SECTION 21 05 00 - FIRE PROTECTION SYSTEM GENERAL

PART 1 - GENERAL

1.1 SCOPE

- A. <u>Design, fabricate, install, and secure required approvals</u> for a complete fire protection automatic sprinkler [and standpipe] system where shown on the Drawings, as specified herein, and as needed for a complete and proper installation in accordance with pertinent requirements of NFPA 13, [NFPA 14,] and local governmental agencies having jurisdiction.
- B. Work includes providing design services; furnishing all labor, material, equipment and installation as necessary and reasonably incidental to the proper completion and proper operation of the fire protection systems. The work shall consist of but shall not necessarily be limited to the following:
 - 1. Standpipe System as specified in Section 21 12 00
 - 2. Automatic wet-pipe sprinkler system as specified in Section 21 13 13.
 - 3. Automatic dry-pipe sprinkler system as specified in Section 21 13 16.
 - 4. Fire Pump system as specified in Section 21 30 00.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 (General Requirements) sections of the Project Manual apply to this Section.
- B. The General Conditions shall be carefully examined before proposals for any work are submitted. Division 21 shall not be interpreted as waiving or overruling any requirements expressed in the General Conditions unless Division 21 specifications contain statements more definitive or more restrictive.

1.3 DEFINITIONS

- A. Words and phrases used throughout the Contract Documents shall be interpreted as indicated below:
 - 1. Construction Documents the basis for the work. It includes both the Drawings (plans) and Project Manual (specifications).
 - 2. Contractor The person or organization awarded the contract for fire protection <u>design</u> <u>and construction</u> services.

In the case of a construction project administered as a multiple-prime contract, the term shall be further defined as the Contractor holding a prime contract for fire protection <u>design and construction</u> work.

The terms "Fire Protection Contractor" and "Sprinkler Contractor" may be used interchangeably with the term Contractor.

- 3. Provide To furnish and install materials, equipment or systems.
- 4. Submittals Submittals shall include Manufacturer's Catalog Data, Shop Drawings, Calculations, Certificates of Compliance, Testing Reports, Samples, and Operation and Maintenance Manuals.
- 5. Professional The Architect and/or Engineer of record.
- 6. Work By Others Work provided by a person or organization other than the Contractor.

1.4 CODES, REFERENCES, AND STANDARDS

- A. The Contractor shall comply with all laws, ordinances, and regulations of all Authorities Having Jurisdiction, including those of all applicable City, County, State, Federal and Public Utility entities. All licenses, permits, fees, inspection fees, etc., shall be obtained by the Contractor and the cost shall be included in the Contract price.
- B. The minimum standard of work under this contract shall be in accordance with the following model building codes and standards:
 - 1. International Code Council (ICC)
 - a. International Building Code with Louisiana Amendments
 - b. International Fire Prevention Code with Louisiana Amendments
 - 2. National Fire Protection Association
 - a. NFPA 13 Standard for the Installation of Sprinkler Systems
 - b. NFPA 14 Standard for the Installation of Standpipe and Hose Systems
 - c. NFPA 20 Standard for the Installation of Centrifugal Fire Pumps
 - d. NFPA 24 Standard for the Installation of Private Fire Service Mains and Their Appurtenances
 - e. NFPA 70 National Electric Code
 - f. Requirements for Automatic Sprinkler Systems, latest edition.
- C. Other publications listed throughout Division 22 form a part of this specification to the extent referenced. <u>All publications shall be the latest edition as adopted by the Authority Having Jurisdiction</u>. The publications are referred to in the text by basic designation only.

1.5 QUALITY ASSURANCE, WORKMANSHIP AND COORDINATION

- A. The Contractor must coordinate his work with that of the other trades so that all work will be performed in an orderly manner and with the least possible interference. Where coordination with other trades is required, the Professional shall make the final decision regarding changes to be made in the work.
- B. The Contractor must thoroughly familiarize himself with all specifications and drawings for the project so that he clearly understands his responsibility in relationship to the work to be performed. The Contractor must plan and perform his work so as to permit the use of the building at the earliest possible date.

- 1. Sprinklers shall be referred to on drawings, submittals, and other documentation, by the sprinkler identification or model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.
- C. The Contractor shall guarantee the workmanship, materials and equipment, furnished against defects, leaks, performance and non-operation for a period of one (1) year after the date of final acceptance. Defective workmanship shall be construed as meaning defective materials and unsatisfactory installation and not intended to apply to ordinary wear and tear. The Contractor shall pay for any repairs or replacements caused by defective workmanship as construed herein within the period covered by the Guarantee, including all incidental work required to correct the deficiency.
- D. The Contractor shall expressly and completely follow all manufacturers' instructions required for validation of the manufacturer's warranty agreement including but not limited to service, maintenance and adjustments of the equipment.
- E. The Contractor will be held responsible for the proper installation of all materials and equipment required for a complete installation within the intent and meaning of the Contract Documents.
 - 1. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 - 2. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.
- F. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).)

1.6 PROJECT RECORD DRAWINGS

- A. Deviations from the Contractor's <u>approved</u> Design and Fabrication Drawings necessary to coordinate the work with other trades, to conform to the building conditions or to conform to the rules and regulations of Authorities Having Jurisdiction shall be made only after obtaining written permission from the Professional.
- B. The Contractor shall keep a record of construction changes and deviations from the original Design and Fabrication Drawings. All changes shall be recorded on a separate set of prints which shall be kept at the job site specifically for that purpose. The record shall be made immediately after the work is completed. Documentation shall include:
 - 1. changes in pipe routing location
 - 2. valve locations
 - 3. Equipment locations, etc.
 - 4. actual capacities and values of equipment provided as indicated in equipment schedules

C. The marked-up record set of drawings shall be submitted to the Professional for review and approval before final acceptance of the Fire Protection Contract work.

1.7 FIELD MEASUREMENTS

- A. Before ordering any equipment and material, or performing any work, the Contractor shall verify all measurements and dimensions at the job site and shall be held responsible for the correctness of same.
- B. No extra compensation will be allowed on account of differences between actual dimensions and measurements and those indicated on the Contractor's drawings.

1.8 PROTECTION OF SERVICES AND EQUIPMENT

- A. The Contractor, at his own expense, shall repair, replace and maintain in service any utilities, facilities or services (underground, aboveground, interior or exterior) damaged, broken, or otherwise rendered inoperative during the course of construction due to activities on the part of the Contractor. The method used by the Contractor in repairing, replacing or maintaining the services shall be approved by the Professional.
- B. The Contractor shall protect, at his own expense, such of his work, materials or equipment that is subject to damage during the project duration. All openings into any piping, ducts or equipment must be securely covered, or otherwise protected, to prevent injury due to carelessly or maliciously dropped tools or materials, grit, dirt, or any foreign material. The Contractor shall be held responsible for all damage so done until his work is fully and finally accepted.
- C. It shall be the responsibility of the Contractor to protect motors, pumps, electrical equipment, and all similar items of equipment from dirt, grime, plaster, water, etc. during all phases of construction. This protection shall be provided by covering equipment with transparent plastic sheeting and/or locating the materials and equipment in an area free from the elements.

1.9 INTERRUPTION OF SERVICES

- A. The Contractor shall schedule his work to avoid any major interruption of any utility services.
- B. Existing utilities serving facilities occupied and used by the Owner or others shall not be interrupted except when such interruptions have been authorized in writing by the Owner or the Professional. Interruptions shall occur only after acceptable temporary utility services have been provided. The Contractor shall provide a minimum of ten (10) working days notice to the Professional and receive written notice to proceed before interrupting any utility.

1.10 CLEANUP

A. The Contractor shall maintain buildings, grounds, and public properties free from accumulations of waste materials, debris and rubbish. At reasonable intervals during the progress of work, and when directed by the Owner's Authorized Representative, the site and public properties shall be cleaned and waste materials, debris and rubbish shall be disposed of in appropriate manner. The Contractor shall provide containers for collection of waste materials,

debris and rubbish. Waste materials, debris and rubbish shall be removed from the job site and legally disposed of at a landfill area in accordance with all applicable regulations. Burning or burying waste materials, debris or rubbish on project site shall not be permitted.

B. At the completion of the Project, remove waste materials, rubbish, tools, equipment, machinery, surplus materials, etc., and clean all sight-exposed fire protection fixtures and equipment. Remove grease, dust, dirt, stains, labels, fingerprints and other foreign materials from sight-exposed fire protection fixtures and equipment. Broom clean paved and concrete surfaces; rake clean other ground surfaces. Repair, patch and touch up marred surfaces to specified finish or to match adjacent surfaces.

1.11 SUBMITTALS

- A. Submittals shall be in accordance with Division o1 of the Project Manual.
- B. General
 - 1. The Contractor shall provide to the Professional for review six (6) copies of required submittals, unless noted otherwise. All Catalog Data, Shop Drawings, Design (hydraulic) Calculations, and Certificates of Compliance shall be submitted as a single package. All delays to the job resulting from the Contractor's failure to provide submittals at one time will be the responsibility of the Contractor. Four (4) copies will be returned to the Contractor.
 - 2. Submittals provided for review shall clearly and completely describe the specific product(s) they represent. Where differences exist between the item specified and that submitted for review, the submittal shall be highlighted.
 - 3. Shop Drawings shall be prepared by a Certified NICET Level III technician. The plans should bear the signature, stamp and certificate number of the technician.
 - 4. Submittals shall bear the review stamp of the Contractor. The review stamp of the Contractor shall be affixed to shop drawings to indicate:
 - a. The Contractor has coordinated the electrical characteristics of the equipment.
 - b. The Contractor has verified that the equipment submitted will physically fit into the space allocated with adequate clearances for maintenance, access, and egress requirements.
 - c. The Contractor shall bear all associated costs that may accrue due to failure to completely represent a given product.
 - 5. Material and equipment shown on the drawings or specified herein shall not be incorporated in the work of this Contract until shop drawings, hydraulic calculations, engineering data and catalog information have been reviewed and accepted by the Professional.
 - 6. Grooved joint couplings and fittings shall be shown on drawings and product submittals, and shall be specifically identified with the applicable style or series designation.
- C. Operation and Maintenance Manuals

- 1. Submit two (2) sets of 8-1/2" x 11" text sixty (60) days prior to operator training/pre-final inspection bound in three D side ring capacity expansion binders with durable plastic covers for review by the Professional.
- 2. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS FIRE PROTECTION SYSTEMS", title of project, and subject matter of binder when multiple binders are required.
- 3. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.
- 4. Contents: Prepare a Table of Contents for each volume, with each Product or system description identified type on thirty (30) pound white paper.
 - a. Part 1: Directory, listing names, addresses, and telephone numbers of Contractor, Subcontractors, and equipment suppliers.
 - b. Part 2: Operation and maintenance instructions arranged by system or process flow and subdivided by specification section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:
 - 1) Significant design criteria.
 - 2) List of equipment.
 - 3) Parts list for each component.
 - 4) Maintenance instructions for equipment and systems.
 - 5) Maintenance instructions for finishes, including recommended cleaning methods and materials and operating instructions.
 - 6) Special precautions identifying detrimental agents.
 - 7) Special Requirements of other sections of this specification noted to be included in the operating and maintenance manual.
 - 8) Original copy (reproductions will not be accepted) of NFPA 25 Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems.
 - c. Part 3: Project documents and certificates, including the following:
 - 1) All approved Submittals
 - 2) Shop Drawings
 - 3) Hydraulic Calculations
 - 4) Certificates of Compliance
 - 5) Photocopies of warranties and bonds
 - 6) Material safety data sheets
- 5. Submit two (2) copies of completed volumes in final form fifteen (15) days prior to owner training. These copies will include Professional's previous review comments.

