.
   2. Refer to architectural plans for device location, mounting and alignment rules and requirements. Coordinate all device and lighting fixture placement with other trades prior to rough-in.
   3. Devices in proximity to each other shall be horizontally and vertically aligned. Devices which are not aligned properly shall be relocated as required to meet alignment requirements at no cost to Owner.
   4. Coordinate device placement and installation with other trades and Architect/Engineer prior to construction and rough-in.

D. NECA Compliance
   1. Install products in accordance with applicable NECA Standards, unless otherwise specified or indicated.

E. Wet, Damp, or Dry Location Work

1. Provide products as appropriate for wet, damp, or dry locations as defined by NFPA 70.

F. Manufacturer Installation Instructions
1. Install equipment in accordance with the manufacturer's installation instructions and recommendations.

G. Fire and Smoke Barrier Penetrations
1. Install firestopping to raceways, boxes and electrical equipment installed in or penetrating fire-rated floor and wall assemblies and smoke barrier assemblies, in a manner which maintains the fire resistance rating or barrier intent.

H. Field Painting
1. Field paint electrical equipment, products, materials, components and systems where indicated.
2. In a manner approved by the manufacturer and satisfactory to the Owner, touch-up or refinish factory-applied paints or finishes which are chipped, defaced, scratched, or in any other way disturbed due to handling, installation, or general construction work.

I. Exposed Construction
1. Take care in areas where the installation is exposed and visible to the public. Install electrical systems and equipment in an organized fashion and field painted. Mounting surfaces shall be repaired, patched, and painted to provide a "like new" appearance.
2. Coordinate systems (e.g. conduit, cable tray, wiring, duct work, piping, hanger, supports, etc.) prior to installation.

J. Personnel Protection from Suspended Work
1. Where suspended equipment, piping or ductwork or any of their supporting or reinforcing members extend 2.1 meters (7 feet) or less above the floor or any other walking surface, cover all edges, projecting surfaces and sharp corners with pre-fabricated soft rubber pads, elastomeric insulation, caps or equivalent to prevent injury to personnel.

K. Retain the following paragraph when appropriate; otherwise delete.Feeder and Branch Circuit Sizing
1. Provide feeder and branch circuit sizing per schedules indicated on drawings.

3.6 ACCEPTANCE TESTING

A. General.
1. **Comply with NETA ATS - Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.**
2. **Comply with the NEC Article 110 - Requirements for Electrical Installations - following all manufacturers' listing and labeling instructions for testing.**
3. Provide necessary test equipment and be responsible for setting-up test equipment, wire checks of factory wiring and any other preliminary work in preparation for the electrical acceptance tests.
4. Perform tests which do not exceed the manufacturer's recommended limit for the equipment being tested.
5. Where required for the validity of tests or safety of equipment and personnel, isolate equipment to be tested from the system.
6. Include the ambient temperature and relative humidity existing at the time when performing insulation resistance, dielectric absorption or high potential tests.
7. Coordinate testing and inspections with commissioning agent.

B. Visual Inspections.
1. Prior to any testing, perform visual inspections to verify the following:
   a. The equipment is completely and properly installed.
   b. The equipment is free from damage and defects.
   c. Shipping blocks and restraints have been removed.
   d. Electrical terminations are properly tightened.
   e. The equipment is properly aligned.
   f. The equipment is properly lubricated.
   g. The ventilation louvers are open and unobstructed.
   h. The equipment is ready to be tested.

C. Manual Operation.
1. Prior to any testing, operate mechanical devices to verify that they function properly and freely.

D. Insulation Resistance Test.
1. Perform test with a voltage source capable of providing a constant direct voltage for the time intervals as specified below.
   a. 150 volts and under - 500 volts.
   b. 151-600 volts - 1000 volts.

c. Hold 1000-volt and 500-volt insulation resistance tests for a minimum of one minute or until the reading reaches a constant value for 15 seconds unless specified otherwise.
d. Apply tests from phase to ground with the other phases grounded. Test each phase in a similar manner.
e. Check phase matching and phase identification immediately prior to energizing equipment.

3.7 FIELD QUALITY CONTROL

A. Field Tests
1. **Comply with NETA MTS - Standard for Maintenance Testing Specifications for Electrical Power Equipment and Systems.**
2. **Comply with the NEC Article 110 - Requirements for Electrical Installations - following all manufacturers' listing and labeling instructions for testing.**
3. Permit Architect and Owner to observe field tests. Provide minimum fiveworking days notice of field test.
4. Schedule tests in coordination with other Contract work. Schedule no more than one equipment or system field test per day.
5. Provide test reports.

B. Inspect installed sleeves and firestopping for damage or faulty work. Replace defective installations.

C. Replace any equipment, system or materials found to be defective or found to be of lesser quality than that specified or shown on the Drawings.

3.8 CLEANING

A. Clean electrical equipment and systems to remove dirt, paint or other foreign materials and restore to match original condition and finish upon completion of construction.

B. All backboxes are to be concealed with metal screw-on cover plates to protect wiring within while painting, fireproofing, and plastering occur to keep conductors concealed from these foreign materials. Metal screw-on cover plates can then be removed immediately before electrical devices are placed into the backboxes.

3.9 TRAINING

A. General
1. Provide training for Owner's personnel in the operation and maintenance of equipment as specified in the applicable Section for the particular equipment and system.
2. Develop training schedule which is acceptable to the Owner. Submit schedule for approval.
3. Provide instruction books, manuals, and other classroom material required as part of the training sessions.
4. Provide instructors who are certified by the equipment and system manufacturers.
5. Provide training for a minimum of three of the Owner's personnel, or as specified in the applicable Section.
6. Conduct training at Project Site after the equipment/system has been installed.

B. Operations and Maintenance Training
1. Train personnel in all aspects of normal operation of the equipment, including starting, adjustments while running, and shutdown.
a. Train personnel to recognize incipient problems, including inefficient or dangerous modes of operation, and provide instruction in corrective actions to be taken.
2. Train personnel to perform all recommended maintenance on the equipment.

END OF SECTION

SECTION 260413 - COMMON SUBMITTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.

B. Related Requirements:
   1. Division 01 submittal requirements.

1.2 DEFINITIONS

A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract, including but not limited to a Construction Manager.
   1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.

B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
   1. Shop Drawings.
   2. Product Data.
   3. Samples.

C. Action Submittals: Written and graphic information and physical samples that require Architect's and Construction Manager's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

D. Informational Submittals: Written and graphic information and physical samples that do not require Architect's and Construction Manager's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

E. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.

1.3 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.

B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.

C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
   1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
   2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
   3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
   4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
      a. Architect reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   1. Initial Review: Allow 10 business days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required.

2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.
3. Resubmittal Review: Allow 10 business days for review of each resubmittal.
4. Sequential Review: Where sequential review of submittals by Architect's consultants, Owner, or other parties is indicated, allow 15 business days for initial review of each submittal.

E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.

1.4 DELEGATED-DESIGN SERVICES

A. Definitions:
1. Delegated Design: A portion or component of the Work identified by the Contract Documents to be designed by the Contractor, or an entity assigned by the Contractor, to satisfy performance and design criteria specified in the Contract Documents for that portion or component.
2. Registered Design Professional: Design professional, assigned by the Contractor, who is responsible for providing the delegated design work, and for certifying that the work is in compliance with the specified performance requirements and design criteria. Design professional shall be legally qualified to practice in jurisdiction where Project is located and shall be experienced in providing delegated design services of the kind indicated. Delegated design services are defined as those performed for installation of the system, assembly or product that are similar in material, design, and extent to those indicated for this Project.

B. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.

C. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally signed PDF electronic file copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.
1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Combine with Submittal Review Sheet before submitting to Architect and Construction Manager.
1. Submittal Compliance Form: Allowed in lieu of some product data and sample submittals. See individual specification sections for specific allowable use. By submitting the form, the Contractor certifies that all products specified in the Section are being submitted exactly as indicated, including all options and features indicated, with no substitutions or comparable products. Where a Basis-of-Design manufacturer/product is indicated, along with a list of other manufacturers, the Contractor certifies that only the Basis-of-Design manufacturer/product will be provided and not any other listed manufacturers/products. Where a single manufacturer/product is indicated, even if specified as "available manufacturer" or manufacturer "included but not limited to the following", Contractor certifies that only the indicated single manufacturer/product will be provided.
    a. Obtain a copy of the Submittal Compliance Form from the Architect, fill in the information required and include as a line item on the Submittal Cover Sheet for each applicable Submittal.
    b. Upon receipt, the Architect will complete the form in the space below "Architect Action" and indicate the Action on the Submittal Cover Sheet.

B. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.

C. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.

D. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

E. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal.

3.2 ARCHITECT'S AND GENERAL CONTRACTOR'S ACTION

A. General: Architect will not review submittals that do not include the Submittal Review Sheet.

B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.

C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.

D. The Final Review Code on the Submittal Review Sheet prevails and governs the action of the overall submittal.

E. Review Code meanings are as follows:
1. Action Codes Permitting Use:
    a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
    b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
    c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
    d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.
2. Action Code Prohibiting Use:
    a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.
3. Action Code for Items Not Required:
    a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.

F. Informational Submittals: For Architect's information only. Architect and Construction Manager will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect and Construction Manager will forward each submittal to appropriate party.
1. Action Code for Information Only:
    a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.

G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.

I. Submittals not required by the Contract Documents may be returned by the Architect without action.
1. Do not submit Material Safety Data Sheets. They will be returned without review.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
   1. Submittal Numbering: See below.
   2. Contact Information: Full Name, Phone Number and Email Address.

B. Submittal Definition
   1. Each submittal consists of items from only ONE Specifications section.
   2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.
   3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).
   4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.

C. Submittal Numbering
   1. Number submittals as described below to assist tracking.
   2. Number each submittal in the format nnnnnn-nn.
      a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
      b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
      c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.
      d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
      e. Examples:
         1) Initial Complete Submittal: 044200-01. First Re-Submittal: 044200-01-R1.
         2) Initial Partial Submittal: 044200-01-P1. Second Partial Submittal: 044200-01-P2.
         3) First Re-submittal of Second Partial Submittal: 044200-R1-P2.

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.

B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.

C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
   1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.

D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.2 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Standards:
   1. Products 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."

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. 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. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 and ASTM B 496 for stranded conductors.

D. Conductor Insulation:
   1. Refer to Part 3 for conductor insulation application. Comply with UL Standard appropriate for cable insulation.

2.2 TRAY CABLE, TYPE TC FOR VFD OUTPUT CIRCUITS

A. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in a nonmetallic jacket.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Alpha Wire Company.
   2. Belden Inc.
   3. Encore Wire Corporation.
   4. General Cable Technologies Corporation.
   5. Okonite Company (The).
   6. Service Wire Co.
   7. Southwire Company.
   8. WESCO.

C. Standards:

1. RoHS compliant.
2. Comply with UL 1277.

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Ground Conductor: Three stranded bare copper ground wires.

F. **Conductor Insulation per DC Courts Standards: Type THWN-2. Comply with UL 83.**

G. Shield: Copper tape shield with a minimum of 50% overlap.

2.3 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M Electrical Products.
2. 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. Jacketed Cable Connectors: For steel jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
1. Material: Bronze or matching conductor material.

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. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

D. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG.

E. Isolated Power System Secondary Conductor Type: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

F. **DC Courts Standard: Minimum size 12AWG, Copper Conductors in all applications.**

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. **Feeders per DC Courts Standards: Type THHN/THWN/THWN-2, single conductors in raceway.**

B. **Exposed Branch Circuits, Including in Crawlspaces per DC Courts Standards: Type THHN/THWN/THWN-2, single conductors in raceway.**

C. **Branch Circuits Concealed in Ceilings, Walls, and Partitions per DC Courts Standards: Type THHN/THWN/THWN-2, single conductors in raceway.**

D. **Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground per DC Courts Standards: Type THHN/THWN/THWN-2, single conductors in raceway.**

E. **Branch Circuits Installed below Raised Flooring per DC Courts Standards: Type THHN/THWN/THWN-2, single conductors in raceway.**

F. **Feeders and Branch Circuits Installed on Rooftops per DC Courts Standards: Type THWN-2, single conductors in raceway.**

G. **Feeders and Branch Circuits, Exposed on Roofs per DC Courts Standards: Type THWN-2, single conductors in raceway.**

H. **Emergency Power System Branch Circuits per DC Courts Standards: Type THHN/THWN/THWN-2, single conductors in raceway.**

I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

J. VFD Output Circuits: Type TC-ER cable with tape shield.

K. **DC Courts Standard: THHN/THWN 600V for Dry and Damp Locations; THWN-2 for Wet Locations.**

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. Install cable per manufacturer's recommendations.

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches **(**150 mm**)**.

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 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."

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform the following:

1. Resistance test of all power/circuiting wiring to verify continuity.
2. Insulation resistance test of all power cables.
3. All torque verification of all terminations.
4. Infra-red scanning of all electrical equipment 9 months after substantial completion.

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 SECTION

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Multimode optical-fiber cabling.
2. UTP cabling.
3. RS-485 cabling.
4. Low-voltage control cabling.
5. Control-circuit conductors.
6. Identification products.

1.2 DEFINITIONS

A. EMI: Electromagnetic interference.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

C. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

D. RCDD: Registered Communications Distribution Designer.

E. UTP: Unshielded twisted pair.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

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.

2.2 PERFORMANCE REQUIREMENTS

A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
1. Flame Travel Distance: 60 inches **(**1520 mm**)** or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.3 BACKBOARDS

A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches **(**19 by 1220 by 2440 mm**)**.

B. Painting: Paint plywood on all sides and edges with a minimum of two coats (over primer) of fire retardant, non-conductive paint, and one coat of white colored semi-gloss topcoat paint.