1.12 ELECTRICAL EQUIPMENT

A. The Contractor shall furnish all motors, combination starters/disconnects, overload protection and controls for equipment required to provide complete and workable systems, unless noted otherwise.

- B. All motors, motor control equipment and wiring shall meet the requirements of the National Electric Code, and shall comply with the requirements of the Public Utility Company furnishing service and with the rules and regulations of all Authorities Having Jurisdiction.
- C. The Contractor shall verify electrical characteristics at the site before ordering electrical equipment.
- Motors under $\frac{1}{2}$ (one-half) horsepower shall be 120 volts. Motors $\frac{1}{2}$ (one-half) horsepower and D. over shall be 3 (three) phase. All motors to be 1750 revolutions per minute (rpm) unless noted otherwise. Combination motor starters shall be of the fused switch type complete with magnetic motor starter. Units shall be of the NEMA size and type applicable to motor size, with 3-pole overload. Overload elements and fuses shall be of the proper size to protect the motor. Unless noted otherwise, units shall be equipped with indicating lights, HAND-OFF-AUTOMATIC (HOA) selector switch, four (4) auxiliary contacts two (2) normally open (N.O.) and two (2) normally closed (N.C.) and fused control transformer to provide 120 volt control voltage. Fusible disconnect switch operating handles shall be interlocked with the door so that the door cannot be opened with the switch in the "ON" position, except through a hidden release mechanism. The operating handle shall be arranged for padlocking in the "OFF" position with up to three padlocks. Fuses shall be furnished by the Contractor as required to comply with NEC requirements. Where R type fuses are indicated, fuse holders shall be provided with rejection clips. Equipment shall be Square D, Allen-Bradley, or General Electric or accepted substitute, and shall be provided with a NEMA Type 1 enclosure, unless noted otherwise.

1.13 CONTROL WIRING

- A. The Contractor shall provide all necessary control wiring and related conduit required for complete and workable systems.
- B. All conduit and wiring shall be in accordance with the latest edition of the National Electrical Code. Installation of control wiring shall be performed in a neat and workmanlike manner by competent workmen. Workmanship shall be as specified in Division 16.
- C. Control circuits shall be wired for 110 volt control, using fused individual control transformers. Circuits shall be fused and shall be interrupted when the disconnect device is opened.

1.14 INSPECTION AND TESTING

- A. General
 - 1. New fire protection systems and parts of existing systems which have been altered, extended or repaired shall be tested to disclose leaks and defects.
 - 2. The Contractor shall notify the Professional a minimum of 5 (five) working days prior to testing to coordinate the testing and inspection procedures.
 - 3. If the Professional determines that the fire protection systems do not pass the prescribed tests, then the Contractor shall be required to make the necessary repairs, at his own expense, and the Contractor shall re-inspect and re-test the systems. Repairing, inspection and testing shall be continued until all systems pass as determined by the Professional.

- 4. All new, altered, extended or replaced fire protection shall be left uncovered and unconcealed until it has been inspected, tested and accepted by the Professional. Where such work has been covered or concealed before it has been inspected, tested and accepted, it shall be uncovered by the Contractor, at his own expense as directed by the Professional.
- 5. All equipment, material, labor, etc., required for testing the fire protection systems shall be furnished by the Contractor.

1.15 INSTRUCTION OF THE OWNER

- A. After acceptance of the Project, the Contractor shall furnish the services of personnel thoroughly familiar with the completed installation to instruct the Owner in the proper operation and maintenance of all equipment and appurtenances provided.
- B. The Contractor shall provide the Owner with two weeks advance notice before the instruction session.

1.16 CHASES AND OPENINGS

- A. All chases and openings required for the installation of the work shall be coordinated with the other trades. The Contractor shall provide the other trades with sufficient time (1 (one) week minimum) for coordination of all chases and openings. The contractor shall be responsible for all work required to cut and patch the required openings. The work shall be performed to the satisfaction of the Professional.
- B. Penetrations made in fire rated chases, partitions, floors, etc., shall be sealed with an approved material and method as required to maintain the integrity of the fire separation.
- C. The Contractor shall provide all sleeves, hangers, and anchors required for installation of work in chases and openings.

1.17 PAINTING

A. Painting shall be in accordance with Division 09.

1.18 RELATED WORK

- A. All work related to providing complete fire protection systems and equipment shall be the responsibility of the Contractor. The following related work shall be provided as indicated in other specification Divisions, unless noted otherwise, but shall remain the responsibility of the Contractor for workmanship and completeness:
 - 1. General Contractor
 - a. Installation of access panels.
 - b. Final painting of existing walls, floors and ceilings where the surfaces are being refinished and remodeled under the General Contract. Refer to General Construction Drawings.

- c. Concrete housekeeping pads for fire protection equipment.
- d. Removal of existing concrete housekeeping pads.
- 2. Food Service Equipment Contractor
 - a. Kitchen hood fire extinguishing systems.
- 3. Electrical Contractor
 - a. Verification of the proper rotation of three phase equipment, and making modifications as required to correct improper rotation.
 - b. Installation of all combination starters/disconnects and overload protectors.

1.19 MISCELLANEOUS STEEL AND ACCESSORIES

A. The contractor shall provide all necessary steel angles, channels, pipe, rods, nuts, bolts, etc., as shown on plans, as specified, or as may be required for complete and proper installation of sprinkler piping, systems and equipment. All material and workmanship shall be of the best quality and shall be installed in accordance with the best practices of the trade.

1.20 ACCESS PANELS

- A. The Contractor shall furnish access doors to the General Contractor for installation in ceilings, walls, partitions and floors for access to valve and other appurtenances.
- B. Access panels shall be of sufficient size to permit removal or access to equipment, except that the minimum size shall be 12-inches by 16-inches.
- C. Access door locations shall be as determined by field conditions for optimum access to equipment, and shall be reviewed by the Professional before final installation
- D. Access doors shall be suitable for installation in the finish material of the ceilings, walls, partitions and floors.
- E. Frame and panel access doors in restrooms, kitchens and as indicated shall be stainless steel.
- F. Access doors with UL Listing shall be provided in rated construction assemblies. Access doors shall be "B-Label" and shall have a UL one and one-half (1-1/2) hour rating at 250 degrees F rating for both door and frame. Maximum size shall be 20" x 20" or 400 square inches in area. Frame shall be sixteen (16) gauge minimum steel, panel shall be twenty (20) gauge minimum steel. Access doors shall be provided with a baked-on enamel finish (prime coat), continuous type hinge on one side, flush-face type lock with key operation and self-latching cylinder locks.
- G. Access doors without UL label shall be provided in all non-rated construction assemblies: Frame shall be sixteen (16) gauge minimum steel, panel shall be fourteen (14) gauge minimum steel. Access doors shall be provided with a baked-on enamel finish (prime coat), concealed spring type hinges and flush-face type lock with key operation and self-latching cylinder locks. Door shall open 175 degrees (minimum).
- H. All access doors shall be keyed alike.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials used on fire protection systems shall meet the requirements of applicable codes, standards, and requirements of Local Authorities Having Jurisdiction and the Owner's Insurance Carrier.

2.3 SPRINKLER AND STANDPIPE PIPING, ABOVE GROUND

A. Piping: black steel meeting ASTM A53, ASTM A135, or ASTM A795.

1.Piping 2-1/2" and larger shall be Schedule 10 or the approximately equal "flow" products with roll-grooved, flanged or welded connections.

2. Piping 2" and smaller shall be Schedule 40 with threaded or welded connections or Schedule 5 with Pressfit® connections.

3. Piping shall be hot-dipped galvanized where specified herein or noted on the drawings.

- B. Fittings: UL-listed, standard weight suitable for pressures up to 250 psig, cast iron meeting ASTM A126 or malleable iron meeting ASTM A197. Threaded cast iron fittings shall meet ANSI B16.4; flanged cast iron fittings shall meet ANSI B16.1. Threaded malleable iron fittings shall meet ANSI B16.3. Grooved fittings and couplings shall be UL-listed and shall be of ductile iron meeting ASTM A536, utilizing an EDPM gasket. Fittings shall be short pattern, with flow equal to standard pattern fittings. Plain-end fittings and couplings, or welded-segmented fittings shall not be used. Changes in pipe diameter shall be made using tapered reducing fittings. Bushings or grooved-end reducing couplings shall not be used unless standard reducing fittings are not regularly available.
 - 1. Grooved joint couplings shall be:
 - a. Rigid Type: Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with NFPA-13. Couplings shall be fully installed at visual pad-to-pad offset contact. (Tongue and recess type couplings, or any coupling that requires exact gapping of bolt pads on each side of the coupling at specified torque ratings, are not allowed.)
 - 1) 1-¹/₂" through 8": Installation-Ready, for direct stab installation without field disassembly. Victaulic Style 009-EZ and Style 107H.
 - 2) Victaulic FireLock[™] Style 005 or Zero-Flex Style 07.
 - b. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for seismic applications. Victaulic Installation-Ready Style 177, Style 75 or 77.
 - 2. Gaskets:

Fire Protection Service	Temp. Range	Gasket Recommendation
Dry Systems	Ambient	FlushSeal®, Grade EPDM, Type A
Freezer Applications	-40°F to 0°F	FlushSeal®, Grade L, Silicone
Water/Wet Systems	Ambient	Grade EPDM, Type A

2.4 VALVES FOR FIRE PROTECTION SYSTEMS

- A. Gates Valves: Class 125, comply with MSS SP-80, bronze body, screwed bonnet, rising stem, solid wedge. 3" and larger; comply with MSS SP-70, iron body, bronze trim, rising stem, hand wheel, OS&Y, flanged or grooved ends. Basis of Design: Victaulic Series 771.
- B. Butterfly Valves:
 - 1. Comply with MSS SP-67, lug type, cast or ductile iron body, chrome plated ductile iron disk, EPDM seat, extended neck, handwheel and gear drive and integral indicating device, built-in tamper proof switch, 200 PSI rating.
 - 2. Grooved end type with ductile iron body, electroless nickel coated ductile iron disc, pressure responsive seat, and stainless steel stem. (Stem shall be offset from the disc centerline to provide full 360-degree circumferential seating.) Handwheel and gear drive and integral indicating devices, with weatherproof actuator and supervisory switches, 300 PSI rating. Victaulic Series 705.
- C. Spring-Actuated Check Valves: 250 PSI rating, grooved end ductile iron one-piece body, stainless steel spring and shaft, suitable for vertical or horizontal installations. Victaulic Series 717.
- D. Check Valves: Class 125, comply with MSS SP-80 bronze body, screwed cap. "Y" pattern swing, bronze disc. 3" and larger, comply with MSS SP-71, class 125, iron body, bronze mounted, horizontal swing, cast iron disc.

2.5 DRAIN VALVES

A. Provide bronze compression stop with hose thread nipple and cap.

PART 3 - EXECUTION

3.1 GENERAL

- A. All materials and equipment used shall be installed in strict accordance with the Standards under which the materials are accepted and approved, and in strict accordance with the manufacturer's instructions.
- B. The Contractor's Drawings shall indicate every bend, offset, change in direction and appurtenance required to provide a complete and workable system.
- C. Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. Gaskets shall be of an elastomer grade suitable for the intended service, and shall be molded and produced by the coupling manufacturer. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review

contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s).)