2.4 OPTICAL-FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Belden Inc.
2. CommScope, Inc.
3. Corning Incorporated.
4. Emerson Connectivity Solutions.
5. General Cable Technologies Corporation.
6. Mohawk; a division of Belden Inc.
7. Nexans; Berk-Tek Products.
8. Siemon Company (The).
9. Superior Essex Inc.
10. SYSTIMAX Solutions; a CommScope, Inc. brand.
11. 3M.
12. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: Multimode, 50/125-micrometer, 24-fiber, nonconductive, tight-buffer, optical-fiber cable.
1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAA-B for detailed specifications.
4. Conductive cable shall be steel -armored type.
5. Maximum Attenuation: 3.5dB/km at 850 nm; 1.5dB/km at 1300 nm.
6. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

C. Jacket:
1. Jacket Color: Aqua for 50/125 -micrometer cable.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches **(**1000 mm**)**.

2.5 OPTICAL-FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ADC.
2. American Technology Systems Industries, Inc.
3. Belden Inc.
4. Corning Incorporated.
5. Dynacom Inc.
6. Hubbell Incorporated.
7. Molex Premise Networks; a division of Molex, Inc.
8. Panduit Corp.
9. Siemon Company (The).

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 36-inch **(**900-mm**)** lengths.

D. Cable Connecting Hardware:
1. Comply with Optical-Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA-568-C.3.
2. Quick-connect, simplex and duplex, Type SC or Type ST or Type LC or Type MT-RJ connectors. Insertion loss of not more than 0.75 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.6 UTP CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ADC.
2. Alpha Wire Company; a division of Belden Inc.
3. Belden Inc.
4. CommScope, Inc.
5. Draka Cableteq USA.

6. Genesis Cable Products; Honeywell International, Inc.
7. Mohawk; a division of Belden Inc.
8. Nexans; Berk-Tek Products.
9. Siemon Company (The).
10. Superior Essex Inc.
11. SYSTIMAX Solutions; a CommScope, Inc. brand.
12. 3M.
13. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. Description: 100-ohm, four-pair UTP, 25-pair UTP covered with a thermoplastic jacket.
1. Comply with ICEA S-90-661 for mechanical properties of Category 5e cables.
2. Comply with ICEA S-102-700 for mechanical properties of Category 6 cables.
3. Comply with TIA-568-C.1 for performance specifications.
4. Comply with TIA-568-C.2, Category 6A.
5. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with NEMA WC 66, UL 444 and NFPA 70 for the following types:
   a. Communications, Plenum Rated: Type CMP complying with UL 1685.
   b. Communications, Riser Rated: Type CMR complying with UL 1666.
   c. Communications, General Purpose: Type CM or Type CMG.
   d. Communications, Limited Purpose: Type CMX.

2.7 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ADC.
2. American Technology Systems Industries, Inc.
3. Belden Inc.
4. Dynacom Inc.
5. Hubbell Incorporated.
6. Leviton Commercial Networks Division.
7. Molex Premise Networks; a division of Molex, Inc.
8. Panduit Corp.
9. Siemon Company (The).
10. Tyco Electronics/AMP Netconnect; Tyco International Ltd.

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
1. Number of Terminals per Field: One for each conductor in assigned cables.

E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
1. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.

F. Jacks and Jack Assemblies: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-C.1.

G. Patch Cords: Factory-made, four-pair cables in 48-inch **(**1200-mm**)** lengths; terminated with eight-position modular plug at each end.
1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.

H. Workstation Outlets: Four-port-connector assemblies mounted in single faceplate.

I. Faceplates:
1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
2. Metal Faceplate: Stainless steel, complying with requirements in Section 262726 "Wiring Devices."
3. For use with snap-in jacks accommodating any combination of UTP, optical-fiber, and coaxial work area cords.

a. Flush-mounted jacks, positioning the cord at a 45-degree angle.

J. Legend:
1. Factory labeled by silk-screening or engraving for stainless steel.
2. Machine printed, in the field, using adhesive tape label.

2.8 TWIN-AXIAL DATA HIGHWAY CABLE

A. Standard Cable: NFPA 70, Type CM.
1. Paired, No. 20 AWG, stranded (7x28) tinned-copper conductors.
2. Polypropylene insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. PVC jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, No. 20 AWG, stranded (7x28) tinned-copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. Plastic jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.9 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CMG.
1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.

B. Plenum-Rated Cable: NFPA 70, Type CMP.
1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262.

2.10 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMG.
1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.11 CONTROL-CIRCUIT CONDUCTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Encore Wire Corporation.
2. General Cable Technologies Corporation.
3. Southwire Company.

B. Class 1 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

C. Class 2 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

E. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.
1. Smoke control signaling and control circuits.

2.12 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP cables according to TIA-568-C.2.

C. Factory test optical-fiber cables according to TIA-568-C.3.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.
1. Test optical-fiber cable to determine the continuity of the strand end to end. Use optical-fiber flashlight or optical loss test set.
2. Test optical-fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
3. Test each pair of UTP cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.
1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
2. Outlet boxes for optical-fiber cables shall be no smaller than 4 inches (102 mm) square by 2-1/8 inches (53 mm) deep with extension ring sized to bring edge of ring to within 1/8 inch (3.1 mm) of the finished wall surface.
3. Flexible metal conduit shall not be used.

B. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. Raceway Installation in Equipment Rooms:
1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering the room from overhead.
4. Extend conduits 3 inches (75 mm) above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

E. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

B. General Requirements for Cabling:
1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems."
3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced.

5. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
10. Support: Do not allow cables to lay on removable ceiling tiles.
11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

C. UTP Cable Installation:
1. Comply with TIA-568-C.2.
2. Install termination hardware as specified in Section 271500 "Communications Horizontal Cabling" unless otherwise indicated.
3. Do not untwist UTP cables more than 1/2 inch (12 mm) at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:
1. Install wiring in raceways. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems."

E. Optical-Fiber Cable Installation:
1. Comply with TIA-568-C.3.
2. Terminate cable on connecting hardware that is rack or cabinet mounted.

F. Open-Cable Installation:
1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 30 inches (760 mm) apart.
3. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

G. Installation of Cable Routed Exposed under Raised Floors:
1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Below each feed point, neatly coil a minimum of 72 inches (1830 mm) of cable in a coil not less than 12 inches (305 mm) in diameter.

H. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inches (305 mm).
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inches (305 mm).

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
   c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.4 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified for future use with a tag.

3.5 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:
   1. Class 1 remote-control and signal circuits; No 14 AWG.
   2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
   3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.6 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-B, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.7 GROUNDING

A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-A; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Visually inspect UTP and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
   2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   3. Test UTP cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross-connection.
      a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

4. Optical-Fiber Cable Tests:
   a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   b. Link End-to-End Attenuation Tests:
      1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
      2) Attenuation test results for links shall be less than 2.0 dB.

D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

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

1.2 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency and testing agency's field supervisor.

B. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

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. Burndy; Part of Hubbell Electrical Systems.
2. ERICO International Corporation.
3. Galvan Industries, Inc.; Electrical Products Division, LLC.
4. ILSCO.
5. O-Z/Gedney; a brand of Emerson Industrial Automation.
6. Robbins Lightning, Inc.
7. Siemens Power Transmission & Distribution, Inc.
8. Thomas & Betts Corporation; A Member of the ABB Group.

2.3 CONDUCTORS

A. Insulated Conductors: Tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Bonding Conductor: No. 6 AWG, minimum, stranded conductor.
4. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches **(**6.3 by 100 mm**)** in cross section, with 9/32-inch **(**7.14-mm**)** holes spaced 1-1/8 inches **(**28 mm**)** apart, unless otherwise indicated or specified. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

D. Lead Content: Less than 300 parts per million.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

F. Conduit Hubs: Mechanical type, terminal with threaded hub.

G. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

H. Water Pipe Clamps:
1. Mechanical type, two pieces with stainless-steel bolts.
   a. Material: Die-cast zinc alloy.
   b. Listed for direct burial.
2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

I. Lead Content: Less than 300 parts per million.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. **DC Courts Standards: Insulated green equipment grounding conductor to be provided for each branch circuit and feeder. Use of conduit as an equipment grounding conductor is not permitted.**

C. Grounding Bus:
1. Install bus horizontally, on insulated spacers 2 inches **(**50 mm**)** minimum from wall.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

D. Conductor Terminations and Connections:
1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Ground separately-derived ac power system neutrals, including distribution transformers, to the grounding electrode system per NFPA 70.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches **(**150 mm**)** from the foundation.

3.4 EQUIPMENT GROUNDING

A. 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.

B. 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.

C. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

C. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

D. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

E. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

F. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
   1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   2. Make connections with clean, bare metal at points of contact.
   3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
   4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
   5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:
   1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
   3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
      a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
      b. Perform tests by fall-of-potential method according to IEEE 81.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. 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.

H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 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.

1.2 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.

1.3 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.

B. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer to design hanger and support system.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube & Conduit; a part of Atkore International.
      b. B-line, an Eaton business.
      c. ERICO International Corporation.
      d. Flex-Strut Inc..
      e. GS Metals Corp.
      f. G-Strut.
      g. Haydon Corporation.
      h. Metal Ties Innovation.
      i. Thomas & Betts Corporation; A Member of the ABB Group.
      j. Unistrut; Part of Atkore International.
      k. 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. 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; 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, stainless 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, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
   4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
   5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
   6. Toggle Bolts: Stainless-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.

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. Steel Conduit - NECA 101.
   3. Aluminum Conduit - NECA 102.
   4. Metal Cable Tray Systems - NECA 105.
   5. Nonmetallic Cable Tray Systems - NECA 111.

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 scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch **(**6 mm**)** 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 two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb **(**90 kg**)**.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   1. To Wood: Fasten with lag screws or through bolts.
   2. To New Concrete: Bolt to concrete inserts.
   3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   4. To Existing Concrete: Expansion anchor fasteners.
   5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches **(**100 mm**)** thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches **(**100 mm**)** thick.
   6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
   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. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

B. 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 **(**100 mm**)** 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 **(**20.7-MPa**)**, 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 **(**0.05 mm**)**.

B. Touchup: Comply with requirements in 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 SECTION

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Metal conduits and fittings.
2. Metal wireways and auxiliary gutters.
3. Surface raceways.
4. Boxes, enclosures, and cabinets.

1.2 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For professional engineer.

B. 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. Calconduit.
e. Electri-Flex Company.
f. FSR Inc.
g. O-Z/Gedney; a brand of Emerson Industrial Automation.
h. Republic Conduit.
i. Southwire Company.
j. Thomas & Betts Corporation; A Member of the ABB Group.
k. Topaz Electric; a division of Topaz Lighting Corp.
l. Western Tube and Conduit Corporation.
m. 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. IMC: Comply with ANSI C80.6 and UL 1242.
5. EMT: Comply with ANSI C80.3 and UL 797.
6. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:
1. Manufacturers: As specified above.
2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Fittings for EMT:
a. Material: Steel.
b. **Type: Compression per DC Courts Standards**.
6. Expansion Fittings: 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 **(**1 mm**)**, with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 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 Pentair Equipment Protection.
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 Pentair Equipment Protection.
7. Hubbell Incorporated.
8. Hubbell Incorporated; Wiring Device-Kellems.
9. Kraloy.
10. O-Z/Gedney; a brand of Emerson Industrial Automation.
11. RACO; Hubbell.
12. Spring City Electrical Manufacturing Company.
13. Thomas & Betts Corporation; A Member of the ABB Group.
14. Topaz Electric; a division of Topaz Lighting Corp.
15. 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. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb **(**23 kg**)**. Outlet boxes designed for attachment of luminaires weighing more than 50 lb **(**23 kg**)** shall be listed and marked for the maximum allowable weight.

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep **(**100 mm square by 60 mm deep**)**.

J. Gangable boxes are allowed.

K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

L. 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. Indoors: Apply raceway products as specified below unless otherwise indicated:
1. EMT
   a. **Exposed, not subject to physical damage per DC Courts Standards**.
   b. Concealed in Ceilings and Interior Walls and Partitions.
2. GRC or IMC
   a. **Exposed and Subject to Physical Damage per DC Courts Standards.**
      1) Mechanical Rooms
      2) Electrical Rooms
   b. Damp or Wet Locations
3. LFMC
   a. **Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Pumps, Electric Solenoid, or Motor-Driven Equipment per DC Courts Standards.**
4. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in damp or wet locations.

B. **Minimum Raceway Size:** 3/4-inch **(**21-mm**) trade size per DC Courts Standards.**

C. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. GRC and IMC: 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 per DC Courts Standards.** Comply with NEMA FB 2.10.
4. LFMC: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

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 nor onto drywall.

E. Keep raceways at least 6 inches **(**150 mm**)** away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. 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.

I. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

J. Support conduit within 12 inches (300 mm) of enclosures to which attached.

K. Raceways Embedded in Slabs:
1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches (50 mm) of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

L. Stub-Ups to Above Recessed Ceilings:
1. Use EMT, or IMC 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 (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

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 (53-mm) 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 (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

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 EMT conduit that is located where environmental temperature change may exceed 100 deg F **(**55 deg C**)** and that has straight-run length that exceeds 100 feet **(**30 m**)**.
2. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches **(**1830 mm**)** of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

Y. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

AA. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

BB. Locate boxes so that cover or plate will not span different building finishes.

CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

EE. Set metal floor boxes level and flush with finished floor surface.

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 SECTION

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Sleeves for raceway and cable penetration of **non-fire-rated** construction walls and floors.
2. Grout.
3. Silicone sealants.

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

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.

B. Sleeves for Conduits Penetrating **Non-Fire-Rated** Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch **(**0.6-mm**)** minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:
1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:
a. For sleeve cross-section rectangle perimeter less than 50 inches **(**1270 mm**)** and with no side larger than 16 inches **(**400 mm**)**, thickness shall be 0.052 inch **(**1.3 mm**)**.
b. For sleeve cross-section rectangle perimeter 50 inches **(**1270 mm**)** or more and one or more sides larger than 16 inches **(**400 mm**)**, thickness shall be 0.138 inch **(**3.5 mm**)**.