3.2 SEISMIC RESTRAINTS

- A. The Sprinkler Contractor shall coordinate with the General Contractor to determine site classification and seismic requirements for this project. Where required, the Sprinkler Contractor shall be responsible for providing restraints to resist the earthquake effects on the Sprinkler system(s).
- B. The Sprinkler Contractor shall refer to the latest edition of the "Seismic Restraint Manual Guidelines for Mechanical Systems" published by SMACNA for guidelines to determine the correct restraints for piping.
- C. The Sprinkler Contractor shall include shop drawings of the specific methods of seismic restraint to be used for this project before installation of piping, ductwork, and equipment.
- D. Any required anchorage of the equipment and materials for this project shall be an integral part of the design and specification of such equipment and materials. Manufacturers of all equipment shall provide anchorage details, isolators, seismic mounts and restraints, etc. necessary to comply with Code requirements.
- E. The Sprinkler Contractor shall retain the services of a Professional Structural Engineer licensed in the State of Louisiana to design seismic restraint elements required for this project. The engineer's computations, bearing his professional seal, shall accompany shop drawings which show Code compliance. Computations and shop drawings shall be submitted for review prior to the purchasing of materials, equipment, systems and assemblies.
- F. Internal seismic restraint elements of manufactured equipment shall be certified by a Professional Engineer retained by the manufacturer. Such certificate applies only to internal elements of the equipment. All equipment anchorage requirements shall be coordinated with the building structure and shall be compatible thereto. All such anchorage shall be reviewed by the project's structural engineer.
- G. The professional engineer retained by the Sprinkler Contractor for seismic restraint calculations shall visit the job site upon completion of the seismic restraint installation. This Engineer shall provide in writing verification of compliance with the approved seismic submittal. This verification shall bear the Engineer's professional seal. Job site inspection by other than this Engineer is not acceptable. This engineer shall also be responsible for any required special inspections and associated documentation.
- H. Review of the seismic design and shop drawings by the Engineer/Architect or his agent shall not relieve the Sprinkler Contractor of his responsibility to comply with the seismic or any other requirements of the International Building Code.

END OF SECTION

SECTION 21 13 16 - DRY-PIPE SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

- A. Section includes dry-pipe sprinkler system guidelines for system design, installation, and certification.
- B. Related Sections:
 - 1. Section 21 05 13 Common Motor Requirements for Fire-Suppression Equipment: Product requirements for motors for placement by this section.
 - 2. Section 21 05 48 Vibration and Seismic Controls for Fire-Suppression Piping and Equipment: Product requirements for vibration isolators for placement by this section.
 - 3. Section 26 05 03 Equipment Wiring Connections: Execution requirements for electric connections to equipment specified by this section.

1.2 REFERENCES

- A. National Fire Protection Association:
 - 1. NFPA 13 Installation of Sprinkler Systems.

1.3 SYSTEM DESCRIPTION

- A. System to provide coverage for attic space and porte cochere
- B. Provide a hydraulically designed system to NFPA 13 occupancy requirements.
- C. <u>Obtain up-to-date flow test data</u>. Determine volume and pressure of incoming water supply from water flow test data. Provide flow test data on the Shop Drawings.
- D. Interface system with building fire and smoke alarm system.
- E. For new systems, provide fire department connections as indicated on Drawings.

1.4 SUBMITTALS

- A. Section 01 33 00 Submittal Procedures: Submittal procedures.
- B. Shop Drawings: Provide layout of finished ceiling areas indicating sprinkler locations coordinated with ceiling installation and the work of other trades (ductwork, lights and any other ceiling mounted devices). Show detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
- C. Product Data: Submit data on sprinklers, valves, pumps, compressors and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.

- D. Design Data: Submit design calculations signed and sealed by a professional engineer.
- E. Sprinklers shall be referred to on drawings, submittals, and other documentation, by the sprinkler identification or model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.

1.5 CLOSEOUT SUBMITTALS

- A. Section 01 70 00 Execution and Closeout Requirements: Closeout procedures.
- B. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.
- C. Operation and Maintenance Data: Submit components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with NFPA 13.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing Work of this section with minimum three years documented experience.
- C. Design system under direct supervision of Professional Engineer experienced in design of this Work and licensed at Project location (state).

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 60 00 Product Requirements: Product storage and handling requirements.
- B. Store products in shipping containers until installation.
- C. Furnish temporary end caps and closures on piping and fittings. Maintain in place until installation.

1.9 WARRANTY

- A. Section 01 70 00 Execution and Closeout Requirements: Product warranties and product bonds.
- B. Furnish five (5) year manufacturer warranty for air compressor and pump.

1.10 EXTRA MATERIALS

- A. Section 01 70 00 Execution and Closeout Requirements: Spare parts and maintenance products.
- B. Furnish extra sprinklers under provisions of NFPA 13.
- C. Furnish suitable wrenches for each sprinkler type.
- D. Furnish metal storage cabinet in location designated by Architect, adjacent to system riser.

PART 2 PRODUCTS

2.1 SPRINKLERS

- A. Suspended Ceiling Type:
 - 1. Type: Concealed pendant type with matching escutcheon plate.
 - 2. Finish: Chrome plated.
 - 3. Escutcheon Plate Finish: Chrome plated.
 - 4. Fusible Link: temperature rated for specific area hazard.
 - 5. Basis of Design: Victaulic Model V36.
- B. Exposed Area Type:
 - 1. Type: Standard upright type
 - 2. Finish: Brass.
 - 3. Fusible Link: temperature rated for specific area hazard.
 - 4. Basis of Design: Victaulic Model V36.
- C. Side wall Type:
 - 1. Type: Semi-recessed horizontal side wall type with matching escutcheon plate
 - 2. Finish: Chrome plated.
 - 3. Escutcheon Plate Finish: Chrome plated.
 - 4. Fusible Link: temperature rated for specific area hazard.
 - 5. Basis of Design: Victaulic Model V36.
- D. Guards: Finish to match sprinkler finish.
- E. Escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.

2.2 PIPING SPECIALTIES

A. Dry Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber faced or aluminum-bronze clapper with elastomer seal to automatically actuate water motor alarm [and electric alarm], with accelerator [; with test and drain]. Valve internal components shall be replaceable without removing the valve from the installed position. Valve shall be externally resettable. Required air pressure shall be 13 psi / 90 kPa. Basis of Design: Victaulic Series 768-NXT.

- B. Electric Alarm: Electrically operated gong with pressure alarm switch. Basis of Design: System Sensor.
- C. Water Flow Switch: Vane type switch for mounting horizontal or vertical, with two contacts; rated 10 amp at 125 volt AC and 2.0 amp at 24 volt DC. Basis of Design: System Sensor.
- D. Fire Department Connections:
 - 1. Type:
 - a. Free standing type with ductile iron pedestal chrome plated finish.
 - 2. Outlets: Two-way with fire department thread size. Threaded dust-cap and chain of matching material and finish.
 - 3. Drain: 3/4 inch automatic drip, outside or connected to drain.
 - 4. Label: "Sprinkler Fire Department Connection"
 - 5. At the low-point near each fire department connection, install a 90-degree elbow with drain connection to allow for system drainage to prevent freezing. Elbow shall be Victaulic #10-DR.

2.3 AIR COMPRESSOR

A. Compressor: Single unit, electric motor driven, motor, motor starter, safety valves, check valves, air maintenance device incorporating electric pressure switch and unloading valve. Basis of Design: Victaulic Company.

2.4 ELECTRICAL CHARACTERISTICS AND COMPONENTS

- A. Motors: In accordance with Section 21 05 13.
- B. Controls: Supervisory switches, Water Level Supervisory Switches, Tank Temperature Supervisory Switches, Room Temperature Supervisory Switches.
- C. Disconnect Switch: Factory mount in control panel or on equipment.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with NFPA 13.
- B. Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent Siamese connectors to allow full swing of fire department wrench handle.
- C. Install outside alarm-gong on building wall as indicated on Drawings
- D. Install piping to minimize obstruction with other work.
- E. Install piping in concealed spaces above finished ceilings.
- F. Center sprinklers in two directions in ceiling tile and install piping offsets.

- 1. The Victaulic Aquaflex multiple-use open-gate stainless steel flexible drop system may be used to properly locate sprinkler heads. The drop system shall be supplied with required supporting members and bracing.
- G. Connect to fire pump system in accordance with Section 21 30 00 and NFPA 13.
- H. Do not install sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install sprinklers with cracked bulbs.
- I. Sprinkler bulb protector shall be removed by hand after installation. Do not use tools or any other device(s) to remove the protector that could damage the bulb in any way.
- J. Install guards on sprinklers where required to protect sprinklers from physical damage.
- K. Install air compressor on vibration isolators. Refer to Section 21 05 48.
- L. Hydrostatically test entire system.
- M. Require test be witnessed by authority having jurisdiction.

3.2 INTERFACE WITH OTHER PRODUCTS

A. Verify devices are installed and connected to fire alarm system.

3.3 CLEANING

- A. Section 01 70 00 Execution and Closeout Requirements: Final cleaning.
- B. Flush entire piping system of foreign matter.

3.4 PROTECTION OF INSTALLED CONSTRUCTION

- A. Section 01 70 00 Execution and Closeout Requirements: Protecting installed construction.
- B. Apply masking tape or paper cover to sprinklers, cover plates, and sprinkler escutcheons not receiving field painted finish. Remove after painting. Replace painted sprinklers with new.

END OF SECTION

SECTION 213113 - ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Split-case fire pumps.
 - 2. Fire-pump accessories and specialties.
 - 3. Flowmeter systems.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
- B. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For fire 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.
- B. Product Certificates: For each fire pump, from manufacturer.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire pumps to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR CENTRIFUGAL FIRE PUMPS

- A. Description: Factory-assembled and -tested fire-pump and driver unit.
- B. Base: Fabricated and attached to fire-pump and driver unit with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
- C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

2.2 HORIZONTALLY MOUNTED, SINGLE-STAGE, SPLIT-CASE FIRE PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. <u>Basis-of-Design Product</u>: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. <u>A-C Fire Pump Systems; a business of ITT Industries</u>.
 - 2. <u>Corcoran Piping System Co</u>.
 - 3. Patterson Pump Company; a subsidiary of the Gorman-Rupp Company.
 - 4. <u>PACO Pumps; Grundfos Pumps Corporation, U.S.A.</u>
 - 5. <u>Peerless Pump, Inc</u>.
 - 6. <u>Pentair Pump Group; Aurora Pump</u>.
 - 7. <u>Reddy-Buffaloes Pump Company</u>.
 - 8. <u>Ruhrpumpen, Inc</u>.
 - 9. <u>S.A. Armstrong Limited</u>.

C. Pump:

- 1. Standard: UL 448, for split-case pumps for fire service.
- 2. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
- 3. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
- 4. Wear Rings: Replaceable bronze.
- 5. Shaft and Sleeve: Steel shaft with bronze sleeve.
 - a. Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - b. Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
- 6. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
- D. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
- E. Driver:
 - 1. Standard: UL 1004A.
 - 2. Type: Electric motor; NEMA MG 1, polyphase Design B.

2.3 FIRE-PUMP ACCESSORIES AND SPECIALTIES

- A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.
- B. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.
- C. Relief Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 2. <u>Basis-of-Design Product</u>: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. <u>BERMAD Control Valves</u>.
 - b. <u>CLA-VAL Automatic Control Valves</u>.
 - c. <u>Kunkle Valve; a part of Tyco International Ltd</u>.
 - d. <u>OCV Control Valves</u>.
 - e. <u>Watts Regulator Company; a division of Watts Water Technologies, Inc</u>.
 - f. Zurn Plumbing Products Group; Wilkins Water Control Products.
- 3. Description: UL 1478, bronze or cast iron, spring loaded; for installation in firesuppression water-supply piping.
- D. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.
- E. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.
- F. Discharge Cone: Closed or open type.
- G. Hose Valve Manifold Assembly:
 - 1. Standard: Comply with requirements in NFPA 20.
 - 2. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
 - 3. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
 - 4. Automatic Drain Valve: UL 1726.
 - 5. Manifold:
 - a. Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
 - b. Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
 - c. Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
 - d. Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - e. Escutcheon Plate: Brass or bronze; rectangular.
 - f. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - g. Exposed Parts Finish: Polished.
 - h. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."
 - 6. Manifold:
 - a. Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
 - b. Body: Exposed type, brass, with number of outlets required by NFPA 20.
 - c. Escutcheon Plate: Brass or bronze; round.

- d. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
- e. Exposed Parts Finish: Polished.
- f. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.4 FLOWMETER SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. <u>Basis-of-Design Product</u>: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Emerson Process Management; Rosemount Division.
 - 2. <u>Fire Research Corp</u>.
 - 3. <u>Gerand Engineering Co</u>.
 - 4. <u>Hydro Flow Products, Inc</u>.
 - 5. <u>Hyspan Precision Products, Inc</u>.
 - 6. Meriam Process Technologies.
 - 7. <u>Preso Meters; Division of Racine Federated Inc</u>.
 - 8. <u>Reddy-Buffaloes Pump Company</u>.
 - 9. <u>Victaulic Company</u>.
- C. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.
- D. Pressure Rating: 175 psig (1200 kPa) minimum.
- E. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.
- F. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter. Include bracket or device for wall mounting.
 - 1. Tubing Package: NPS 1/8 or NPS 1/4 (DN 6 or DN 10) soft copper or plastic tubing with copper or brass fittings and valves.
- G. Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter and with two 12-foot- (3.7-m-) long hoses in carrying case.

2.5 GROUT

- A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink and recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.6 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
 - 1. Verification of Performance: Rate fire pumps according to UL 448.
- B. Fire pumps 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 equipment bases and anchorage provisions, with Installer present, for compliance with requirements and for conditions affecting performance of fire pumps.
- B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
- B. Equipment Mounting:
 - 1. Install fire 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 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
 - 3. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."
- C. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.
- D. Support piping and pumps separately so weight of piping does not rest on pumps.
- E. Install valves that are same size as connecting piping. Comply with requirements for fireprotection valves specified in Section 211313 "Wet-Pipe Sprinkler Systems."

- F. Install pressure gages on fire-pump suction and discharge flange pressure-gage tappings. Comply with requirements for pressure gages specified in Section 211313 "Wet-Pipe Sprinkler Systems."
- G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
- H. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
- I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
- J. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.3 ALIGNMENT

- A. Align split-case pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
- B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
- C. Align piping connections.
- D. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

3.4 CONNECTIONS

- A. Comply with requirements for piping and valves specified in Section 211313 "Wet-Pipe Sprinkler Systems." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps and equipment to allow service and maintenance.
- C. Connect relief-valve discharge to drainage piping or point of discharge.
- D. Connect flowmeter-system meters, sensors, and valves to tubing.
- E. Connect fire pumps to their controllers.

3.5 IDENTIFICATION

A. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.6 FIELD QUALITY CONTROL

- A. Test each fire pump with its controller as a unit. Comply with requirements for electric-motordriver fire-pump controllers specified in Section 213900 "Controllers for Fire-Pump Drivers."
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 - 1. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
 - 2. Test according to NFPA 20 for acceptance and performance testing.
 - 3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 213113

PLUMBING PIPE, TUBE AND FITTINGS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes: Pipe and pipe fittings for the following systems:
 - 1. Domestic water piping within 5 feet of building.
 - 2. Sanitary waste and vent piping, within 5 feet of building.
 - 3. Storm water piping within 5 feet of building.
 - 4. Equipment drains and over flows.
 - 5. Flue and Combustion Air piping for sealed combustion, direct vent water heaters.
 - 6. Unions and flanges.
 - 7. Underground pipe markers.
- B. Related Sections:
 - 1. Division 08 Access Doors and Frames
 - 2. Division 09 Painting and Coating
 - 3. Section 22 05 23 General-Duty Valves for Plumbing Piping: Product requirements for valves for placement by this section.
 - 4. Section 22 05 29 Hangers and Supports for Plumbing Piping and Equipment: Product requirements for pipe hangers and supports [and firestopping] for placement by this section.
 - 5. Section 22 07 00 Plumbing Insulation: Product requirements for piping insulation for placement by this section.
 - 6. Division 31 Soils for Earthwork.
 - 7. Division 31 Aggregates for Earthwork.
 - 8. Division 31 Excavation ,Trenching and Backfill

1.2 **REFERENCES**

- A. American Society of Mechanical Engineers:
 - 1. ASME Section IX Boiler and Pressure Vessel Code Welding and Brazing Qualifications.
- B. ASTM International:
 - 1. ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

- 2. ASTM A74 Standard Specification for Cast Iron Soil Pipe and Fittings.
- 3. ASTM B42 Standard Specification for Seamless Copper Pipe, Standard Sizes.
- 4. ASTM B75 Standard Specification for Seamless Copper Tube.
- 5. ASTM B88 Standard Specification for Seamless Copper Water Tube.
- 6. ASTM B306 Standard Specification for Copper Drainage Tube (DWV).
- 7. ASTM D1785 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- 8. ASTM D2665 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
- C. American Welding Society:
 - 1. AWS A5.8 Specification for Filler Metals for Brazing and Braze Welding.
 - 2. AWS D1.1 Structural Welding Code Steel.
- D. American Water Works Association:
 - 1. AWWA C104 American National Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
 - 2. AWWA C151 American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water.
 - 3. AWWA C900 Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. through 12 in., for Water Distribution.
- E. Cast Iron Soil Pipe Institute:
 - 1. CISPI 301 Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
 - 2. CISPI 310 Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
 - 3. <u>All cast iron soil pipe and fittings shall be marked with the collective trademark</u> of the Cast iron Soil Pipe institute (CISPI) and be listed by NSF International.

1.3 SUBMITTALS

- A. Division 01 Submittal Procedures.
- B. Shop Drawings: Indicate layout of piping systems, including equipment, critical dimensions, and sizes.
- C. Product Data: Submit data on pipe materials and fittings. Submit manufacturers catalog information.

- D. Welders' Certificate: Include welders' certification of compliance with ASME Section IX.
- E. Grooved joint couplings and fittings shall be shown on drawings and product submittals, and shall be specifically identified with the applicable Victaulic style or series number.

1.4 QUALITY ASSURANCE

- A. Perform Work in accordance with ASME B31.9 code for installation of piping systems and ASME Section IX for welding materials and procedures.
- B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.
- C. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum five years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum 10 years documented experience.
- C. Design pipe hangers and supports under direct supervision of Professional Engineer experienced in design of this Work and licensed at Project location

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Division 01 Requirements for transporting, handling, storing, and protecting products.
- B. Furnish temporary end caps and closures on piping and fittings. Maintain in place until installation.
- C. Protect piping from entry of foreign materials by temporary covers, completing sections of the Work, and isolating parts of completed system.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 Environmental conditions affecting products on site.
- B. Do not install underground piping when bedding is wet or frozen.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.9 COORDINATION

- A. Division 01 Requirements for coordination.
- B. Coordinate installation of buried piping with trenching.

PART 2 PRODUCTS

2.1 DOMESTIC WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

Pipe 3 inch and larger:

- A. Ductile Iron Pipe: AWWA C151.
 - 1. Fittings: AWWA C110, ductile or gray iron, standard thickness.
 - 2. Joints: AWWA C111, rubber gasket with rods.

Pipe $2\frac{1}{2}$ inch and smaller:

- B. Copper Tubing: ASTM B88, Type K hard drawn or annealed.
 - 1. Fittings: ASME B16.18, cast copper, or ASME B16.22, wrought copper.
 - 2. Joints:
 - a. 1" and smaller: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
 - b. 1-1/4" and larger: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F.

2.2 DOMESTIC WATER PIPING, ABOVE GRADE

- A. Copper Tubing: ASTM B88, Type L hard drawn.
 - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - 2. Joints:
 - a. 1" and smaller: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
 - b. 1-1/4" and larger: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F.
 - c. 1-1/2" and smaller: Copper, Push-To-Connect Fittings: ASME B16.18 cast copper alloy or ASME B16.22 wrought copper with stainless steel teeth and EPDM synthetic rubber o-ring seal in each end (UL classified in accordance with NSF-61 for hot (+180°F) and cold (+86°F) potable water service) with push-to-connect ends instead of solder-joint ends.
- B. Copper Tubing: ASTM B88, Type L hard drawn, rolled grooved ends.
 - 1. Fittings: ASME B16.18 cast copper alloy, or ASME B16.22 wrought copper and bronze, or ASTM B584 bronze sand castings,] grooved ends.
 - 2. Joints: Grooved mechanical couplings meeting ASTM F1476.

- a. Housing Clamps: ASTM A395/A395M and ASTM A536 ductile iron, cast with offsetting, angle-pattern bolt pads to provide rigidity, coppercolored enamel coated, compatible with copper tubing sizes, to engage and lock designed to permit some angular deflection, contraction, and expansion. "Installation-Ready" design for direct stab installation onto roll grooved copper tube without field disassembly. Victaulic Style 607 QuickVicTM.
- B. Gasket: Elastomer composition, Grade "EHP" EPDM synthetic rubber gasket (UL/ULC classified in accordance with ANSI/NSF-61 for domestic water service) for operating temperature range from -30 degrees F to 230 250 degrees F.
- c. Accessories: Stainless steel bolts, nuts, and washers.
- C. Stainless Steel Pipe: ASTM A312, type 304/304L, Schedule 10S.
 - 1. Fittings: Precision cold drawn austenitic stainless steel housing, with synthetic rubber O-ring seals, Grade HNBR (UL/ULC classified in accordance with ANSI/NSF-61 for domestic water service), pipe stops and Pressure-Sealed end connections.
 - 2. Joints: Vic-Press 304^{TM} with 'PFT510' series tool.

2.3 SANITARY WASTE PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Cast Iron Soil Pipe: ASTM A74, service weight bell and spigot ends.
 - 1. Fittings: Cast iron, ASTM A74.
 - 2. Joints: Hub-and-spigot, CISPI HSN compression type with ASTM C564 neoprene gaskets.
- B. Cast Iron Pipe: CISPI 301, hub-less.
 - 1. Fittings: Cast iron, CISPI 301.
 - 2. Joints: CISPI 310, neoprene gasket and stainless steel clamp and shield assemblies.

Do not use PVC pipe for high temperature waste water (140° F or higher).

- C. PVC Pipe: ASTM D1785, Schedule 40, polyvinyl chloride (PVC) material, bell and spigot style solvent sealed joint ends.
 - 1. Fittings: ASTM D2466, Schedule 40, PVC.
 - 2. Joints: ASTM D2855, solvent weld with ASTM D2564 Solvent cement.
- D. Plastic Pipe: ASTM D2665, polyvinyl chloride (PVC) material.
 - 1. Fittings: PVC, ASTM D2665.
 - 2. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.

2.4 SANITARY WASTE AND VENT PIPING, ABOVE GRADE

- A. Cast Iron Pipe: CISPI 301, hub-less, service weight.
 - 1. Fittings: Cast iron, CISPI 301.
 - 2. Joints: CISPI 310, neoprene gaskets and stainless steel clamp-and-shield assemblies.
- B. Copper Tube: ASTM B306, DWV.
 - 1. Fittings: ASME B16.23, cast bronze, or ASME B16.29, wrought copper.
 - 2. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.