2.2 GROUT

A. Description: Nonshrink; recommended 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 **(**34.5-MPa**)**, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.3 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

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

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade **Non-Fire-Rated** Concrete and Masonry-Unit Floors and Walls:
   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
      a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
      b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
   2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
   3. Size pipe sleeves to provide 1/4-inch **(**6.4-mm**)** annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
   4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
   5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches **(**50 mm**)** above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating **Non-Fire-Rated** Gypsum Board Assemblies:
   1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
   2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch **(**25-mm**)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.

END OF SECTION

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 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. Comply with NFPA 70E and Section 260573 "Power System Studies" requirements for arc-flash warning labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F **(**67 deg C**)**, ambient; 180 deg F **(**100 deg C**)**, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:
   1. Color: **Black letters on an orange background.**
   2. Legend: Indicate voltage.

B. Accessible Fittings for Raceways and Cables within Buildings (Junction and Pull Boxes):
   1. Color: **Black letters on a white background**.
   2. Legend: Indicate voltage and load type.

C. Phase- and Voltage-Level Conductors at 600 V or Less: Use colors listed below:
   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:
      a. 208/120-V Circuits: White.
      b. 480/277-V Circuits: Grey.
   5. Color for Equipment Grounds: Green.
   6. Colors for Isolated Grounds: Green with two or more yellow stripes.
   7. Legend: Indicate panelboard and circuit number with **black letters on a white background**.

D. Floor Marking Tape: **Black and white stripes** with a clear overlay.

E. Equipment Nameplate Identification Colors:

1. Equipment with manufacturer standard finish on normal power (e.g. Panelboards, Disconnect Switches, VFDs): **White letters on a black background.**
2. Equipment with manufacturer standard finish on emergency power (e.g. Panelboards, Disconnect Switches, VFDs): **White letters on a red background.**

F. Warning Signs:
1. Color: **Black letters on an orange background**.
2. Legend: Identify system voltage.
3. Legend for Multiple Power Source Warning: Identify Multiple Power Sources.

G. Lock-Out Signs:
1. Color: **White letters on a red background.**
2. Legend: Numeric list of lock-out procedures.

H. Wiring Device Identification Colors:
1. Devices and faceplates that are lighter in finish (e.g. White, Light Almond, Ivory, Red): **Black lettering on a clear background.**
2. Devices and faceplates that are darker in finish (e.g. Charcoal Gray, Bronze, Black): **White lettering on a clear background.**

I. Cable Tie Colors:
1. Raceways, cables, and fittings that are lighter in finish (e.g. White, Light Almond, Ivory): **White**.
2. Raceways, cables, and fittings that are red or manufacturer standard finish: **Clear**.
3. Raceways, cables, and fittings that are darker in finish (e.g. Charcoal Gray, Bronze, Black): **Black**.

2.3 MANUFACTURERS

A. Subject to compliance with requirements, provide products by the following:
1. Brady Corporation.
2. Carlton Industries, LP.
3. Champion America.
4. emedco.
5. Hellermann Tyton
6. Ideal Industries, Inc.
7. LEM Products Inc.
8. Marking Services, Inc.
9. Panduit Corp.
10. Seton Identification Products.

2.4 LABELS

A. Self-Adhesive Electrical Markers: Pre-printed, 5-mil- **(**0.125-mm-**)** thick, vinyl flexible label with acrylic pressure-sensitive adhesive.
1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; protective shield over the legend.
2. Marker for Labels: Machine-printed, permanent, waterproof, ink by printer manufacturer.
3. Nominal Size: Maximize available dimensions of Electrical Marker labels with the raceway or cable size to maximize visibility.

B. Self-Adhesive Raised Rectangular Labels: Polyester, 0.0256-inch- **(**0.65-mm-**)** thick, thermal transfer-printed, abrasion-resistant, chemical-resistant, corrosion-resistant, permanent acrylic foam-backed adhesive.
1. Marker for Labels: Machine-printed, permanent, waterproof, ink by printer.
2. Minimum Nominal Size: 1 by 3 inches (25 by 76 mm).

C. Self-Adhesive Wraparound Labels: Vinyl, thermal transfer-printed, 4-mil- (0.1mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; protective shield over the legend.
2. Marker for Labels: Machine-printed, permanent, waterproof, ink by printer.
3. Minimum Nominal Size: 1-1/2 inch (38 mm) width with 1/2 inch (13 mm) printable area dimensions.

D. Arc Flash Hazard Labeling: See "26 0573 - Power System Studies" for more specific requirements.
1. Generic Arc Flash labels shall not be utilized. Arc Flash Hazard Labels are specific to each piece of electrical equipment and information printed on each label has specific information as a result of the Arc Flash Hazard Analysis. Labels shall be submitted under Specification section 260573 for review.

2.5 TAPES

A. Floor Marking Tape: 2-inch- (50-mm-) wide, 5-mil- (0.125-mm-) thick pressure-sensitive vinyl tape.

2.6 SIGNS

A. Phenolic Plastic Equipment Nameplates:
1. Adhesive mounting.
2. Engraved legend with a minimum of 4 text lines.
3. Thickness: 1/16 inch (1.6 mm).
4. Minimum Nominal Size: 4 by 2 inches (102 mm by 51 mm).

B. Polyester Signs:
1. An indoor/outdoor safety sign, with surface-printed polyester and a polyester overlaminate.
2. Can withstand temperature variations up to 230 degrees F.
3. Permanent, pressure sensitive adhesive.
4. Minimum Nominal Size: 7 by 10 inches (178 mm by 254 mm).

C. Vinyl Signs:
1. Final nominal size shall have minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer, load shedding, etc.
2. Self-adhesive, laminated, dirt resistant, and 3-mil- (0.07-mm-) in thickness.

2.7 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).

B. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).

PART 3 - EXECUTION

3.1 PREPARATION

A. 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. If identification is found to be incorrect after being applied in the field, identification is to be revised and completely reordered with the correct information. Applying temporary solutions (e.g. marker or tape) to correct identification labels is unacceptable.

H. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

I. Raceways and Cables Carrying Circuits at 600V or Less:
1. Identification shall be oriented such that viewers can read the marker from left to right. Secure tight to surface of cable, or raceway.
2. Locate identification directly above / below electrical equipment, at changes in direction, at penetrations of walls and floors, at 50-foot **(**15-m**)** maximum intervals in straight runs, and at 25-foot **(**7.6-m**)** maximum intervals in congested areas.

J. Accessible Fittings for Raceways and Cables within Buildings (Junction and Pull Boxes):
1. Identification shall be placed in the center of the junction / pull box and oriented parallel to the junction and pull box perimeter such that viewers can read the label from left to right. Secure tight to surface.
2. Font size on label to be maximized for viewer's ease of readability.

K. Wiring Device Faceplates:
1. Identification shall be placed onto the faceplate directly above the device, centered on the faceplate, and oriented such that viewers can read the label from left to right. Secure tight to surface.

L. Conductor Identification at 600V or Less:
1. Identification shall be placed such that viewers can read the marker as is from left to right without having to force-rotate the conductor to read the label. Secure tight to surface of conductor.
2. Locate identification at conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility.

M. Working Clearance Identification:
1. Apply **floor marking tape** evenly to finished surfaces for all electrical equipment that has required working clearances per NFPA 70. 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.
2. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Equipment Identification Labels:
1. Apply identification for equipment nameplate near the top of the front of the equipment, centered on the front of the equipment.
2. Identification shall be oriented parallel to the front of the equipment's edges such that viewers can read the sign from left to right. Secure tight to equipment surface.

O. Warning Signs:
1. Apply to exterior of door, cover, or other access to indoor cabinets, boxes, and enclosures for power and lighting.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
   a. Power-transfer switches.
   b. Controls with external control power connections.

P. Lock-Out Signs:
1. Apply **vinyl sign** directly adjacent to power transfer / load shedding equipment. Secure tight to surface at a location with high visibility and accessibility.

Q. 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. Accessible Raceways and Cables at 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with **self-adhesive electrical markers.** Legend examples are below:
1. 120 VOLTS
2. 208 VOLTS
3. 277 VOLTS
4. 480 VOLTS

C. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with **self-adhesive raised rectangular labels** containing the wiring system legend and system voltage. Legend examples are below:
   1. 120V EQUIPMENT
   2. 120V LEGALLY REQUIRED EQUIPMENT
   3. 120V LIFE SAFETY EQUIPMENT
   4. 120V LIGHTING
   5. 120V OPTIONAL STANDBY EQUIPMENT
   6. 120V RECEPTACLE POWER
   7. 208V EQUIPMENT
   8. 277V LIFE SAFETY LIGHTING
   9. 277V LIGHTING
   10. 480V EQUIPMENT

D. For Wiring Device Faceplates, use **self-adhesive vinyl labels** to identify the panelboard and circuit number. Legend examples are below:
   1. ML1H - 1
   2. DP-M1G - 18,20

E. Power-Circuit Conductors at 600 V or Less: For conductors in pull and junction boxes, use **self-adhesive wraparound labels** to identify the panelboard and circuit number. Legend examples are below:
   1. ML1H - 1
   2. DP-M1G - 18,20

F. Control-Circuit Conductors: For conductors and cables in pull and junction boxes, manholes, and handholes, use **self-adhesive wraparound labels** with the conductor or cable designation, origin, and destination.

G. Control-Circuit Conductors: For conductors and cables in pull and junction boxes, use **self-adhesive wraparound labels** with the conductor or cable designation, origin, and destination.

H. Control-Circuit Conductor Terminations: For identification at terminations, provide **self-adhesive wraparound labels** with the conductor designation.

I. Conductors to Be Extended in the Future: Attach **self-adhesive wraparound label** to conductors and list origin.

J. Equipment Identification Labels:
   1. Identify the equipment below with **phenolic plastic equipment nameplates**:
      a. Enclosures and electrical cabinets
      b. Access doors and panels for concealed electrical items.
      c. Emergency system boxes and enclosures.
      d. Enclosed switches.
      e. Enclosed circuit breakers.
      f. Enclosed controllers.
      g. Low-voltage distribution transformers.
      h. Variable-speed controllers.
      i. Push-button stations.
      j. Remote-controlled switches, dimmer modules, and control devices.
      k. Monitoring and control equipment.
   2. Include the following information on equipment labels per the Drawings:
      a. Line 1: Equipment Identification (e.g., "ML1H").
      b. Line 2: Amperage, Voltage (e.g., "400A, 208/120V").
      c. Line 2 for Transformers: Load, Voltage (e.g., "75kVA, 480/277V to 208/120V").
      d. Line 3: Source of power (e.g., "FED FROM SWBD-SHL1B IN VAULT B").
      e. Line 4 (If Applicable): What is being fed (e.g., "FEEDS ML1H-2 IN VAULT A").

K. Warning Signs for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Use **polyester signs** to identify voltage. Legend examples are below:
   1. HIGH VOLTAGE
   2. Legend for Multiple Power Source Warning: "ELECTRICAL HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

END OF SECTION

SECTION 260573 – POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes a computer-based, fault-current study to determine:
   1. The minimum interrupting capacity of circuit protective devices.
   2. Overcurrent protective device settings for selective tripping.
   3. The arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

B. **There is an existing Power System Study from 2023 that is to be obtained to aid in the completion of the Power System Study for this project. Contractor shall coordinate request of most current study from DC Courts representative.**

1.2 ACTION SUBMITTALS

A. Submit study reports indicated in this section **prior** to receiving final approval of the distribution equipment submittals, including but not limited to panelboards, transformers, switchboards, switchgear, substations, transfer switches, generators, motor controllers, and disconnect switches. If formal completion of studies will cause delay in equipment manufacturing, provide preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

B. Submit the following in digital form:
   1. Power system study input data, including completed computer program input data sheets.
   2. Power system study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
      a. Revised single-line diagram, reflecting field investigation results and results of power system studies.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Power System Study Specialist.

B. Product Certificates: For power system study software, certifying compliance with IEEE 399.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
   1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Power System Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the International Electrical Testing Association (NETA) or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

A. Software Developers: Subject to compliance with requirements, perform studies utilizing software by one of the following:
   1. ESA Inc., EasyPower
   2. SKM Systems Analysis, Inc.
   3. ETAP.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:
1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.

G. Short-Circuit Study Output:
1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    a. Voltage.
    b. Calculated fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Equivalent impedance.
2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Calculated asymmetrical fault currents:
        1) Based on fault-point X/R ratio.
        2) Based on calculated symmetrical value multiplied by 1.6.
        3) Based on calculated symmetrical value multiplied by 2.7.
3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. No AC Decrement (NACD) ratio.
    e. Equivalent impedance.
    f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

2.3 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:
1. Protective device designations and ampere ratings.
2. Cable size and lengths.

3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Protective Device Coordination Study:
1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
   a. Phase and Ground Relays:
      1) Device tag.
      2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
      3) Recommendations on improved relaying systems, if applicable.
   b. Circuit Breakers:
      1) Adjustable pickups and time delays (long time, short time, ground).
      2) Adjustable time-current characteristic.
      3) Adjustable instantaneous pickup.
      4) Recommendations on improved trip systems, if applicable.
   c. Fuses: Show current rating, voltage, and class.

F. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
   a. Power utility's overcurrent protective device.
   b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
   c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
   d. Transformer full-load current, magnetizing inrush current.
   e. Ground-fault protective devices.
   f. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

2.4 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary.

B. Study descriptions, purpose, basis and scope.

C. One-line diagram, showing the following:
1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Arc-Flash Study Output:
1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. No AC Decrement (NACD) ratio.

e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

F. Incident Energy and Flash Protection Boundary Calculations:
1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.
9. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the study.
1. **There is an existing Power System Study from 2023 that is to be obtained to aid in the completion of the Power System Study for this project.**
2. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of the Electrical Engineer.
3. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Electrical Survey Data: Gather and tabulate the following input data to support the power system study:
1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For generators, include voltage rating, power rating (kW/kVA), and alternator sub-transient reactance values.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
8. Motor horsepower and NEMA MG 1 code letter designation.
9. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic)
10. Calculation shall be performed in all DC Courts power operating conditions to determine the worst case arc flash and short circuit values. This should include but not be limited all DC Cours load scenarios such as operation from each switchgear main source on the main tie main switch gear and in a generator run condition

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. The extent of the electrical power system to be studied is indicated on Drawings.

D. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
1. To normal system low-voltage load buses where fault current is 10 kA or less, or as required to satisfy coordination study and arc-flash study requirements.

E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

F. The calculations shall include the ac fault-current decay from induction motors. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
   1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

G. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
   1. Electric utility's supply termination point.
   2. Generators.
   3. Incoming switchgear.
   4. Low-voltage switchgear.
   5. Motor-control centers.
   6. Control panels.
   7. Automatic transfer switches.
   8. Power distribution panelboards.
   9. Branch circuit panelboards.
   10. Disconnect switches.

H. Equipment short-circuit ratings and protective device interrupting ratings shall be selected based on the results of the fault current study.

3.3 PROTECTIVE DEVICE COORDINATION STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

C. Evaluate overcurrent protective devices serving transformers and verify that the devices will not open upon energization of the transformer. Where device rating and/or type must be changed to avoid opening upon energization, notify the Contractor and Electrical Engineer and record recommended device changes in the report.

D. Evaluate overcurrent protective device coordination against project selective coordination criteria. Where the system devices and/or configuration cannot achieve the required selective coordination criteria, evaluate alternate overcurrent device selections that will meet the criteria and record recommendations in the report.

3.4 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Calculate maximum and minimum contributions of fault-current size.
   1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
   2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

C. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.

D. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.

E. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors shall be decremented as follows:
   1. Fault contribution from induction motors should not be considered beyond three to five cycles.

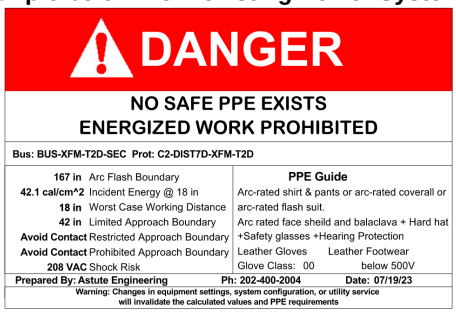
F. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
   1. When the circuit breaker is in a separate enclosure.
   2. When the line terminals of the circuit breaker are separate from the work location.

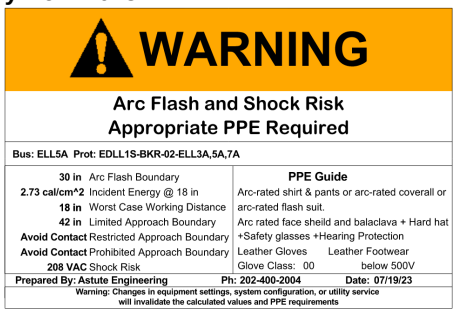
G. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

H. Labels: Print and install (2) labels - one for the equipment and one for DC Courts record - for each modeled piece of electrical equipment (new and altered) including but not limited to: switchboards, switchgear, enclosed panelboards, industrial control panels, meter socket enclosures, low-voltage transformers, disconnect switches, and variable frequency drives. **Provide orange bordered labels for PPE category 0 to 3, and red bordered labels for PPE category 4 & dangerous. Label format shall be coordinated with DC Courts standard label format and included in submittal for final approval.** Labels shall have flash protection, shock protection and shall include:

1. Flash Hazard in inches
2. Arc Flash rating in cal/sq. cm
3. Flash protection boundary in inches
4. Glove class
5. PPE clothing category
6. Shock hazard in volts
7. Limited Approach distance in inches
8. Restricted Approach distance in inches
9. Prohibited Approach distance in inches
10. Bus Designation
11. Upstream overcurrent protection designation
    a. Where applicable: Indication if values are based on “maintenance mode” on or off. Where temporary settings are utilized in the upstream overcurrent protection device for arc energy reduction purposes, provide two separate labels for each condition.
12. Oversize print of Warning or Danger
13. **See sample below from existing Power System Study from 2023:**

a.





3.5 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

B. Set field-adjustable overcurrent protective devices to the recommended settings based on results from the power systems studies. **All adjustable breaker settings shall be tested by a NETA Certified Testing Agency.**

3.6 DEMONSTRATION

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION

SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes Cx process requirements for the following electrical components, systems, assemblies, and equipment:
   1. Electrical equipment connected to Normal power systems, including the following:
      a. Transformers.
      b. Distribution and branch-circuit panelboards.
      c. Grounding systems.
   2. Electrical equipment connected to Essential power systems that provide an alternative source of power in the absence of power from the Normal power system, including the following:
      a. Distribution and branch-circuit panelboards.
      b. Grounding systems.
   3. Controls and instrumentation, including the following:
      a. Equipment monitoring systems.
      b. Energy monitoring and control systems.
      c. Electrical metering and metering system.
      d. Lighting control systems.
   4. Systems testing and verification, including Normal and Essential power systems, and transitions from Normal to Essential power systems and back.

B. Related Requirements:
   1. Division 01 for general Cx process requirements and CxA responsibilities.

1.2 DEFINITIONS

A. BoD: Basis-of-Design Document, as defined in Division 01.

B. Cx: Commissioning, as defined in Division 01.

C. CxA: Commissioning Authority, as defined in Division 01.

D. Essential Power Systems: A power system that a facility transitions to in the absence of Normal power. This power includes all systems classified as "standby" or "emergency," including "legally required."

E. Low Voltage: 600 V and below.

F. Medium Voltage: 601 V and above.

G. Normal Power Systems: A power system that provides primary power to a facility.

H. OPR: Owner's Project Requirements, as defined in Division 01.

I. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For BAS and electrical testing technician.

B. Construction Checklists: Include the following and comply with requirements in Division 01 for construction checklists:
   1. Instrumentation and control for electrical systems.
   2. Instrumentation and control for lighting control systems.
   3. Low-voltage power cables.
   4. Control voltage power cables.
   5. Electrical feeders and branch circuits.
   6. Dry-type transformers.
   7. Switchgear and switchboard assemblies rated 1200 A or greater.
   8. Metal-enclosed bus duct.
   9. Busway.
   10. Motor-control centers.
   11. Low-voltage motor starters.
   12. Low-voltage insulated case circuit breakers.

13. Low-voltage surge protective devices.
14. Protective relays.
15. Metering devices.
16. Molded-case circuit breakers.
17. Low-voltage power circuit breakers.
18. Grounding systems.
19. Ground-fault protection systems.
20. Panelboards.
21. Receptacles and devices.
22. Variable-frequency drives.
23. AC synchronous motors and generators.
24. AC induction motors and generators.
25. DC motors and generators.
26. Lighting.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electrical systems and components to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Testing Technician Qualifications: Technicians to perform electrical Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
   1. Journey level or equivalent skill level. Vocational school four-year-program graduate or an Associate's degree in electrical systems, or similar field. Degree may be offset by three years' experience as an apprentice or a journey-level electrician. Generally, required knowledge includes electrical and HVAC&R concepts, building operations, and application and use of tools and instrumentation to measure performance of electrical equipment, assemblies, and systems.
   2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.

B. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform electrical Cx work, perform the following:
   1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:
      a. Equipment/instrument identification number.
      b. Planned Cx application or use.
      c. Manufacturer, make, model, and serial number.
      d. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
   2. Test equipment and instrumentation shall meet the following criteria:
      a. Capable of testing and measuring performance within the specified acceptance criteria.
      b. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
      c. Be maintained in good repair and operating condition throughout duration of use on Project.
      d. Be recalibrated/repaired if dropped or damaged in any way since last calibrated.

C. Proprietary Test Instrumentation and Tools:
   1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, perform the following:
      a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:
         1) Instrument or tool identification number.
         2) Equipment schedule designation of equipment for which the instrument or tool is required.
         3) Manufacturer, make, model, and serial number.
         4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.
      b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.

c. Electrical proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLISTS

A. Prepare detailed construction checklists for electrical systems, subsystems, equipment, and components. Complete and submit construction checklists.

3.2 CONSTRUCTION CHECKLIST REVIEW

A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.

B. Return draft Construction Checklist review comments within 10 days of receipt.

C. When review comments have been resolved, CxA will provide final construction checklists, marked "Approved for Use, (date)."

D. Use only construction checklists, marked "Approved for Use, (date)."

3.3 GENERAL TESTING REQUIREMENTS

A. Certify that electrical systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved Shop Drawings and submittals.

B. Certify that electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.

C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

D. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions to verify compliance with acceptance criteria.

E. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and response according to acceptance criteria.

F. Construction Checklists: Prepare and submit detailed construction checklists for electrical systems, subsystems, equipment, and components.
   1. Contributors to development of construction checklists shall include, but are not limited to, the following:
      a. Electrical systems and equipment installers.
      b. Electrical instrumentation and controls installers.

G. Perform tests using design conditions, whenever possible.
   1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
   2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
   3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

H. If tests cannot be completed because of a deficiency outside the scope of the electrical system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.

I. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

J. Coordinate schedule with, and perform Cx activities at the direction of the CxA.

K. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Sections specifying electrical systems and equipment.

L. Provide technicians, instrumentation, tools, and equipment to complete and document the following:
1. Performance tests.
2. Demonstration of a sample of performance tests.
3. Cx tests.
4. Cx test demonstrations.

3.4 Cx TESTS FOR ELECTRICAL SYSTEMS

A. Verification of Normal Power System Operation:
1. Prerequisites: Acceptance of results for construction checklists for Division 26 electrical components associated with Normal power system.
2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
3. Test Purpose: Verify operation of Normal power system.
4. Test Conditions: Energize components of Normal power system, one at a time.
5. Acceptance Criteria: Proper operation of Normal power system over a 24 -hour period.

B. Verification of Essential Power System Operation:
1. Prerequisites:
a. Acceptance of results for construction checklists for Division 26 electrical components associated with Essential power system.
b. Completion of "Verification of Normal Power System Operation" tests.
2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
3. Test Purpose: Verify operation of Essential power system.
4. Test Conditions:
a. Energize components of Normal power system.
b. Simulate a failure of Normal power system.
5. Acceptance Criteria: Transfer of power from Normal to Essential power system within OPR.

C. Verification of Control and Instrumentation:
1. Prerequisites: Acceptance of results for construction checklists.
a. Section 260913 "Electrical Power Monitoring and Control."

D. Test Purpose: Verify operation of control and monitoring systems for Normal and Essential power systems.

E. Test Conditions:
1. Energize components of Normal power system.
2. Test operation of equipment.

F. Acceptance Criteria: Operation of equipment according to OPR.

END OF SECTION

SECTION 260913 - ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes equipment and systems used to monitor and control electrical consumption:
1. Multifunction Energy Meters.
2. Electrical Power Monitoring and Control Software.
3. Network Configuration Software.
4. Monitoring and Control of Power Distribution Equipment.
5. Raceways and Boxes.
6. Wires and Cables.
7. Surge Protection Devices.

1.2 DEFINITIONS

A. Active Power: The average power consumed by a unit. Also known as "real power."

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. Apparent (Phasor) Power: "S = VI" where "S" is the apparent power, "V" is the rms value of the voltage, and "I" is the rms value of the current.

D. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

E. KY Pulse: A method of measuring consumption of electricity that is based on a relay operating like a SPST switch.

F. KYZ Pulse: A method of measuring consumption of electricity based on a relay operating like a SPDT switch.

G. LAN: Local area network.

H. L-G: Line to ground.

I. L-L: Line to line.

J. L-N: Line to neutral.

K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

L. Modbus TCP/IP: An open protocol for exchange of process data.

M. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

N. N-G: Neutral to ground.

O. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.

P. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

Q. TCP/IP: Transport control protocol/Internet.

R. UPS: Uninterruptible power supply; used both in singular and plural context.

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 power monitoring and control.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For power monitoring and control equipment.
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.
      a. Attach copies of approved Product Data submittals for products (such as panelboards, switchboards, and switchgear) that describe the following:
         1) Location of the meters and gateways, and routing of the connecting wiring.
         2) Details of power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
   3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
   4. Network naming and numbering scheme.
   5. Include diagrams for power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
   6. Specifications for workstations.
   7. Surge Suppressors: Data for each device used and where applied.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Design Data:
   1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.
      a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
      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 the 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 do the following:
         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 compact disk or portable storage device with a USB interface.
      j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
      k. Complete original-issue copies of furnished software, including operating systems, custom programming language, workstation software, and graphics software on compact disk or portable storage device with a USB interface.
      l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
      m. Owner training materials.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power monitoring and control units to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Software licenses.
3. Software service agreement.
4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Provide separately for each PC.
5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on compact disk or portable storage device with a USB interface of the hard-copy submittal.
6. Program Software Backup: On compact disk or portable storage device with a USB interface, complete with data files.
7. Device address list.
8. Printout of software application and graphic screens.

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. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
   2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.8 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.
   1. Match components and interconnections for optimum performance of specified functions.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:
   1. Electrical meters that monitor, control, and connect to the data transmission network.
   2. LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.

B. The electrical power monitoring and control system shall be Internet based.
   1. System software shall be based on server thin-client architecture, designed around open standards of internet technology.
   2. Intent of thin-client architecture is to provide operators complete access to power monitoring and control system via an Internet browser. No special software other than an Internet browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
   3. Internet access shall be password protected.

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.

D. UL Compliance: Listed and labeled as complying with UL 61010-1.

2.2 PERFORMANCE REQUIREMENTS

A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
   1. Minimum Protection for Power Lines 120 V and More: SPDs complying with UL 1449, listed and labeled for intended use by an NRTL acceptable to authorities having jurisdiction.
   2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

B. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

C. Interface with DDC System for HVAC: Provide factory-installed hardware and software to enable the DDC system for HVAC to monitor, display, and record data for use in processing reports.
   1. Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely monitor meter information from a DDC system for HVAC workstation. Control features and monitoring points displayed locally at metering panel shall be available through the DDC system for HVAC.

D. Backup Power Source:
   1. Electrical power distribution equipment served by a backup power source for controls shall have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.