2.5 STORM WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Cast Iron Pipe: ASTM A74, service weight [extra heavy], bell and spigot ends.
 - 1. Fittings: Cast iron, ASTM A74.
 - 2. Joints: ASTM C564, rubber gasket joint devices or lead and oakum.
- B. Cast Iron Pipe: CISPI 301, hub-less, service weight.
 - 1. Fittings: Cast iron, CISPI 301.
 - 2. Joints: Neoprene gaskets and stainless steel clamp-and-shield assemblies.
- C. PVC Pipe: ASTM D2665 or ASTM D3034, polyvinyl chloride (PVC) material.
 - 1. Fittings: PVC, ASTM D2665 or ASTM D3034.
 - 2. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.
- D. PVC Pipe: ASTM D2665, ASTM D3034, or ASTM F679, polyvinyl chloride (PVC) material.
 - 1. Fittings: PVC, ASTM D2665, ASTM D3034, or ASTM F679.
 - 2. Joints: ASTM F477, elastomeric gaskets.

2.6 STORM WATER PIPING, ABOVE GRADE

- A. Cast Iron Pipe: CISPI 301, hub-less, service weight.
 - 1. Fittings: Cast iron, CISPI 301.
 - 2. Joints: Neoprene gaskets and stainless steel clamp-and-shield assemblies.

2.7 EQUIPMENT DRAINS AND OVERFLOWS

- A. Copper Tubing: ASTM B88, Type DWV.
 - 1. Fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper.

- 2. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.
- 3. Fittings: ASME B16.18 cast copper alloy, or ASME B16.22 wrought copper and bronze, or ASTM B584 bronze sand castings with copper tube dimensioned grooved ends (flaring of tube and fitting ends to IPS dimensions is not permitted).
- 4. Joints: Grooved mechanical couplings meeting ASTM F1476.
 - a. Housing Clamps: ASTM ASTM A536 ductile iron, cast with offsetting, angle-pattern bolt pads to provide rigidity, copper-colored enamel coated, compatible with copper tubing sizes, to engage and lock designed to permit some angular deflection, contraction, and expansion.
 "Installation-Ready" design for direct stab installation without field disassembly. Victaulic Style 607H QuickVicTM.
 - b. Gasket: Grade "EHP" EPDM gasket for water service with operating temperature range from -30 degrees F to 250 degrees F or Grade "T" Nitrile gasket for oil service with operating temperature range from -20 degrees F to 180 degrees F.
 - c. Accessories: Stainless steel bolts, nuts, and washers.

Do not use PVC pipe for high temperature waste water (140 F or higher).

Do not use PVC pipe in return plenum ceilings.

- B. PVC Pipe: ASTM D1785, Schedule 40 polyvinyl chloride (PVC) material.
 - 1. Fittings: ASTM D2466, Schedule 40, PVC.
 - 2. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.
 - 3. Couplings: Victaulic Style 177, 77, or 75 flexible type couplings only may be used with schedule 40 or 80 PVC pipe at ambient temperatures not exceeding 100 deg F.

2.8 NATURAL GAS PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Steel Pipe: ASTM A53/A53M Schedule 40 black.
 - 1. Fittings: ASTM A234/A234M forged steel welding type.
 - 2. Joints: ASME B31.9, welded.
 - 3. Jacket: AWWA C105 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.

2.9 NATURAL GAS PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53/A53M Schedule 40 black.

- 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M forged steel welding type.
- 2. Joints: Threaded for pipe 2 inch and smaller; welded for pipe 2-1/2 inches and larger.

2.10 FLUE AND COMBUSTION AIR PIPING

Note: Use only solid core PVC pipe for exhaust piping; cellular core or "foam" core PVC pipe shall only be used when specifically approved by the water heater manufacturer.

- A. PVC Pipe: ASTM D1785, Schedule 40, polyvinyl chloride (PVC) material.
 - 1. Fittings: ASTM D2466, Schedule 40, PVC.
 - 2. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement. Prime joints with a contrasting color.
- B. PVC Pipe: ASTM D1785, Schedule 80, polyvinyl chloride (PVC) material.
 - 1. Fittings: ASTM D2467, Schedule 80, PVC.
 - 2. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement. Prime joints with a contrasting color.

2.11 UNIONS AND FLANGES

- A. Unions for Pipe 2 inches and Smaller:
 - 1. Ferrous Piping: Class 150, malleable iron, threaded.
 - 2. Copper Piping: Class 150, bronze unions with soldered joints.
 - 3. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.
 - 4. PVC Piping: PVC.
 - 5. CPVC Piping: CPVC.
- B. Flanges for Pipe 2-1/2 inches and Larger:
 - 1. Ferrous Piping: Class 150, forged steel, slip-on flanges.
 - 2. Copper Piping: Class 150, slip-on bronze flanges.
 - 3. PVC Piping: PVC flanges.
 - 4. CPVC Piping: CPVC flanges.
 - 5. Gaskets: 1/16 inch thick preformed neoprene gaskets.
- C. Flange Adapter for Pipe 2 inches and Larger:
 - 1. Ferrous Piping: Class 125, 150 & 300, ductile iron, flat faced. Victaulic Style 741, 743 & W741.

- 2. Copper Piping: 300 psi, ductile iron coated with copper-colored enamel, flat faced. Victaulic Style 641.
- D. PVC Pipe Materials: For connections to equipment and valves with threaded connections, furnish solvent-weld socket to screwed joint adapters and unions, or ASTM D2464, Schedule 80, threaded, PVC pipe.

PART 3 EXECUTION

- 3.1 EXAMINATION
 - A. Division 01 Verification of existing conditions before starting work.
 - B. Verify excavations are to required grade, dry, and not over-excavated.
 - C. Verify trenches are ready to receive piping.

3.2 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.3 INSTALLATION - BURIED PIPING SYSTEMS

- A. Verify connection to site piping system size, location, and invert are as indicated on Drawings.
- **B**. Establish elevations of buried piping with not less than 2 ft of cover.
- C. Establish minimum separation from other services in accordance with applicable codes.
- D. Install pipe to elevation as indicated on Drawings.
- E. Install pipe on prepared bedding.
- F. Route pipe in straight line.
- G. Install pipe to allow for expansion and contraction without stressing pipe or joints.
- H. Install plastic ribbon tape continuous, buried 12 inches below finish grade and above pipe line; coordinate with Division 31. Refer to Section 22 05 00.
- I. Pipe Cover and Backfilling:
 - 1. Backfill trench in accordance with Section 22 05 00.

3.4 INSTALLATION - ABOVE GROUND PIPING

A. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.

- B. Install piping to maintain headroom without interfering with use of space or taking more space than necessary.
- C. Group piping whenever practical at common elevations.
- D. Sleeve pipe passing through partitions, walls and floors. Refer to Section 22 05 29.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 22 07 00.
- G. Provide access where valves and fittings are not accessible. Coordinate size and location of access doors with Division 08.
- H. Install non-conducting dielectric connections wherever jointing dissimilar metals.
- I. Establish invert elevations, slopes for drainage to 1/8 inch per foot minimum (1/4 inch per foot for 2" pipes). Maintain gradients.
- J. Slope piping and arrange systems to drain at low points.
- K. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the Work, and isolating parts of completed system.
- L. Install piping penetrating roofed areas to maintain integrity of roof assembly.
- M. Install valves in accordance with Section 22 05 23.
- N. Insulate piping. Refer to Section 22 07 00.
- O. Install pipe identification in accordance with Section 22 05 53.
- P. Grooved joint piping systems shall be installed in accordance with the manufacturer's (Victaulic) guidelines and recommendations. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by Victaulic. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. A Victaulic factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.
- Q. Vic Press 304TM Pressure-Sealed Joints: Pipe shall be square cut, +/- 0.030", properly deburred and cleaned. Pipe ends shall be marked at the required location, using a manufacturer-supplied gauge, to ensure full insertion into the coupling or fitting during assembly. Use a Victaulic "PFT510" Series tool with the proper sized jaw for pressing.
- R. PermaLynx Push-To-Connect Joints: Install in accordance with manufacturer's latest recommendations. Follow the latest published literature as provided by Victaulic. Pipe ends shall be cleaned, free from indentations, projections, burrs, and foreign matter. Use a tube preparation tool as supplied by Victaulic to clean. Apply installation mark in accordance with Victaulic instructions. Push copper tube into fittings to installation

depth mark, per Victaulic installation instructions. Keep fittings free of dirt and oil; use only on potable water or oil-free compressed air systems.

3.5 INSTALLATION - DOMESTIC WATER PIPING SYSTEMS

A. Install domestic water piping system in accordance with ASME B31.9.

3.6 INSTALLATION - SANITARY WASTE AND VENT PIPING SYSTEMS

- A. Install sanitary waste and vent piping systems in accordance with ASME B31.9.
- B. Install sanitary waste and vent piping systems in accordance with local plumbing code.
- C. Install bell and spigot pipe with bell end upstream.
- D. Support cast iron drainage piping at every joint.

3.7 INSTALLATION - STORM DRAINAGE PIPING SYSTEMS

- A. Install storm drainage piping systems piping in accordance with ASME B31.9.
- B. Install storm drainage piping systems in accordance with local plumbing code.
- C. Install bell and spigot pipe with bell end upstream.
- D. Support cast iron drainage piping at every joint.

3.8 INSTALLATION - GAS PIPING SYSTEMS

- A. Install natural gas piping in accordance with NFPA 54.
- B. Install LPG piping in accordance with NFPA 58.
- C. Provide support for utility meters in accordance with requirements of utility company.
- D. Install vent piping from gas pressure reducing valves to outdoors and terminate in weatherproof hood.
- E. Install gas pressure regulator vent full size opening on regulator and terminate outdoors or as indicated on Drawings.

3.9 FIELD QUALITY CONTROL

- A. Refer to Division 01 Execution and Closeout Requirements: Field inspecting, testing and adjusting.
- B. Test domestic water piping system in accordance with applicable code. Refer to Section 22 05 00.
- C. Test sanitary waste and vent piping system in accordance with applicable code. Refer to Section 22 05 00.
- D. Test storm drainage piping system in accordance with applicable code. Refer to Section 22 05 00.
- E. Pressure test natural gas piping in accordance with NFPA 54.
F. Test for Compressed Air Piping Leak Test: Prior to initial operation, clean and test compressed air piping in accordance with ASME B31.9.

3.10 CLEANING

- A. Division 01 Execution and Closeout Requirements: Field inspecting, testing and adjusting.
- B. Clean and disinfect domestic water distribution system in accordance with Section 22 05 00.

END OF SECTION

SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 COORDINATION

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C
- 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.

COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- D. Multispeed Motors: Separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- G. Temperature Rise: Match insulation rating.
- H. Insulation: Class F.
- I. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

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

- 2. Split phase.
- 3. Capacitor start, inductor run.
- 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 220513

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 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.
- 3. Design seismic-restraint hangers and supports for piping and equipment.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- 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.
- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of trapeze hangers.
 - 2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 - 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.

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

2.2 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 FASTENER SYSTEMS

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

2.4 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: Plastic or 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 stainlesssteel, 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 structuralsteel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.5 PIPE POSITIONING SYSTEMS

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

2.6 EQUIPMENT SUPPORTS

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

2.7 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 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. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- E. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- F. 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.
- G. 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.
- H. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- I. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- K. 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.
- L. Install lateral bracing with pipe hangers and supports to prevent swaying.