2.3 MULTIFUNCTION ENERGY METERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Square D; by Schneider Electric.

B. Multifunction Energy Meter: Internally mounted, modular, permanently installed, solid-state, digital I/O instrument for power and energy metering and monitoring; complying with UL 61010-1.
   1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
   2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

C. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   1. Indoor installation in non-air-conditioned spaces that have environmental controls to maintain ambient conditions of minus 4 deg to 158 deg F **(**minus 20 to plus 70 deg C**)** dry bulb and 5 to 95 percent relative humidity, noncondensing.
   2. Comply with IEC 60529 degree of protection code of IP65 (NEMA 250 Type 4 / 4X) for the front of the meter, and code of IP30 (NEMA 250 Type 1) for the body.

D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

E. Accuracy:
   1. Comply with ANSI C12.20, Class 0.5.
   2. Neutral Current Measurement: Not more than 0.65 percent.
   3. Power Factor: 1.0 percent.
   4. Frequency: 0.1 percent.
   5. THD: 1.0 percent.
   6. Waveform Sampling: 64 per cycle.

F. Data Link:
   1. RS-485 Modbus, RTU protocol, 4-wire connection to host devices with a compatible port.

G. Meter Physical Characteristics:
   1. Display: Backlit LCD with antiglare and scratch-resistant lens.
   2. Display of Metered Values:
      a. One screen to show at least three user-selected values displayed at the same time. Selections available to display shall include the following:
         1) All meters.
         2) Measurements.
         3) THD.
         4) Energy.
         5) Demand.
         6) Minimum and maximum values.
         7) Power demand.

H. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 64 samples per cycle, simultaneously on all voltage and current channels of the meter.

I. Meters:
   1. Instantaneous, rms:
      a. Current: Each phase, neutral and three-phase average.
      b. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
      c. Active Power (kW): Each phase and three-phase total.

d. Reactive Power (kVAR): Each phase and three-phase total.
e. Apparent Power (kVA): Each phase and three-phase total.
f. Power Factor: Each phase and three-phase total.

2. Energy:
   a. Active Energy (kWh): Three-phase total.
3. Demand, Derived from Instantaneous rms Meters:
   a. Current: Present and maximum.
   b. Active: Present and maximum.
   c. Reactive: Present and maximum.
   d. Apparent: Present and maximum.
4. Power Quality Measurements:
   a. THD: Current and voltage from measurements simultaneously from the same cycle, as can be calculated from the specified sampling rate.

J. I/O: Two optically isolated digital outputs for KY pulsing or control. Output signal characteristics shall be 150 mA at 200 V.
   1. KY Pulse: Generate standard KY pulses for a user-defined increment of metered active energy as follows:
      a. User-defined pulse output, associated with kWh.
      b. User-defined pulse output, associated with kVARh.

K. Capacities and Characteristics:
   1. Power Supply: 120-V ac, 60 Hz.
   2. Circuit Connections:
      a. Voltage: Measurement autoranging, 60- to 400-V ac L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
      b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
      c. Frequency: 45 to 65 Hz.
      d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.4 POWER MONITORING AND CONTROL SOFTWARE

A. Data Storage and Data Sharing:
   1. Query and download logs of interval data stored on metering devices.
   2. Query and download logs of alarm and event data stored on metering devices.
   3. Query and download logs of waveform capture data stored on metering devices.
   4. Query and download logs of interval data generated by the software and calculated by the meters.
   5. Query and download logs of alarm and event data generated by the software and calculated by the meters.
   6. Automatically re-arm the waveform recorders, on upload of information.
   7. Provide a facility to archive, trim, and back up the database on demand, or on a schedule.
   8. Provide a facility to view historical data from archived databases.
   9. Support user changes to the database.
      a. Support on-line changes while the data storage/retrieval application is running.
      b. Suffer no interruption to its operation while changes are being made.
      c. Require no restart once the configuration has been performed.

B. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:
   1. Plan for each building floor, showing the following:
      a. Locations and identification of all monitored and controlled electrical equipment.
   2. Control schematic for each device that is controlled by the meters of this Section, including a graphic system schematic representation, with device identification.
   3. Graphic display for each piece of equipment connected to the electrical monitoring and control system through a data link.
   4. Electrical power monitoring and control system network riser diagram that shows schematic layout for entire system including meters, gateways, and other network devices.

2.5 NETWORK CONFIGURATION SOFTWARE

A. Network Management Graphical Interface Features:
   1. Add and remove devices in the power monitoring and control network.
   2. Application for naming devices based on a user-defined naming scheme.

3. Add and remove I/O servers in the power monitoring and control network.
4. Edit communication properties for devices including timeouts and delays.
5. Display mandatory fields when adding a new device.
6. Allow to manually connect and disconnect serial, Ethernet, modem, and Ethernet gateway sites.
7. Enable and disable devices and sites in the power monitoring and control network without interruption to other devices or sites.
8. Pool modem resources so that the software uses any available modem.
9. Monitor the following diagnostics:
    a. Communication request/response and error rates, and timeouts.
    b. Log acquisition services.

B. Database Maintenance Features:
1. Backup, archive, and trim data, event, and waveform logs.
    a. Record start and end date for operation.
    b. Allow copying data to another database.
    c. Be capable of selecting any or all of the logs specified for the meters that are Work of this Section.
        1) Data logs.
        2) Event logs.
        3) Waveform logs.

C. Web Reporter: Allow viewing historical data in preformatted report templates via a web browser.
1. Features:
    a. User-configurable report generator to trigger on event, based on a schedule, or manual initiation.
    b. Format reports in HTML, PDF, TIF, Excel, XML, or user-selected printer, or network folder.
    c. Distribution of reports via email.
2. Report on power and demand profiles.
3. Power quality report with CBEMA evaluation.
4. EN 50160 compliance report.
5. 100-ms PQ report.
6. Energy over Period Report:
    a. User-defined rollup interval by day, week, month, or year.
    b. Compare daily energy to the following:
        1) Previous day.
        2) Same day, previous week.
        3) Same day, previous month.
        4) User-defined specific day.
    c. Compare weekly energy to the following:
        1) Previous week.
        2) Same week from previous month.
        3) Same week from previous year.
        4) User-defined specific week.
    d. Compare monthly energy to the following:
        1) Previous month.
        2) Same month from previous year.
        3) User-defined specific month.
    e. Compare annual energy to the following:
        1) Previous year.
        2) User-defined specific year.
7. Energy by daily period report for the user-defined periods. Aggregate consumption of the periods by the day, week, and year.
8. Tabular Report: Show values for multiple measurements and measurements from multiple devices in tabular format.
9. Trend Report:
    a. Show values for multiple measurements and measurements from multiple devices in any of the following graphical formats:
        1) Line chart.
        2) Pie graph.
        3) Bar chart.
        4) Column chart.
        5) Smooth line chart.
        6) Stacked column chart.

7) Stacked bar chart.

10. Alarm and Event History: User formatted, based on the meters and priority; and with user-defined alarm and event reports.
11. System Configuration Report:
    a. Device name.
    b. Device type.
    c. Device address.
    d. Connection status.
    e. Device protocol.
    f. Device description.
12. Each default report shall include the following:
    a. Summary aggregation of data from the selected devices.
    b. Individual device information.
    c. Raw data.
13. The reporting tool shall provide a graphical interface to create and manage multiple Time of Use schedules:
    a. Tariffs including energy cost rates per kWh, kVARh, and kVAh, and demand charges per kW, kVAR, and kVA.
    b. Off-peak and on-peak times.

2.6 MONITORING AND CONTROL OF POWER DISTRIBUTION EQUIPMENT

A. Power Distribution Equipment: Web-enabled, direct connected to the LAN or intranet.

B. Instrument Transformers: Comply with IEEE C57.13.
1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

C. Ethernet Connectivity:
1. A multipoint, RS-485 Modbus serial communications network shall be included within the equipment to interconnect breaker trip units, protective relays, drives, and metering devices equipped with communications.
2. Serial communications network shall be wired to an Ethernet server in the incoming section of the equipment. Hardware and cabling required for the connection to the network shall be included within the power distribution equipment.
3. Serial communications devices within the equipment shall be factory addressed and tested to verify reliable communications to the equipment's Ethernet Server.

D. Ethernet Gateways:
1. User configurable; complying with UL 60950-1, and IEEE 802.3, Class 3 PoE.
2. Include provisions to set initial Ethernet parameters via a local operator interface, or standard (RJ-45) Ethernet port, that is accessible from the front of the equipment. Initial setup shall be limited to basic Ethernet addressing parameters, as assigned by Owner.
3. Common Gateway Features:
    a. User configurable, with secure password-protected login process.
    b. Include communications diagnostic information for serial and Ethernet ports as well as internal health status and memory management information through embedded HTML web pages for viewing using a standard web browser.
    c. Include embedded HTML pages providing real-time information from devices connected to the Ethernet gateway's RS-485 port(s) through a standard web browser.
    d. Allow firmware upgrades through the communications port.
4. Include a "Quick-Start" guide with the equipment to describe the commissioning process for setting the equipment's Ethernet network address and for ensuring trouble-free data access from any PC on the network, using a standard web browser.
5. Implement a common user interface ("look and feel") across all styles of power equipment.

E. Distribution Equipment Monitoring:
1. Main menu and summary pages, factory configured, to display data for each communicating device within the power equipment lineup.
2. Display Data:
    a. Circuit summary page to display circuit name, three-phase average rms current, real power (kW), power factor, and breaker status (if applicable).

b. Load current summary page to display circuit name, and phase a, b, and c rms current values.
c. Demand current summary page to display circuit name, and phase a, b, and c average demand current values.
d. Power summary page to display circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
e. Energy summary page to display circuit name, real energy (kWh), reactive energy (kVARh), and time/date of last reset.
f. For unit substations equipped with dry-type transformer(s) and microbased temperature controller(s), the circuit summary web page listed above shall be augmented with transformer coil temperatures, phase a, b and c current values, and cooling fan status (on/off).
g. sample rates up to 48,000 Hz.

2.7 RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

B. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables" for control wiring, RS-232 cable, and NFPA 70 Class 2 remote-control and signaling circuits.

2.8 WIRES AND CABLES

A. Electrical Power Wiring: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
1. Copper conductors are Type THHN/THWN-2.

B. Control Wiring: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
1. Optical-Fiber Cable: Multimode, 50/125-micrometer OM3, six-fiber, nonconductive, tight-buffer, optical-fiber cable, with aqua jacket.
2. Balanced Twisted Pair Cable: 100-ohm, four-pair Category 6.
3. Workstation Outlets: Four-port-connector assemblies mounted in single or multigang faceplate. Coordinate color and labels with Section 262726 "Wiring Devices."
4. RS-485 Cable: Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
5. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 16 AWG copper, minimum.
a. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
b. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
c. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

C. RS-232 Cable:
1. PVC-Jacketed, RS-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
a. Type CM.
b. Flame Resistance: UL 1581, vertical tray.
2. Plenum-Type, RS-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
a. Type CMP.
b. Flame Resistance: NFPA 262, flame test.

2.9 SURGE PROTECTION DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB France.
2. Advanced Protection Technologies Inc. (APT).
3. ALLTEC.
4. Eaton.
5. Emerson Electric Co.
6. GE Zenith Controls.
7. LEA International.
8. Leviton Manufacturing Co., Inc.

9. Mersen USA.
10. PowerLogics, Inc./PQ Protection.
11. Schneider Electric USA, Inc.
12. Siemens Industry, Inc.

B. SPDs: Comply with UL 1449, Type 2.
1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual metal-oxide varistors in a given mode.

D. Comply with UL 1283.

E. Protection modes and UL 1449 SPD for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits shall not exceed the following:
1. L-N: 1200 V for 480Y/277 V.
2. L-G: 1200 V for 480Y/277 V.
3. N-G: 1200 V for 480Y/277 V.
4. L-L: 2000 V for 480Y/277 V.

F. SCCR: Equal or exceed 100 kA.

G. Nominal Rating: 20 kA.

H. Indoor Enclosures: NEMA 250, Type 1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.

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

3.2 POWER MONITORING AND CONTROL SYSTEM INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Wiring and Cabling Installation:
1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
2. Comply with Section 260523 "Control-Voltage Electrical Power Cables" for control wiring.

E. Raceways Installation:
1. Comply with Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
2. Comply with Section 260523 "Control-Voltage Electrical Power Cables" for control wiring, RS-232 cable, and NFPA 70 Class 2 remote-control and signaling circuits.

F. Identification Installation:
1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.

3.3 WORKSTATION INSTALLATION

A. Desktop Workstations Installation:
   1. Install workstation(s) at location(s) directed by Owner.
   2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single, duplex electrical power receptacle.
   3. Install software on workstation(s) and verify that software functions properly.
   4. Develop Project-specific graphics, trends, reports, logs, and historical database.
   5. Power workstation through a UPS unit. Locate UPS adjacent to workstation.

B. Graphics Application:
   1. Use system schematics indicated as starting point to create graphics.
   2. Develop Project-specific library of symbols for representing system equipment and products.
   3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
   4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.
   5. Seek Owner input in graphics development once using graphics software.
   6. Final editing shall be done on-site with Owner's review and feedback.
   7. Refine graphics as necessary for Owner acceptance.
   8. On receiving Owner acceptance, print a hard copy to include in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of the system operation and maintenance manual.

3.4 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner, existing Building Automation System (BAS), and existing ASCO power monitoring system to provide unique naming and addressing for networks and devices.