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

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (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 Section 099113 "Exterior Painting."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and copper 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.
- 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 steelpipe 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.
- 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.
- 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 Ibeams for heavy loads.
 - 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel Ibeams 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-69 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 mechanical-expansion anchors instead of building attachments where required in concrete construction.
- S. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Stencils.
 - 5. Valve tags.
 - 6. Warning tags.

1.3 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.

1.4 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Brass, 0.032-inch (0.8-mm) or anodized aluminum, 0.032-inch (0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. 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).
 - 3. 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-fourths the size of principal lettering.
 - 4. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.
 - 2. Letter Color: Conform to campus standard.
 - 3. Background Color: Conform to campus standard.
 - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
 - 5. 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).
 - 6. 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-fourths the size of principal lettering.
 - 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
- D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.

- B. Letter Color: Conform to campus standards.
- C. Background Color: Conform to campus standards.
- 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-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches (38 mm)high.

2.4 VALVE TAGS

- A. 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) or anodized aluminum, 0.032-inch (0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link or beaded chain; or S-hook.
- B. 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. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 - 1. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum.
 - 2. Fasteners: Brass grommet and wire.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

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

3.3 PIPE LABEL INSTALLATION

- A. 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, on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- C. 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.

3.4 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: 2 inches (50 mm), round.
 - b. Hot Water: 2 inches (50 mm), round.

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION 220553

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following plumbing piping services:
 - 1. Domestic cold-water piping.
 - 2. Domestic hot-water piping.
 - 3. Domestic recirculating hot-water piping.
 - 4. Storm-water piping exposed to freezing conditions.
 - 5. Roof drains and rainwater leaders.
 - 6. Supplies and drains for handicap-accessible lavatories and sinks.
- B. Related Sections:
 - 1. Section 220716 "Plumbing Equipment Insulation."

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Detail 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. Sample sizes are as follows:
 - 1. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN 50).
 - 2. Jacket Materials for Pipe: 12 inches (300 mm) long by NPS 2 (DN 50).

- 3. Sheet Jacket Materials: 12 inches (300 mm) square.
- 4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- 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.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
- C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
 - 1. Piping Mockups:
 - a. One 10-foot (3-m) section of NPS 2 (DN 50) straight pipe.
 - b. One each of a 90-degree threaded, welded, and flanged elbow.
 - c. One each of a threaded, welded, and flanged tee fitting.
 - d. One NPS 2 (DN 50) or smaller valve, and one NPS 2-1/2 (DN 65) or larger valve.
 - e. Four support hangers including hanger shield and insert.
 - f. One threaded strainer and one flanged strainer with removable portion of insulation.
 - g. One threaded reducer and one welded reducer.
 - h. One pressure temperature tap.
 - i. One mechanical coupling.

- 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
- 3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
- 4. Obtain Architect's approval of mockups before starting insulation application.
- 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
- 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
- 7. Demolish and remove mockups when directed.
- D. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

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

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 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. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Block Insulation: ASTM C 552, Type I.
 - 2. Special-Shaped Insulation: ASTM C 552, Type III.
 - 3. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 - 4. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
 - 5. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
- H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- I. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. 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.
- J. Phenolic:
 - 1. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
 - 2. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.

- 3. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- 4. Factory-Applied Jacket: ASJ. Requirements are specified in "Factory-Applied Jackets" Article.
- K. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
- C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. 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 (minus 73 to plus 93 deg C).
 - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. 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. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. 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. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. 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).
 - 2. 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."
- E. Phenolic Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).

- 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- F. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. 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."
- G. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. 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. 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.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 4. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
 - 2. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 - 3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 - 4. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

- 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
- 2. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
- 3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
- 4. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 3. Solids Content: 60 percent by volume and 66 percent by weight.
 - 4. 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. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
 - 3. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
 - 4. Color: White.

2.6 SEALANTS

- A. Joint Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Permanently flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 - 4. Color: White or gray.
 - 5. 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).
 - 6. 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. FSK and Metal Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - 4. Color: Aluminum.
 - 5. 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).

- 6. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - 4. Color: White.
 - 5. 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).
 - 6. 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.
 - 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
- B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for pipe.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

2.10 FIELD-APPLIED JACKETS

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

- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Adhesive: As recommended by jacket material manufacturer.
 - 2. Color: White.
 - 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
- C. Metal Jacket:
 - 1. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Factory cut and rolled to size.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heatbonded polyethylene and kraft paper.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
 - 2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
 - a. Factory cut and rolled to size.
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heatbonded polyethylene and kraft paper.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.

- 5) End caps.
- 6) Beveled collars.
- 7) Valve covers.
- 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- D. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

2.11 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches (75 mm).
 - 2. Thickness: 11.5 mils (0.29 mm).
 - 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Width: 3 inches (75 mm).
 - 2. Thickness: 6.5 mils (0.16 mm).
 - 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
 - 1. Width: 2 inches (50 mm).
 - 2. Thickness: 6 mils (0.15 mm).
 - 3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 - 4. Elongation: 500 percent.
 - 5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Width: 2 inches (50 mm).
 - 2. Thickness: 3.7 mils (0.093 mm).
 - 3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 - 4. Elongation: 5 percent.
 - 5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.12 SECUREMENTS

- A. Bands:
 - 1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 3/4 inch (19 mm) wide with wing seal or closed seal.
 - 2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 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.

2.13 PROTECTIVE SHIELDING GUARDS

- A. Protective Shielding Pipe Covers:
 - 1. Description: Manufactured plastic wraps for covering plumbing fixture hot- and coldwater supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
- B. Protective Shielding Piping Enclosures:
 - 1. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and coldwater 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 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.
- 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 CELLULAR-GLASS INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
 - 1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - 3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - 4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
 - 1. Install preformed pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
 - 4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (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. Secure according to manufacturer's written instructions.
 - 2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed sections of cellular-glass insulation to valve body.
 - 2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 - 1. Install pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 - 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.
 - 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
 - 1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - 3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches (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.

3.9 INSTALLATION OF PHENOLIC INSULATION

- A. General Installation Requirements:
 - 1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
 - 2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
- B. Insulation Installation on Straight Pipes and Tubes:
 - 1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 - 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 - 3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
 - 4. For insulation with factory-applied jackets with vapor retarders 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.
- C. Insulation Installation on Pipe Flanges:
 - 1. Install preformed pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

- 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
- D. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
- E. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
 - 2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.

3.10 INSTALLATION OF POLYOLEFIN INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
 - 1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 - 1. Install pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
 - 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of polyolefin pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
 - 2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.11 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with 2-inch (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, 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.

3.12 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. 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.

3.13 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.

3.14 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.

3.15 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:
 - 1. NPS 1-1/4" and Smaller: Insulation shall be the following:
 - a. Cellular Glass: 1/2 inch thick.
 - b. Flexible Elastomeric: 1/2 inch (13 mm) thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - d. Phenolic: 1 inch (25 mm) thick.
 - e. Polyolefin: 1/2 inch (13 mm) thick.
 - 2. NPS 1-1/2" and Larger: Insulation shall be the following:

- a. Cellular Glass: 1" thick.
- b. Flexible Elastomeric: 1 inch (25 mm) thick.
- c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
- d. Phenolic: 1 inch (25 mm) thick.
- e. Polyolefin: 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. Cellular Glass: 1" thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - d. Phenolic: 1 inch (25 mm) thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
 - 2. NPS 1-1/2 (DN 40) and Larger: Insulation shall be the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 1-1/2 inches (38 mm) thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch (25 mm) thick.
 - d. Phenolic: 1-1/2 inches (38 mm) thick.
 - e. Polyolefin: 1-1/2 inches (38 mm) thick.
- C. Stormwater and Overflow:
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1 inch (25 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - d. Phenolic: 1 inch (25 mm) thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
- D. Roof Drain and Overflow Drain Bodies:
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1 inch (25 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - d. Phenolic: 1 inch (25 mm) thick.
 - e. Polyolefin: 1 inch (25 mm) thick.
- E. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet (3 m) of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1 inch (25 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.

- c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
- d. Phenolic: 1 inch (25 mm) thick.
- e. Polyolefin: 1 inch (25 mm) thick.

3.16 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Domestic Water Piping:
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Flexible Elastomeric: 2 inches (50 mm) thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - d. Phenolic: 2 inches (50 mm) thick.
 - e. Polyolefin: 2 inches (50 mm) thick.

3.17 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

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

END OF SECTION 220719

SECTION 221123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. In-line, sealless centrifugal pumps.
 - 2. Horizontally mounted, in-line, separately coupled centrifugal pumps.
 - 3. Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - 4. Vertically mounted, in-line, close-coupled centrifugal pumps.

1.3 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water pumps to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with pump manufacturer's written rigging instructions for handling.

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.
- B. Pump Construction:
 - 1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
 - 2. Casing: Bronze, with threaded or companion-flange connections.
 - 3. Impeller: Plastic.
 - 4. Motor: Single speed, unless otherwise indicated.

2.2 VERTICALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhungimpeller centrifugal pumps designed for installation with pump and motor shaft mounted vertical.
- B. Pump Construction:
 - 1. Casing: Radially split, cast iron, with wear rings and threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections.
 - 2. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.
 - 3. Shaft and Shaft Sleeve: Stainless-steel shaft, with copper-alloy shaft sleeve.
 - 4. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
 - 5. Bearings: Oil-lubricated; bronze-journal or ball type.
 - 6. Shaft Coupling: Flexible or rigid type if pump is provided with coupling.
- C. Motor: Single speed, with grease-lubricated ball bearings; and rigidly mounted to pump casing.

2.3 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.4 CONTROLS

- A. Pressure Switches: Electric, adjustable for control of water-supply pump.
 - 1. Type: Water-immersion pressure sensor, for installation in piping.
 - 2. Enclosure: NEMA 250, Type 4X.
 - 3. Operation of Pump: On or off.
 - 4. Transformer: Provide if required.
- B. Thermostats: Electric; adjustable for control of hot-water circulation pump.
 - 1. Type: Water-immersion temperature sensor, for installation in piping.
 - 2. Range: 50 to 125 deg F (10 to 52 deg C).
 - 3. Enclosure: NEMA 250, Type 4X.
 - 4. Operation of Pump: On or off.
 - 5. Transformer: Provide if required.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install in-line, sealless centrifugal pumps with shaft horizontal unless otherwise indicated.
- C. Install horizontally mounted, in-line, separately coupled and close-coupled centrifugal pumps with shaft(s) horizontal.
- D. Install vertically mounted, in-line, close-coupled centrifugal pumps with shaft vertical.
- E. Install pressure switches in water supply piping.
- F. Install thermostats in hot-water return piping.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps to allow service and maintenance.
- C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
 - 1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
 - a. Horizontally mounted, in-line, separately coupled centrifugal pumps.
 - b. Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - c. Vertically mounted, in-line, close-coupled centrifugal pumps.
 - d. Comply with requirements for flexible connectors specified in Section 221116 "Domestic Water Piping."
- D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping," and comply with requirements for strainers specified in Section 221119 "Domestic Water Piping Specialties."
 - 1. Install pressure gage at suction of each pump and pressure gage at discharge of each pump. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Comply with requirements for pressure gages and snubbers specified in Section 220519 "Meters and Gages for Plumbing Piping."
- E. Connect thermostats, to pumps that they control.
- F. Interlock pump between water heater and hot-water storage tank with water heater burner and time-delay relay.

3.4 IDENTIFICATION

A. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.5 ADJUSTING

- A. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature set points.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 221123

SECTION 221123.13 - DOMESTIC-WATER PACKAGED BOOSTER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:1. Multiplex, variable-speed booster pumps.

1.3 DEFINITIONS

A. VFC: Variable-frequency controller(s).

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Booster pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the booster pump will remain in place without separation of any parts from the booster pump when subjected to the seismic forces specified and the booster pump will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, and dimensions of individual components and profiles.
- B. Shop Drawings: For booster pumps. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For booster pumps, accessories, and components, from manufacturer.

DOMESTIC-WATER PACKAGED BOOSTER PUMPS

- 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.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For booster pumps to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Comply with ASME B31.9 for piping.
- C. UL Compliance for Packaged Pumping Systems:
 - 1. UL 508, "Industrial Control Equipment."
 - 2. UL 508A, "Industrial Control Panels."
 - 3. UL 778, "Motor-Operated Water Pumps."
 - 4. UL 1995, "Heating and Cooling Equipment."
- D. Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Retain protective coatings and flange's protective covers during storage.

1.10 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 MULTIPLEX, VARIABLE-SPEED BOOSTER PUMPS

- A. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.
- B. Motors: Single speed, with pre-greased, permanently shielded, ball-type bearings. Select motors that will not overload through full range of pump performance curve.

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- C. Piping: Stainless-steel pipe and fittings.
- D. Valves:
 - 1. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: lug-type butterfly valve, in each pump's suction and discharge piping and in inlet and outlet headers.
 - 2. Check Valves NPS 2-1/2 (DN 65) and Larger: Silent type in each pump's discharge piping.
 - 3. Thermal-Relief Valve: Temperature-and-pressure relief type in pump's discharge header piping.
- E. Dielectric Fittings: With insulating material isolating joined dissimilar metals.
- F. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for multiple-pump, variable-speed operation, with load control and protection functions.
 - 1. Control Logic: Solid-state system with transducers, programmable microprocessor, VFC, and other devices in controller. Install VFC for pump motors larger than 25 hp in separate panel; same type as motor control panel enclosure.
 - 2. Motor Controller: NEMA ICS 2, variable-frequency, solid-state type.
 - 3. Enclosure: NEMA 250, Type 4.
 - 4. Motor Overload Protection: Overload relay in each phase.
 - 5. Starting Devices: Hand-off-automatic selector switch for each pump in cover of control panel, plus pilot device for automatic control.
 - a. Duplex, Automatic, Alternating Starter: Switches lead pump to lag main pump and to two-pump operation.
 - b. Triplex, Sequence (Lead-Lag-Lag) Starter: Switches lead pump to one lag main pump and to three-pump operation.
 - 6. Pump Operation and Sequencing: Pressure-sensing method.
 - a. Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.
 - 7. VFC: Voltage-source, pulse-width, modulating-frequency converter for each pump.
 - 8. Manual Bypass: Magnetic contactor arranged to transfer to constant-speed operation upon VFC failure.
 - 9. Instrumentation: Suction and discharge pressure gages.
 - 10. Lights: Running light for each pump.
 - 11. Alarm Signal Device: Sounds alarm when backup pumps are operating.
 - a. Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with automatic reset.
 - 12. Thermal-bleed cutoff.
 - 13. Low-suction-pressure cutout.
 - 14. High-suction-pressure cutout.
 - 15. Low-discharge-pressure cutout.
 - 16. High-discharge-pressure cutout.

- 17. Building Automation System Interface: Provide auxiliary contacts for interface to owner's preferred building automation system. Building automation systems are specified in Section 230900 "Instrumentation and Control for HVAC." Include the following:
 - a. On-off status of each pump.
 - b. Alarm status.
- G. Base: Structural steel.

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in NFPA 70.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for booster pumps to verify actual locations of piping connections before booster-pump installation.

3.2 INSTALLATION

- A. Equipment Mounting:
 - 1. Install booster pumps on cast-in-place concrete equipment base(s).
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
 - 3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."
- B. Support connected domestic-water piping so weight of piping is not supported by booster pumps.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect domestic-water piping to booster pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge piping.

- 1. Install shutoff valves on piping connections to booster-pump suction and discharge piping. Install ball, butterfly, or gate valves same size as suction and discharge piping. Comply with requirements for general-duty 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 union, flanged, or grooved-joint connections on suction and discharge piping at connection to domestic-water piping. Comply with requirements for unions and flanges specified in Section 221116 "Domestic Water Piping."
- 3. Install valved bypass, same size as and between piping, at connections to booster-pump suction and discharge piping. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."
- 4. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge piping. Comply with requirements for flexible connectors specified in Section 221116 "Domestic Water Piping."
- 5. Install piping adjacent to booster pumps to allow service and maintenance.

3.4 IDENTIFICATION

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

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Perform visual and mechanical inspection.
 - 2. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Pumps and controls will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

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. Adjust booster pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust pressure set points.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain booster pumps.

END OF SECTION 221123.13

SECTION 23 05 03 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes TAB to produce design objectives for the following:
 - 1. Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - c. Multizone systems.
 - 2. Hydronic Piping Systems:
 - a. Constant-flow systems.
 - b. Variable-flow systems.
 - 3. HVAC equipment quantitative-performance settings.
 - 4. Kitchen hood airflow balancing.
 - 5. Existing systems TAB.
 - 6. Verifying that automatic control devices are functioning properly.
 - 7. Reporting results of activities and procedures specified in this Section.

1.2 SUBMITTALS

- A. Strategies and Procedures Plan: Within 30 days from Contractor's Notice to Proceed, submit 4 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
- B. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- C. Warranties specified in this Section.

1.3 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by NEBB.
- B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard forms from NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

1.4 PROJECT CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.5 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.6 WARRANTY

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

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

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

- 1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flowcontrol devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 1 Section "Project Record Documents."
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.
- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.
- L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.
- M. Examine strainers for clean screens and proper perforations.
- N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

- O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- P. Examine system pumps to ensure absence of entrained air in the suction piping.
- Q. Examine equipment for installation and for properly operating safety interlocks and controls.
- R. Examine automatic temperature system components to verify the following:
 - 1. Dampers, valves, and other controlled devices are operated by the intended controller.
 - 2. Dampers and valves are in the position indicated by the controller.
 - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
 - 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
 - 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 - 6. Sensors are located to sense only the intended conditions.
 - 7. Sequence of operation for control modes is according to the Contract Documents.
 - 8. Controller set points are set at indicated values.
 - 9. Interlocked systems are operating.
 - 10. Changeover from heating to cooling mode occurs according to indicated values.
- S. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

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

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling unit components.
- L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.

- c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
- d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
- 2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
- 3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
- 4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
- 5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
- 6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
 - 1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
 - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 - 2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure terminal outlets and inlets without making adjustments.
 - 1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

- 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
- 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
- B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - 1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
 - 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 - 3. Measure total system airflow. Adjust to within indicated airflow.
 - 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 - 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 - 6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
 - 7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 - 8. Record the final fan performance data.
- C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - 1. Balance systems similar to constant-volume air systems.
 - 2. Set terminal units and supply fan at full-airflow condition.

- 3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
- 4. Readjust fan airflow for final maximum readings.
- 5. Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.
- 6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
- 7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
- 8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
- D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - 1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
 - 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
 - 3. Set terminal units at full-airflow condition.
 - 4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 - 5. Adjust terminal units for minimum airflow.
 - 6. Measure static pressure at the sensor.
 - 7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.7 PROCEDURES FOR MULTIZONE SYSTEMS

- A. Set unit at full flow through the cooling coil if coil has that capacity.
- B. Adjust each zone damper to indicated airflow.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

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

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

3.9 PROCEDURES FOR HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
 - 1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 - 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 - 4. Report flow rates that are not within plus or minus 5 percent of design.
- B. Set calibrated balancing valves, if installed, at calculated presettings.
- C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 - 1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
 - 1. Determine the balancing station with the highest percentage over indicated flow.

- 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
- 3. Record settings and mark balancing devices.
- F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.10 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.11 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 - 1. Manufacturer, model, and serial numbers.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. Efficiency rating.
 - 5. Nameplate and measured voltage, each phase.
 - 6. Nameplate and measured amperage, each phase.
 - 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.12 PROCEDURES FOR CHILLERS

- A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 - 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 - 2. If water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
 - 3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
 - 4. Power factor if factory-installed instrumentation is furnished for measuring kilowatt.
 - 5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatt.

- 6. Capacity: Calculate in tons of cooling.
- 7. If air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.13 PROCEDURES FOR COOLING TOWERS

- A. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:
 - 1. Measure condenser-water flow to each cell of the cooling tower.
 - 2. Measure entering- and leaving-water temperatures.
 - 3. Measure wet- and dry-bulb temperatures of entering air.
 - 4. Measure wet- and dry-bulb temperatures of leaving air.
 - 5. Measure condenser-water flow rate recirculating through the cooling tower.
 - 6. Measure cooling tower pump discharge pressure.
 - 7. Adjust water level and feed rate of makeup-water system.

3.14 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

3.15 PROCEDURES FOR BOILERS

- A. If hydronic, measure entering- and leaving-water temperatures and water flow.
- B. If steam, measure entering-water temperature and flow and leaving steam pressure, temperature, and flow.

3.16 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Water Coils: Measure the following data for each coil:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 4. Dry-bulb temperature of entering and leaving air.
 - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 - 6. Airflow.
 - 7. Air pressure drop.
- B. Electric-Heating Coils: Measure the following data for each coil:
 - 1. Nameplate data.

- 2. Airflow.
- 3. Entering- and leaving-air temperature at full load.
- 4. Voltage and amperage input of each phase at full load and at each incremental stage.
- 5. Calculated kilowatt at full load.
- 6. Fuse or circuit-breaker rating for overload protection.
- C. Refrigerant Coils: Measure the following data for each coil:
 - 1. Dry-bulb temperature of entering and leaving air.
 - 2. Wet-bulb temperature of entering and leaving air.
 - 3. Airflow.
 - 4. Air pressure drop.
 - 5. Refrigerant suction pressure and temperature.

3.17 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
- C. Measure outside-air, wet- and dry-bulb temperatures.

3.18 PROCEDURES FOR COMMERCIAL KITCHEN HOODS

- A. Measure, adjust, and record the airflow of each kitchen hood. For kitchen hoods designed with integral makeup air, measure and adjust the exhaust and makeup airflow. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.
 - 1. Install welded test ports in the sides of the exhaust duct for the duct Pitot-tube traverse. Install each test port with a threaded cap that is liquid tight.
- B. After balancing is complete, do the following:
 - 1. Measure and record the static pressure at the hood exhaust-duct connection.
 - 2. Measure and record the hood face velocity. Make measurements at multiple points across the face of the hood. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter. Calculate the average of the measurements recorded. Verify that the hood average face velocity complies with the Contract Documents and governing codes.
 - 3. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to room airflow patterns to achieve optimum results.

- C. Visually inspect the hood exhaust duct throughout its entire length in compliance with authorities having jurisdiction. Begin at the hood connection and end at the point it discharges outdoors. Report findings.
 - 1. Check duct slopes as required.
 - 2. Verify that duct access is installed as required.
 - 3. Verify that point of termination is as required.
 - 4. Verify that duct air velocity is within the range required.
 - 5. Verify that duct is within a fire-rated enclosure.
- D. Report deficiencies.

3.19 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.
 - 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, filter, and coil face velocity.
 - 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 and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
 - 4. Air balance each air outlet.