3.5 GROUNDING

A. For data communication wiring, comply with NECA/BICSI 568.

B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   2. Visually inspect balanced twisted pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
   3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   4. Test balanced twisted pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
      a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
   5. Optical-Fiber Cable Tests:

a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
b. Link End-to-End Attenuation Tests:
   1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to IEC 61280-4-1.
   2) Attenuation test results for links shall be less than 2.0 dB.
c. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

6. Power Monitoring and Control System Tests.
   a. Test Analog Signals:
      1) Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
      2) Check analog current signals using a precision current meter at zero, 50, and 100 percent.
      3) Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
   b. Test Digital Signals:
      1) Check digital signals using a jumper wire.
      2) Check digital signals using an ohmmeter to test for contact making or breaking.
   c. I/O Control Loop Tests:
      1) Test every I/O point to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
      2) Test every I/O point throughout its full operating range.
      3) Test every control loop to verify that operation is stable and accurate.
      4) Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
      5) Test and adjust every control loop for proper operation according to sequence of operation.
      6) Test software and hardware interlocks for proper operation.
      7) Operate each analog point at the following:
         a) Upper quarter of range.
         b) Lower quarter of range.
         c) At midpoint of range.
      8) Exercise each binary point.
      9) For every I/O point in the system, read and record each value at workstation, at controller, and at field instrument simultaneously. Value displayed at workstation and at field instrument shall match.
      10) Prepare and submit a report documenting results for each I/O point in the system, and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.7 FINAL REVIEW

A. Submit written request to Architect when the power monitoring and control system is ready for final review. Written request shall state the following:
   1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
   2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
   3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.
   4. The system is complete and ready for final review.

B. Review by Architect will be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Final review shall include a demonstration to parties participating in final review.

3.8 MAINTENANCE SERVICE

A. Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include semiannual preventive maintenance, repair or replacement of defective components, cleaning, and adjusting as required for proper system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.9 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the power monitoring and control system.

B. Extent of Training:
   1. Base extent of training on scope and complexity of power monitoring and control system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
   2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
   3. Minimum Training Requirements:
      a. Provide no fewer than two days of training total.
      b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
      c. Total days of training shall be broken into not more than two separate training classes.
      d. Each training class shall be no fewer than one consecutive day(s).

C. Attendee Training Manuals:
   1. Provide each attendee with a color hard copy of all training materials and visual presentations.
   2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
   3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

D. Instructor Requirements:
   1. One or multiple qualified instructors, as required, to provide training.
   2. Instructors shall have no fewer than five years of providing instructional training on no fewer than five past projects with similar electrical monitoring and control system scope and complexity.

E. Training Outline: Submit training outline for Owner review at least 10 business days before scheduling training. Outline shall include a detailed agenda for each training day that is broken down into each training session that day, training objectives for each training session, and synopses for each lesson planned.

F. On-Site Training:
   1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
   2. Instructor shall provide training materials, projector, and other audiovisual equipment used in training.
   3. Provide as much of training located on-site as deemed feasible and practical by Owner.
   4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
   5. The workstation provided with the system shall be used in training. If workstation is not indicated, provide a temporary workstation to convey training content.

G. Off-Site Training:
   1. Provide conditioned training rooms and workspace with ample tables, chairs, power, and data connectivity for each attendee.

2. Provide capability to remotely access to Project monitoring and control system for use in training.
3. Provide a workstation for use by each attendee.

3.11 At Completion of Training:

A. Staff familiar with the system installed are capable of demonstrating operation of the system during final review.

B. Demonstration shall include, but not be limited to, the following:
1. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
2. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and workstations.
3. Trends, summaries, logs, and reports set-up for Project.
4. Software's ability to communicate with controllers, workstations, and uploading and downloading of control programs.
5. Software's ability to edit control programs off-line.
6. Data entry to show Project-specific customizing capability including parameter changes.
7. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
8. Execution of digital and analog commands in graphic mode.
9. Spreadsheet and curve plot software and its integration with database.
10. Online user guide and help functions.
11. For Each Meter:
    a. Memory: Programmed data, parameters, trend, and alarm history collected during normal operation is not lost during power failure.
    b. Operator Interface: Ability to connect directly to each meter with a portable workstation.
    c. Wiring Labels: Match control drawings.
    d. Network Communication: Ability to locate a meter on the network. Communication architecture matches Shop Drawings.
    e. Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
12. For Each Workstation:
    a. I/O point lists agree with naming conventions.
    b. Graphics are complete.
    c. UPS unit, if applicable, operates.

END OF SECTION

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 ACTION SUBMITALLS

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, all devices and equipment shown on lighting plans, drawn to scale.
   3. Include diagrams for power, signal, and control wiring.

1.2 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's warranties.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On manufacturer's website. Provide names, versions, and website addresses for locations of installed software.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.4 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 software.
      b. Faulty operation of lighting control devices.
   2. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY AND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bryant Electric.
   2. Cooper Industries, Inc.
   3. Hubbell Building Automation, Inc.
   4. Intermatic, Inc.
   5. Leviton Manufacturing Co., Inc.
   6. Lithonia Lighting; Acuity Brands Lighting, Inc.
   7. Lutron Electronics Co., Inc.
   8. nLight by Acuity Brands Lighting, Inc.
   9. NSi Industries LLC.
   10. Philips Lighting Controls.
   11. RAB Lighting.
   12. Sensor Switch, Inc.
   13. Square D.
   14. WattStopper; a Legrand? Group brand.

B. General Requirements for Sensors:
   1. Wall-mounted, solid-state indoor vacancy sensors.
   2. Dual technology.
   3. Integrated 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. 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.
7. Sensor Output: Sensor is powered from the power pack.
8. Power: Line voltage.
9. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-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.
10. Mounting:
    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch **(**13-mm**)** knockout in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.

C. Dual-Technology Type: Wall 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- **(**150-mm-**)** minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. **(**232 sq. cm**)**, and detect a person of average size and weight moving not less than 12 inches **(**305 mm**)** in either a horizontal or a vertical manner at an approximate speed of 12 inches/s **(**305 mm/s**)**.
3. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 2000 square feet **(22**0 square meters**)** when mounted 48 inches **(**1200 mm**)** above finished floor.

2.2 SWITCHBOX-MOUNTED VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bryant Electric.
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
4. Intermatic, Inc.
5. Leviton Manufacturing Co., Inc.
6. Lithonia Lighting; Acuity Brands Lighting, Inc.
7. Lutron Electronics Co., Inc.
8. nLight by Acuity Brands Lighting, Inc.
9. NSi Industries LLC.
10. Philips Lighting Controls.
11. RAB Lighting.
12. Sensor Switch, Inc.
13. Square D.
14. WattStopper.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. 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.Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F **(**0 to 49 deg C**)**.
3. Switch Rating: Not less than 800-VA LED load at 120 V, 1200-VA LED load at 277 V.

C. Wall-Switch Sensor Tag OS:
1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. **(**84 sq. m**)**.
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."

4. Capable of controlling load in three-way application.
5. Voltage: Match the circuit voltage.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc **(**108 to 1600 lux**)**. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
9. Color: White.
10. Faceplate: Color matched to switch.

D. Wall-Switch Sensor Tag OSD:
1. Same as type OS except with 0-10V dimming capability.

2.3 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. 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 CONTACTOR INSTALLATION

A. Comply with NECA 1.

B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.4 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 **(**13 mm**)**.

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.

3.5 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.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate lighting control devices and perform tests and inspections.

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

C. Perform the following tests and inspections with the assistance of a 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.

D. Lighting control devices will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 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.

3.8 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
   1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in other sections.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION

SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
   2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
   3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Source quality-control reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

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

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.
   1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Square D; by Schneider Electric.

B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Transformers Rated 15 kVA and Larger:
1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
1. One leg per phase.
2. Grounded to enclosure.

C. Coils: Continuous windings without splices except for taps.
1. Coil Material: Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: Bolted.

D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

E. Enclosure: Ventilated.
1. NEMA 250, Type 3R: Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.
4. Finish: Comply with NEMA 250.
   a. Finish Color: ANSI 61 gray weather-resistant enamel.

F. Taps for Transformers 3 kVA and Smaller: None.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

K. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

L. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.

M. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

N. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.

2.4 IDENTIFICATION

A. Nameplates: Self-adhesive **phenolic plastic equipment nameplate** for each distribution transformer. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
2. Ratio tests at rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at rated voltage connections.
4. No load losses, and excitation current and rated voltage at rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:
    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.
9. Temperature tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

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

3.2 INSTALLATION

A. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

B. Construct concrete bases according to Division 03 and anchor floor-mounted transformers according to manufacturer's written instructions, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."
1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Secure transformer to concrete base according to manufacturer's written instructions.

D. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

E. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. 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.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:
1. Visual and Mechanical Inspection.
    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, and grounding.
    c. Verify that resilient mounts are free and that any shipping brackets have been removed.
    d. Verify the unit is clean.
    e. Perform specific inspections and mechanical tests recommended by manufacturer.
    f. Verify that as-left tap connections are as specified.
    g. Verify the presence of surge arresters and that their ratings are as specified.
2. Electrical Tests:
    a. Measure resistance at each winding, tap, and bolted connection.
    b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
    c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
    d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

E. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:
1. Visual and Mechanical Inspection:
    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, and grounding.
    c. Verify that resilient mounts are free and that any shipping brackets have been removed.
    d. Verify the unit is clean.
    e. Perform specific inspections and mechanical tests recommended by manufacturer.
    f. Verify that as-left tap connections are as specified.
    g. Verify the presence of surge arresters and that their ratings are as specified.
2. Electrical Tests:
    a. Measure resistance at each winding, tap, and bolted connection.
    b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
    c. Perform power-factor or dissipation-factor tests on all windings.
    d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
    e. Perform an excitation-current test on each phase.
    f. Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
    g. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

F. Remove and replace units that do not pass tests or inspections and retest as specified above.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 262300 - LOW-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Description: Metal-enclosed, low-voltage switchgear with drawout fused, where indicated, power circuit breakers, with accessories and metering components.
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Comply with IEEE C37.20.1.
   3. Listed and labeled as complying with UL 1558.
   4. Listed and labeled for use as service entrance equipment.

2.2 CIRCUIT BREAKERS

A. Drawout type, unfused, power operated, with electromechanical or electronic trip devices. Comply with IEEE C37.13, IEEE C37.13a, and UL 1066.

2.3 IDENTIFICATION

A. Compartment Nameplates: Engraved, laminated-acrylic, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:
   1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of the Work.

B. Examine roughing-in of conduits and grounding systems to verify the following:
   1. Wiring entries comply with layout requirements.
   2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross the section barriers to reach load or line lugs.

C. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be five ohms at the switchgear location.

D. Proceed with installation only after examinations are complete and unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Terminate all grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.

C. Complete switchgear grounding and surge-protector connections prior to making any other electrical connections.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:
   a. NFPA 70B reference in first subparagraph below contains requirements for qualifications of test operators and test equipment.
   2. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
   3. Perform each visual and mechanical inspection and electrical test as recommended by the switchgear manufacturer. Certify compliance with test parameters.
   4. Visual and Mechanical Inspection:
      a. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study, as well as to the circuit breaker's address in the control network.
      b. Verify that current and voltage transformer ratios correspond to Drawings.
      c. Inspect bolted electrical connections for high resistance using one of the following two methods:
         1) Use a low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA MTS, data. In the absence of manufacturer's published data, use NETA MTS,
      d. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
         1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
         2) Make key exchange with devices operated in off-normal positions.
      e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
      f. Inspect insulators for evidence of physical damage or contaminated surfaces.
      g. Verify correct barrier and shutter installation and operation.
      h. Exercise active components.
      i. Inspect mechanical indicating devices for correct operation.
      j. Verify that filters are in place and that vents are clear.
      k. Perform visual and mechanical inspection of instrument transformers according to "Instrument Transformer Field Tests" Paragraph.
      l. Inspect control power transformers.
         1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
         2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
         3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.
      m. Perform system function tests according to "System Function Tests" Article.
      n. Verify operation of space heaters.
      o. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

C. Circuit-Breaker Field Tests:
   1. Visual and Mechanical Inspection:
      a. Inspect physical and mechanical condition.
      b. Inspect anchorage, alignment, and grounding.
      c. Verify that all maintenance devices are available for servicing and operating the breaker.
      d. Verify the unit is clean.
      e. Verify that the arc chutes are intact.
      f. Inspect moving and stationary contacts for condition and alignment.
      g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
      h. Perform mechanical operator and contact alignment tests on both the breaker and its operating mechanism according to manufacturer's published data.
      i. Verify cell fit and element alignment.
      j. Verify racking mechanism operation.
      k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

l. Perform adjustments for final protective-device settings according to coordination study provided by Owner.
m. Record as-found and as-left operation counter readings.

D. Instrument Transformer Field Tests:
1. Visual and Mechanical Inspection:
a. Verify that equipment nameplate data complies with the Contract Documents.
b. Inspect physical and mechanical condition.
c. Verify correct connection of transformers with system requirements.
d. Verify that adequate clearances exist between primary and secondary circuit wiring.
e. Verify that the unit is clean.
f. Inspect bolted electrical connections for high resistance using one of the following two methods:
1) Use a low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
g. Verify that required grounding and shorting connections provide contact.
h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
i. Verify correct primary and secondary fuse sizes for voltage transformers.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
2. Electrical Tests of Current Transformers:
a. Perform insulation-resistance test of each current transformer and its secondary wiring for ground at 1000-V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's written instructions. Investigate and correct values of insulation resistance less than manufacturer's written instructions or NETA ATS, Table 100.5.
b. Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
c. Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall be according to IEEE C57.13.
d. Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by manufacturer or be according to IEEE C57.13.1.
e. Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. Measured burdens shall be compared to, and shall match, instrument transformer ratings.

E. Microprocessor-Based Protective Relay Field Tests:
1. Visual and Mechanical Inspection:
a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of LEDs, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded according to manufacturer's written instructions.
g. Set the relay according to results in Section 260573 "Power System Studies."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.
2. Electrical Tests:
a. Perform insulation-resistance tests from each circuit to the grounded frame according to manufacturer's published data.
b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.

F. Switchgear components will be considered defective if they do not pass tests and inspections.

G. Remove and replace defective units and retest.

H. Prepare test and inspection reports. Record as-left set points of adjustable devices.

3.5 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality-control tests have been completed and all components have passed specified tests.
   1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
   2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
   3. Verify the correct operation of sensing devices, alarms, and indicating devices.

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

C. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Disconnecting and overcurrent protective devices.
2. Instrumentation.
3. Control power.

B. Related Requirements
1. Section 260573 "Power System Studies" for arc-flash analysis and arc-flash label requirements.

1.2 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
8. Include diagram and details of proposed mimic bus.
9. Include schematic and wiring diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field Quality-Control Reports:
1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components 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. Routine maintenance requirements for switchboards and all installed components.
b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Accredited by NETA.
1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 FIELD CONDITIONS

A. Environmental Limitations:

1. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
   b. Altitude: Not exceeding 6600 feet (2000 m).

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify **Construction Manager** no fewer than **seven** days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without **Owner's** written permission.
4. Comply with NFPA 70E.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.
1. Warranty Period: **Three** years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices 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 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long and short time adjustments.
   d. Ground-fault pickup level, time delay, and I squared t response.
2. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
   c. Application Listing: Appropriate for application.
   d. Ground-Fault Protection: Integral relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
   g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   i. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   k. Arc Energy Reducing Maintenance Switch: A dedicated switch for temporarily modifying the trip settings of the circuit breaker to reduce the available arc energy during maintenance. When activated, a blue LED shall be illuminated, with a permanently applied placard that reads "Maintenance Mode". Provide Maintenance Switch for all circuit breakers with frame ratings of 1200A or greater and for other devices as indicated on Drawings.

B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.

3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Time adjustments for long- and short-time pickup.
   c. Ground-fault pickup level, time delay, and I squared t response.
4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Arc Energy Reducing Maintenance Switch: A dedicated switch for temporarily modifying the trip settings of the circuit breaker to reduce the available arc energy during maintenance. When activated, a blue LED shall be illuminated, with a permanently applied placard that reads "Maintenance Mode". Provide Maintenance Switch for all circuit breakers with frame ratings of 1200A or greater and for other devices as indicated on Drawings.
9. Control Voltage to match control power supply40-V dc.

C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Boltswitch, Inc.
   b. Eaton.
   c. Square D.
2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
   a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
5. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
   a. Configuration: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   b. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
   c. No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
   d. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
6. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

2.2 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:
1. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, single secondary; bar or window type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
   a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
   b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
   c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
   d. Megawatts: Plus or minus 1 percent.
   e. Megavars: Plus or minus 1 percent.

f. Power Factor: Plus or minus 1 percent.
g. Frequency: Plus or minus 0.1 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.3 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install switchboards and accessories according to **NEMA PB 2.1**.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch **(**100-mm**)** nominal thickness. Comply with requirements for concrete base specified in Division 3

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches **(**50-mm**)** above concrete base after switchboard is anchored in place.
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 switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, surge protection devices, and instrumentation.

G. Comply with NECA 1.

3.2 CONNECTIONS

A. Support and secure conductors within the switchboard according to NFPA 70.

B. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:
   1. Acceptance Testing:
      a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
      b. Test continuity of each circuit.
   2. Test ground-fault protection of equipment for service equipment per NFPA 70.
   3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges per Section 260573 "Power System Studies".

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.
   1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
   2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details.
   2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
   3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
   4. Detail bus configuration, current, and voltage ratings.
   5. Short-circuit current rating of panelboards and overcurrent protective devices.
   6. Include evidence of NRTL listing for SPD as installed in panelboard.
   7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   8. Include wiring diagrams for power, signal, and control wiring.
   9. Key interlock scheme drawing and sequence of operations.
   10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.2 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Address List for Distribution Board Electronic Trip Breakers. Coordinate with Owner and existing Building Automation System to confirm unique naming for devices.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and GFEP Types: Equal to 1 percent of quantity installed for each size and type, but no fewer than two of each size and typeFuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   3. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; storage in a dry space with adequate heating to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.7 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
   b. Altitude: Not exceeding 6600 feet (2000 m).

PART 2 - PRODUCTS

2.1 PANELBOARDS GENERAL REQUIREMENTS

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Flush and Surface-mounted, as indicated, dead-front cabinets.
   1. Rated for environmental conditions at installed location.
      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250,Type 3R.
      c. Wash-Down Areas: NEMA 250, Type 4X, stainless steel
      d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4X.
      e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
   2. Height: 84 inches (2.13 m) maximum.
   3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
   4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
   5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
   6. Finishes:
      a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
         1) Standard grey finish is acceptable in equipment rooms.
         2) Where panelboards are in finished spaces, manufacturer's finish is to match the finish of the wall (e.g., white, light almond, black, etc.).
      b. Back Boxes: Galvanized steel.
      c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

F. Phase, Neutral, and Ground Buses:
   1. Material: Hard-drawn copper, 98 percent conductivity for all ampacities.
      a. Plating shall run entire length of bus.
      b. Bus shall be fully rated the entire length.
   2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
   3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
   4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
   5. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.

6. Split Bus: Vertical buses divided into individual vertical sections.

G. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Same as buses.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.

H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
1. Panelboards and overcurrent protective devices rated 240 V or less shall have minimum short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical where supplied from transformers rated less than 75kVA and not less than 22,000 A rms symmetrical where supplied from transformers rated 112.5kVA or greater. Final Short-Circuit current rating shall be greater than the maximum available fault current as determined in the power system study specified in Section 260573 "Power System Studies".
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have minimum short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical. Final Short-Circuit current rating shall be greater than the maximum available fault current as determined in the power system study specified in Section 260573 "Power System Studies".

2.2 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, distribution type.

C. Circuit Breakers: Electronic Trip so future tie-in can be made with the Building Automation System for remote monitoring and recording of values and status.

D. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches **(**914 mm**)** high, provide two latches, keyed alike.

E. Mains: As indicated.

F. Branch Overcurrent Protective Devices for Circuit-Breaker: Bolt-on circuit breakers or Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal or fused switches as indicated.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: As indicated.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

F. Column-Type Panelboards: Single row of overcurrent devices with narrow gutter extension and overhead junction box equipped with ground and neutral terminal buses.
1. Doors: Concealed hinges secured with multipoint latch with tumbler lock; keyed alike.

2.4 ELECTRONIC-GRADE PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. Square D; by Schneider Electric.

B. Panelboards: NEMA PB 1; with factory-installed, integral SPD; labeled by an NRTL for compliance with UL 67 and UL 1449 after installing SPD.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

D. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

E. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.

F. Buses:
1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
2. Copper equipment and isolated ground buses.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
1. Eaton.
2. Square D; by Schneider Electric.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers:
   a. Inverse time-current element for low-level overloads.
   b. Instantaneous magnetic trip element for short circuits.
   c. Adjustable magnetic trip setting for circuit-breaker frame sizes 150 A and larger.
2. Electronic Trip Circuit Breakers:
   a. For distribution board circuit breakers.
   b. RMS sensing.
   c. Field-replaceable rating plug or electronic trip.
   d. Digital display of settings, trip targets, and indicated metering displays.
   e. Multi-button keypad to access programmable functions and monitored data.
   f. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
   g. Integral test jack for connection to portable test set or laptop computer.
   h. Field-Adjustable Settings:
      1) For all circuit breakers with frame sizes equal to or greater than 400A or where specifically indicated on Drawings with "I" subscript on a circuit breaker:
         a) Instantaneous trip.
      2) For all circuit breakers with frame sizes equal to or greater than 400A or where specifically indicated on Drawings with "L" subscript on a circuit breaker:
         a) Long-time pickup level.
         b) Long-time time adjustment.
      3) For all circuit breakers with frame sizes equal to or greater than 400A or where specifically indicated on Drawings with "S" subscript on a circuit breaker:
         a) Short-time pickup levels.
         b) Short-time time adjustment.
      4) Where indicated on Drawings with "G" subscript on a circuit breaker or where required by NEC for circuit breakers with frame sizes rated 1000A and greater on 480V and 480Y/277V circuits:
         a) Ground-fault pickup level, time delay, and I squared T response.
3. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
4. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Breaker handle indicates tripped status.
   c. UL listed for reverse connection without restrictive line or load ratings.
   d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   e. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
   g. Shunt Trip: 24-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
   h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltagewith field-adjustable 0.1- to 0.6-second time delay.
   i. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.

j. Auxiliary Contacts: One, SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
k. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
l. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
m. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
n. Multipole units enclosed in a single housing with a single handle or factory assembled to operate as a single unit.
o. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.
p. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position. Provide one for each branch circuit overcurrent device serving fire alarm equipment. Handle clamps installed for fire alarm overcurrent devices shall have a red finish.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."
2. Fused Switch Features and Accessories:
a. Standard ampere ratings and number of poles.
b. Mechanical cover interlock with a manual interlock override, to prevent the opening of the cover when the switch is in the on position. The interlock shall prevent the switch from being turned on with the cover open. The operating handle shall have lock-off means with provisions for three padlocks.
c. Auxiliary Contacts: Two normally open and normally closed contact(s) that operate with switch handle operation.

2.6 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, AIC rating, number of phases, number of wires, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.
2. Directory to include, but is not limited to:
a. Panelboard Name
b. Location
c. Supply From
d. Enclosure
e. Voltage
f. Number of Phases
g. Number of Wires
h. AIC Rating
i. Amperage
j. Number of Poles
k. Circuit Names
l. Volt-Amp load of each circuit
m. Total Connected Amperage
n. Total Estimated Demand Amperage

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting:
   1. Install power panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases in Division 3.
   2. Attach panelboard to the vertical finished or structural surface behind the panelboard.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Mount panelboard cabinet plumb and rigid without distortion of box.

G. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

H. Mount surface-mounted panelboards to steel slotted supports 5/8 inch (16 mm) in depth. Orient steel slotted supports vertically.

I. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.
   2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

J. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

K. Install filler plates in unused spaces.

L. Install handle clamps on all branch circuit overcurrent devices serving fire alarm equipment.

M. For Flush-Mounted Panelboards: Stub three 1-inch **(**25 mm**)** empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub three1-inch **(**25 mm**)** empty conduits into raised floor space or below slab not on grade.

N. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

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

B. Acceptance Testing Preparation:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Panelboards will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges per Coordination Study.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 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.

C. Samples: Where indicated or specified in each color specified.

1.2 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.3 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.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

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. RoHS compliant.

D. Comply with NEMA WD 1 and NEMA WD 6.

E. Devices indicated as "tamper-resistant" shall have integral shutters that operate only when both prongs of a plug are inserted in the receptacle.

F. Devices indicated as "weather-proof" or "weather-resistant" shall have the following:
1. Spring-loaded, gasketed, "weather-proof-in-use" cover.
2. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

G. Devices for Owner-Furnished Equipment:
1. Receptacles: Match plug configurations.

H. Device Color:
1. Wiring Devices Connected to Normal Power System: **Grey** unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Electrical System: **Red.**

I. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A:
1. Manufacturers**: Subject to compliance with requirements, provide products by one of the following per DC Courts Standards:**
   a. Hubbell Incorporated; Wiring Device-Kellems 8300 Series.
   b. Leviton Manufacturing Co., Inc. 8300 Series.
   c. Pass & Seymour/Legrand (Pass & Seymour) PS8300H Series.
2. Description: Two pole, three wire, and self-grounding.
3. Configuration: Heavy-duty, NEMA 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Leviton Manufacturing Co., Inc.
   c. Pass & Seymour/Legrand (Pass & Seymour).
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 per DC Courts Standards.**
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

2.4 TOGGLE SWITCHES, 120/277 V, 20 A

A. Snap Switches, 120/277 V, 20 A :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand (Pass & Seymour).
2. Standards: Comply with UL 20 and FS W-S-896.

2.5 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: Smooth, high-impact thermoplastic, color to match device color.
3. Material for Unfinished Spaces: Galvanized stainless steel faceplates.
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 thermoplastic 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.
4. Existing Conductors:
   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:
1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Type:
1. Install GFCI receptacles for all receptacles supplied by single-phase branch circuits rated 150V or less to ground in the following spaces/locations:
   a. Where the receptacle is installed within 6 feet of the edge of a sink.
   b. Indoor damp and wet locations.
   c. Garages, accessory buildings, service bays, and similar areas.
2. Install GFCI receptacles at the following equipment supplied by single-phase branch circuits rated 150V or less to ground and 60 amperes:
   a. Sump pumps
3. Where GFCI receptacles cannot be installed in a readily accessible location or are not available in the receptacle configuration required to serve a specific load, provide equivalent ground fault circuit interrupter protection by installing a GFCI type circuit breaker as the branch circuit overcurrent protective device for the load.

F. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

G. 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.

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 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

3.3 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. In healthcare facilities, prepare reports that comply with NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. 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 SECTION

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Cartridge fuses rated 600 V ac and less for use in the following:
      a. Control circuits.
      b. Panelboards.
      c. Switchboards.
      d. Enclosed controllers.
      e. Enclosed switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
   1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
      a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
      b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
   2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
   3. Current-limitation curves for fuses with current-limiting characteristics.
   4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in PDF format.
   5. Coordination charts and tables and related data.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 include the following:
   1. Ambient temperature adjustment information.
   2. Current-limitation curves for fuses with current-limiting characteristics.
   3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in PDF format.
   4. Coordination charts and tables and related data.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.5 FIELD CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Bussmann, an Eaton business.
   2. Edison; a brand of Bussmann by Eaton.
   3. Littelfuse, Inc.
   4. Mersen USA.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
   1. Type RK-1: 600-V, zero- to 600-A rating, 100 kAIC, time delay.
   2. Type RK-5: 600-V, zero- to 600-A rating, 100 kAIC, time delay.
   3. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Provide fuses from the same manufacturer to insure retention of selective protective device coordination.
   2. Fuses rated 600 amperes and less: UL Class RK-1 unless otherwise indicated or specified, current-limiting, time-delay, per UL 198E, with an interrupting rating of 100,000 amperes rms.
      a. Provide UL Class RK-5 fuses current-limiting, time-delay, per UL 198E, with an interrupting rating of 100,000 amperes rms, as follows:
         1) Motor starters size 3 and smaller.
         2) Panelboard main fuses where the amperage ratio between the main fuse to the largest feeder fuse is at least 2:1.
   3. Fuses rated greater than 600 amperes: UL Class L, current-limiting, per UL 198C, with an interrupting rating of 200,000 amperes RMS.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers.
   1. Include plans, elevations, sections, details, and attachments to other work.
   2. Include wiring diagrams for power, signal, and control wiring.

1.2 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Field quality-control reports.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton.
   2. Square D; by Schneider Electric.

B. Type HD, Heavy Duty:
   1. Single throw.
   2. Three pole, unless otherwise indicated.
   3. 240 or 600-V ac.
   4. Ampacity as indicated or scheduled.
   5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified or indicated fuses.
   6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
   3. Early Break Auxiliary Contacts: 1 set of normally open contacts that has an early break feature which breaks the contacts prior to the disconnect switch being fully placed in the OFF position.
   4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

5. Arc-Energy Reduction Relay: For switches rated 1200A, provide internally mounted device compliant with NFPA 70 article 240.67 requirements, with external display containing pushbutton and visual indicator for maintenance mode.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Type and Finish shall be:
1. NEMA 250 Type 1: Baked enamel paint, electrodeposited on cleaned, phosphatized steel.
2. NEMA 250 Type 12 or 3R: Baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel.
3. NEMA 250 Types 4 and 4X stainless steel: Brush finish on Type 304 stainless steel.

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts.

D. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

PART 3 - EXECUTION

3.1 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Kitchen and Wash-Down Areas: NEMA 250, Type 4X , stainless steel .
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4 .
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.2 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated. Per NEC 240.24, the center of the grip of the handle cannot exceed 6'-7" above finished floor.

C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NFPA 70 and NECA 1.

F. Where motor disconnect switches are installed downstream of a variable frequency drive (VFD), provide 2#12 AWG conductors from the disconnect switch to the VFD. Terminate wiring in disconnect switch at early break auxiliary contacts and coordinate programming and terminating of conductors at VFD with VFD installer.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with equipment nameplate.

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 for Switches:
   1. Visual and Mechanical Inspection:
      a. Inspect physical and mechanical condition.
      b. Inspect anchorage, alignment, grounding, and clearances.
      c. Verify that the unit is clean.
      d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
      e. Verify that fuse sizes and types match the Specifications and Drawings.
      f. Verify that each fuse has adequate mechanical support and contact integrity.
      g. Inspect bolted electrical connections for high resistance using one of the two following methods:
         1) Use a low-resistance ohmmeter.
            a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
            a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
      h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
      i. Verify correct phase barrier installation.
      j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
   2. Electrical Tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
      b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
      c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
      d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
      e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

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

E. Prepare test and inspection reports.
   1. Test procedures used.
   2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
   3. List deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION

SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.2 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. LED: Light-emitting diode.

F. NC: Normally closed.

G. NO: Normally open.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. RFI: Radio-frequency interference.

K. VFC: Variable-frequency motor controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.
   1. Include dimensions and finishes for VFCs.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.
   1. Include mounting and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Required working clearances and required area above and around VFCs.
   2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
   3. Show support locations, type of support, and weight on each support.
   4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Product Certificates: For each VFC from manufacturer.

D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Division 01, 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 setting field-adjustable overload relays.
   c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
   d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
   e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
   f. 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.

1.6 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. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
   2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
   3. Indicating Lights: Two of each type and color installed.
   4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
   5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: **Subject to compliance with requirements, provide products by one of the following per DC Courts Standards:**
   1. ABB Low Voltage HVAC Drives - ACH550 Series.
   2. Yaskawa Electric America, Inc. - E7 Series.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:
   1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 61800-5-1.

B. Application: Variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
   1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
   2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
   3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:
   1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
   2. Input AC Voltage Unbalance: Not exceeding 5 percent.
   3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
   4. Minimum Efficiency: 97 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: 65 kA.
   7. Ambient Temperature Rating: Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
   8. Humidity Rating: Less than 95 percent (noncondensing).
   9. Altitude Rating: Not exceeding 3300 feet (1000 m).
   10. Vibration Withstand: Comply with NEMA ICS 61800-2.
   11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
   12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
   13. Speed Regulation: Plus or minus 5 percent.
   14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
   15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
   1. Signal: Electrical.

I. Internal Adjustability Capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.
   3. Acceleration: 0.1 to 999.9 seconds.
   4. Deceleration: 0.1 to 999.9 seconds.
   5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:
   1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 2.
   2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
   3. Under- and overvoltage trips.
   4. Inverter overcurrent trips.
   5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
   6. Critical frequency rejection, with three selectable, adjustable deadbands.
   7. Instantaneous line-to-line and line-to-ground overcurrent trips.
   8. Loss-of-phase protection.
   9. Reverse-phase protection.

10. Short-circuit protection.
11. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: UL 489, molded-case switch, with power fuse block and current-limiting fuses with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
4. NO alarm contact that operates only when circuit breaker has tripped.

2.3 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:
1. Electric Input Signal Interface:

a. A minimum of two programmable analog inputs: 4- to 20-mA dc.
b. A minimum of six multifunction programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
   a. 0- to 10-V dc.
   b. 4- to 20-mA dc.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.
3. Output Signal Interface: A minimum of one programmable analog output signal(s) (4- to 20-mA dc), which can be configured for any of the following:
   a. Output frequency (Hz).
   b. Output current (load).
   c. DC-link voltage (V dc).
   d. Motor torque (percent).
   e. Motor speed (rpm).
   f. Set point frequency (Hz).
4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

F. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.
1. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.4 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

B. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

2.5 OPTIONAL FEATURES

A. Damper control circuit with end-of-travel feedback capability.

B. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.

C. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.

D. Remote digital operator kit.

E. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

2.6 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.7 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
1. Push Buttons: Covered, lockable, shielded.
2. Pilot Lights: Push to test.

3. Selector Switches: Rotary type.

B. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

C. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

D. Supplemental Digital Meters:
1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

E. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

F. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Cooling Fan and Exhaust System: For NEMA 250, Type 12; UL 508 component recognized: Supply fan, with stainless-steel intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

2.8 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches **(**2000 mm**)** above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in each fusible-switch VFC.

D. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

E. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

F. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

G. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.
   1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
   2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each VFC with equipment nameplate.
   3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

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

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
   3. Test continuity of each circuit.
   4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).
   5. Test each motor for proper phase rotation.
   6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
      c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

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

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 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.

3.7 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 the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Power System Studies."

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes lightning protection system for ordinary structures.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
1. Include layouts of the existing and new lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment details, coordinated with existing roof installation.
5. Calculations required by NFPA 780 for bonding of metal bodies.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Lightning protection cabling attachments to roofing and MEP systems and accessories.
2. Lightning protection strike termination device attachment to roofing and MEP systems, coordinated with the roofing and MEP system manufacturer.
3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

B. Qualification Data: For Installer.

C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For lightning protection system to include in maintenance manuals.
1. In addition to items specified in Division 01, include the following:
a. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

B. Completion Certificate:
1. UL Letter of Findings Limited Scope Inspection Report.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: UL-listed installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advanced Lightning Technology, Ltd.
2. East Coast Lightning Equipment Inc.
3. ERICO International Corporation.
4. Harger Lightning & Grounding.
5. Heary Bros. Lightning Protection Co. Inc.
6. Hicks Lightning Protection.
7. Independent Protection Co.
8. National Lightning Protection.
9. Preferred Lightning Protection.
10. Robbins Lightning, Inc.
11. Thompson Lightning Protection, Inc.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class II buildings.

B. UL Lightning Protection Standard: Comply with UL 96A requirements for Class II buildings.

C. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

A. Air Terminals:
1. Aluminum unless otherwise indicated.
2. 1/2-inch (12.7-mm) diameter by 12 inches (305 mm) long.
3. Pointed tip.
4. Integral base support.

B. Class II Main Conductors:
1. Aluminum: 192,000 circular mils in diameter.

C. Secondary Conductors:
1. Aluminum: 41,400 circular mils in diameter.

D. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Survey existing lightning protection system prior to developing shop drawings with new lightning protection additions included.

B. Install lightning protection components and systems according to UL 96A and NFPA 780.

C. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches (203 mm) in radius and narrow loops.

D. Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building. Comply with requirements for concealed installations in UL 96A.
1. Install conduit where necessary to comply with conductor concealment requirements.
2. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: bolted connectors.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. **Verify the existing lightning protection system utilizing a clamp-on earth tester before and after install of new lightning protection system. Record both values for report and submit for approval.**
2. Perform inspections as required to obtain a UL Master Label for system.

B. Prepare test and inspection reports and certificates.

END OF SECTION

SECTION 265100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. LED: Light-emitting diode.

D. LER: Luminaire efficacy rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting fixture, including ballast housing if provided.

G. L70: Point in time where light fixture lumen output is 70% of initial light output.

H. McAdams Ellipses: Color consistency of LED's from chip to chip.

1.2 SUBMITTALS

A. Refer to Sections 012500 "Substitution Procedures" and 013300 "Submittal Procedures."

B. Product Data: For each type of lighting fixture, arranged in order of fixture designation as listed on the fixture schedule. Include data on features, accessories, finishes, and the following:
1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. Energy-efficiency data.
4. Lamp data: rated life, lumen output, CCT, CRI and wattage.
5. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.

C. Photometric Data Submittals
1. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, for the following lighting fixture types. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
   a. Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.
   b. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
2. Include the following in the photometric report:
   a. List the measured candela values of the photometric distribution in at least three planes, except in the case of an axially symmetrical lighting fixture. Candela curves, lux (footcandle) and lumen tables, and iso-lux (iso-footcandle) contours are not acceptable.
   b. List the type of lamps, ballasts, and lighting control devices, such as lenses and louvers, used with the tested lighting fixture.

D. Shop Drawings: For nonstandard or custom lighting fixtures as indicated on the fixture schedule. Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

E. Samples: Production run samples for each lighting fixture in the Interior Lighting Fixture Schedule indicated for sample. Each Sample shall include the following:
1. Lamps and drivers, installed.
2. Minimum 6-foot cords and NEMA configured, grounded, straight blade plug for 120-volt operation plugs.
3. Pendant support system.

F. Installation instructions.

G. 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. Lighting fixtures.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extends to within 12 inches (305 mm) of the plane of the luminaires.
4. Ceiling-mounted projectors.
5. Structural members to which suspension systems for lighting fixtures will be attached.
6. Other items in finished ceiling including the following:
    a. Air outlets and inlets.
    b. Speakers.
    c. Sprinklers.
    d. Smoke and fire detectors.
    e. Occupancy sensors.
    f. Access panels.
7. Perimeter moldings.

H. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

I. Product Certificates: Compatibility for each type of ballast for bi-level and dimmer-controlled lamps and fixtures as specified, from manufacturer.

J. Field quality-control reports.

K. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

L. Warranty: Sample of special warranty.

1.3 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. Provide fixtures U.L. listed and labeled for the application.

1.4 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.5 WARRANTY

A. Special Warranty for LED Lighting Fixtures: Manufacturer's standard form in which manufacturer of lightingfixture agrees to repair or replace components, including driver/power supplies and thermal management, that fail in materials or workmanship within five years date of substatial completion.

1.6 EXTRA MATERIALS

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: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Plastic Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. LED Drivers: One for every 100 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product by manufacturers indicated on Drawings and specified.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. LED Fixtures: Minimum rated lifetime of L70 at 50,000 hours based on IES LM-79 testing; passive thermal management only unless otherwise indicared.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

F. Diffusers and Globes:
1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
    a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
    b. Distribution: as indicated
    c. UV stabilized.
2. Glass: Annealed crystal glass unless otherwise indicated.

G. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located 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 and ballast characteristics:
    a. "USE ONLY" and include specific lamp type.

2.3 LED MODULES/BOARDS

A. Minimum rated lifetime of L70 at 50,000 hours based on IES LM-80 testing; 4-step McAdams Ellipse maximum color consistency unless otherwise indicated; 80 CRI minimum unless otherwise indicated.

2.4 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).

F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General
1. Install lighting systems in accordance with NECA/IESNA 500, 501 and 502.
2. Assemble and install lighting fixtures in a manner to insure a straight and true installation without dents, warps, and other irregularities.
3. Where lighting fixtures are specified or indicated for installation in continuous rows, install fixtures in a continuous end-to-end manner without gaps between fixture segments, and with vertical and horizontal variations, along the length of the continuous installation, no greater than 6 mm (1/4 inch).

4. Coordinate the lighting system installation with relevant trades so as to eliminate installation interferences, such as with hangers, mechanical ducts, sprinklers, piping and steel structure.
5. Install lighting fixtures in a common area space so that the orientation of the lens and louver door latches and hinges are in the same direction.
6. Provide plaster frames for recessed fixtures installed in other than suspended grid ceiling systems.

B. Lighting fixtures:
1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
2. Install lamps in each luminaire.

C. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

D. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.
1. Install ceiling support system rods or wires for each fixture, independent of the ceiling suspension devices. Locate not more than 6 inches (150 mm) from lighting fixture corners. Do not use steel roof decking for light fixture supports; provide additional steel to building structure to provide a suitable support for light fixture support wires.
2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.

E. Suspended Lighting Fixture Support:
1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure. Do not use steel roof decking for light fixture supports; provide additional steel to building structure to provide a suitable support for light fixture support wires.
5. Install suspended lighting fixtures at mounting heights specified or indicated, plus or minus 6 mm (1/4-inch).

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 CLEANING

A. Clean interior surfaces of lighting fixtures of dirt and construction debris upon completion of installation. Clean fingerprints, smudges, and other marks from lenses, louvers, and reflecting surfaces. Leave free of visible marks.

3.4 STARTUP SERVICE

A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
1. Adjust the lamp socket position in downlight lighting fixtures per the manufacturer's recommendations for the specified lamp type and voltage. Optimize the lighting output of the lighting fixture by properly locating the light center within the reflector.
2. Upon final completion of the installation of the lighting fixtures and any associated lighting control systems, notify the Architect in writing to arrange for the final adjustment and aiming of lighting equipment requiring aiming and adjustment.
3. Adjust aimable luminaires in the presence of Architect and Lighting Designer.

END OF SECTION