3.20 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.
- D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.
- F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
- G. Check the interaction of electrically operated switch transducers.
- H. Check the interaction of interlock and lockout systems.
- I. Check main control supply-air pressure and observe compressor and dryer operations.
- J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
- K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.21 TOLERANCES

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

3.22 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
 - 1. Pump curves.

- 2. Fan curves.
- 3. Manufacturers' test data.
- 4. Field test reports prepared by system and equipment installers.
- 5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
 - 1. Title page.
 - 2. Name and address of TAB firm.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB firm who certifies the report.
 - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 - 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 - 12. Nomenclature sheets for each item of equipment.
 - 13. Data for terminal units, including manufacturer, type size, and fittings.
 - 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 - 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
 - 1. Quantities of outside, supply, return, and exhaust airflows.
 - 2. Water 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.

3.23 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 23 05 03

SECTION 23 05 13 - MOTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes basic requirements for factory-installed and field-installed motors.
- B. Related Sections include the following:
 - 1. Division 23 Section "Mechanical Vibration and Seismic Controls" for mounting motors and vibration isolation and seismic-control devices.
 - 2. Division 23 Sections for application of motors and reference to specific motor requirements for motor-driven equipment.

1.3 DEFINITIONS

- A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.
- B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.4 SUBMITTALS

- A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.
- B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:
 - 1. Each installed unit's type and details.
 - 2. Nameplate legends.
 - 3. Diagrams of power and control wiring. Provide schematic wiring diagram for each type of motor and for each control scheme.

- C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around field-installed motors. Show motor layout, mechanical power transfer link, driven load, and relationship between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- D. Manufacturer Seismic Qualification Certification: Submit certification that motors, accessories, and components will withstand seismic forces defined in Division 23 Section "Mechanical Vibration and Seismic Controls." Include the following:
 - 1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Dimensioned Outline Drawings of Motorized Equipment: 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.
- E. Qualification Data: For testing agency.
- F. Test Reports: Written reports specified in Parts 2 and 3.
- G. Operation and Maintenance Data: For field-installed motors to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.
- B. Source Limitations: Obtain field-installed motors of a single type through one source from a single manufacturer.
- C. Product Options for Field-Installed Motors: Drawings indicate size, profiles, and dimensional requirements of motors and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- D. 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.
- E. Comply with NFPA 70.
1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect at least two days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.
 - 2. Indicate method of providing temporary utilities.
 - 3. Do not proceed with utility interruptions without Architect's written permission.

1.7 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:
 - 1. Compatible with the following:
 - a. Magnetic controllers.
 - b. Multispeed controllers.
 - c. Reduced-voltage controllers.
 - 2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
 - 3. Matched to torque and horsepower requirements of the load.
 - 4. Matched to ratings and characteristics of supply circuit and required control sequence.
- B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.
- C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

- A. Motor requirements apply to factory-installed and field-installed motors except as follows:
 - 1. Different ratings, performance, or characteristics for a motor are specified in another Section.
 - 2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 MOTOR CHARACTERISTICS

- A. Motors 1/2 HP and Larger: Three phase.
- B. Motors Smaller Than 1/2 HP: Single phase.
- C. Frequency Rating: 60 Hz.
- D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.
- E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
- F. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.
- G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
- H. Enclosure: Open dripproof.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Standard efficiency according to NEMA MG 1, Para. 12.59 and Table 12-10.
- C. Stator: Copper windings, unless otherwise indicated.
 - 1. Multispeed motors shall have separate winding for each speed.
- D. Rotor: Squirrel cage, unless otherwise indicated.
- E. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.
- F. Temperature Rise: Match insulation rating, unless otherwise indicated.
- G. Insulation: Class F, unless otherwise indicated.
- H. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- I. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.
 - 1. Finish: Gray enamel.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Designed with critical vibration frequencies outside operating range of controller output.
 - 2. Temperature Rise: Matched to rating for Class B insulation.
 - 3. Insulation: Class H.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with nonhygroscopic material.
 - 1. Finish: Chemical-resistant paint over corrosion-resistant primer.
- D. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:
 - 1. Measure winding resistance.
 - 2. Read no-load current and speed at rated voltage and frequency.
 - 3. Measure locked rotor current at rated frequency.
 - 4. Perform high-potential test.

2.5 SINGLE-PHASE MOTORS

- A. Type: One of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split-phase start, capacitor run.
 - 3. Capacitor start, capacitor run.
- B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.
- C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.
- D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, prelubricated-sleeve type for other single-phase motors.
- E. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:

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

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of conduit systems to verify actual locations of conduit connections before motor installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 MOTOR INSTALLATION

- A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.
- B. Install motors on concrete bases complying with Division 3.
- C. Comply with mounting and anchoring requirements specified in Division 23 Section "Mechanical Vibration and Seismic Controls."

3.3 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
 - 2. Test interlocks and control features for proper operation.
 - 3. Verify that current in each phase is within nameplate rating.
- B. Testing: Owner will engage a qualified testing agency to perform the following field quality-control testing:
- C. Testing: Engage a qualified testing agency to perform the following field quality-control testing:
- D. Testing: Perform the following field quality-control testing:

- 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.15.1. Certify compliance with test parameters.
- 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- E. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with requirements.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Verify bearing lubrication.
 - 4. Verify proper motor rotation.
 - 5. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance.

3.4 ADJUSTING

A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.5 CLEANING

- A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 23 05 13

SECTION 23 05 53 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following mechanical identification materials and their installation:
 - 1. Equipment nameplates.
 - 2. Equipment markers.

1.2 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

- A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
 - 1. Data:
 - a. Manufacturer, product name, model number, and serial number.
 - b. Capacity, operating and power characteristics, and essential data.
 - c. Labels of tested compliances.
 - 2. Location: Accessible and visible.
 - 3. Fasteners: As required to mount on equipment.
- B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.
 - 1. Terminology: Match schedules as closely as possible.
 - 2. Size: 2-1/2 by 4 inches.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

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

3.2 EQUIPMENT IDENTIFICATION

- A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
 - 1. Fuel-burning units, including boilers, furnaces and heaters.
 - 2. Condensing units.
 - 3. Packaged HVAC rooftop, central-station and zone-type units.
 - 4. Fans
- B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment.
 - 1. Letter Size: Minimum 1/2 inch.
 - 2. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
 - a. Fuel-burning units, including boilers, furnaces and heaters.
 - b. Condensing units.
 - c. Packaged HVAC central-station and zone-type units.

3.3 ADJUSTING AND CLEANING

- A. Relocate mechanical identification materials and devices that have become visually blocked by other work.
- B. Clean faces of mechanical identification devices.

END OF SECTION 23 05 53

SECTION 23 07 13 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes semirigid and flexible duct and plenum insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

1.3 SUBMITTALS

- A. Product Data: Identify thermal conductivity, density, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details for the following:
 - 1. Removable insulation sections at access panels.
 - 2. Application of field-applied jackets.
 - 3. Applications at linkages for control devices.

1.4 QUALITY ASSURANCE

- A. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

1.5 COORDINATION

A. Coordinate clearance requirements with duct Installer for insulation application.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Mineral-Fiber Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Johns Manville
 - e. Or approved substitute.
 - 2. Flexible Elastomeric Thermal Insulation:
 - a. Armstrong World Industries, Inc.
 - b. Rubatex Corp.
 - c. Or approved substitute.

2.2 INSULATION MATERIALS

- A. Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film, 3 lb/cf, k=0.23@ 75 deg. F.
- B. Mineral-Fiber Blanket Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film, 1.5 lb/cf, k=0.25@ 75 deg. F.

2.3 FIELD-APPLIED JACKETS

- A. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209, and having an integrally bonded moisture barrier over entire surface in contact with insulation. Metal thickness and corrugation dimensions are scheduled at the end of this Section.
 - 1. Finish: Stucco-embossed finish.

2.4 ACCESSORIES AND ATTACHMENTS

A. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

2.5 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

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

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each duct system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Apply multiple layers of insulation with longitudinal and end seams staggered.
- E. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- F. Keep insulation materials dry during application and finishing.
- G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- H. Apply insulation with the least number of joints practical.
- I. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
- J. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.
- K. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

- L. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
 - 3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- M. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
- N. Install vapor-retarder mastic on ducts and plenums scheduled to receive vapor retarders.
 - 1. Ducts with Vapor Retarders: Overlap insulation facing at seams and seal with vaporretarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.
 - 2. Ducts without Vapor Retarders: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.
- O. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
 - 1. Seal penetrations with vapor-retarder mastic.
 - 2. Apply insulation for exterior applications tightly joined to interior insulation ends.
 - 3. Seal insulation to roof flashing with vapor-retarder mastic.
- P. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.
- Q. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.
- R. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.
 - 1. For insulation indicated to have vapor retarders, taper termination and seal insulation ends with vapor-retarder mastic.

3.4 MINERAL-FIBER INSULATION APPLICATION

- A. Blanket Applications for Ducts and Plenums: Secure blanket insulation with adhesive and anchor pins and speed washers.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to sides and bottoms of horizontal ducts and to all surfaces of vertical ducts, fittings and transitions.
 - 3. Install anchor pins and speed washers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

- a. On duct sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
- b. On duct sides with dimensions larger than 18 inches. Space 16 inches o.c. each way, and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
- c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
- d. Do not overcompress insulation during installation.
- 4. Impale insulation over anchors and attach speed washers.
- 5. 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.
- 6. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1 inch o.c., and cover with pressure-sensitive tape having same facing as insulation.
- 7. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Apply insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
- 8. Insulate duct stiffeners, hangers, and flanges that protrude beyond the insulation surface with 6-inch- wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.
- 9. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.
- B. Board Applications for Ducts and Plenums: Secure board insulation with adhesive and anchor pins and speed washers.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to sides and bottoms of horizontal ducts and to all surfaces of vertical ducts, fittings and transitions.
 - 3. Space anchor pins as follows:
 - a. On duct sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches. Space 16 inches o.c. each way, and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
 - c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - 4. 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. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1 inch o.c., and cover with pressure-sensitive tape having same facing as insulation.
 - 6. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Groove and score insulation to fit as closely as possible to outside and

inside radius of elbows. Apply 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 the insulation surface with 6-inch- wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.
- 8. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

3.5 FIELD-APPLIED JACKET APPLICATION

A. Apply aluminum jacket directly over insulation with factory-applied jackets where exposed to the weather in accordance with manufacturers instructions.

3.6 DUCT SYSTEM APPLICATIONS

- A. Insulation materials and thicknesses are specified in schedules at the end of this Section.
- B. Materials and thicknesses for systems listed below are specified in schedules at the end of this Section.
- C. Insulate the following plenums and duct systems:
 - 1. Indoor concealed supply-, return-, and outside-air ductwork.
 - 2. Indoor exposed supply-, return-, and outside-air ductwork.
 - 3. Outdoor exposed supply and return ductwork.
 - 4. Indoor exposed range-hood exhaust ductwork.
 - 5. Indoor concealed range-hood exhaust ductwork.
 - 6. Indoor exposed oven and dishwasher exhaust ductwork.
 - 7. Indoor concealed oven and dishwasher ductwork.
- D. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 - 1. Metal ducts with duct liner.
 - 2. Factory-insulated flexible ducts.
 - 3. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
 - 4. Flexible connectors.
 - 5. Vibration-control devices.
 - 6. Access panels and doors in air-distribution systems.

Edit insulation schedules below to suit Project.

3.7 INDOOR DUCT AND PLENUM APPLICATION SCHEDULE

- A. Service: Round, supply-air ducts, concealed.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 1-1/2 inches.

- 3. Number of Layers: One.
- 4. Vapor Retarder Required: Yes.
- B. Service: Round, return-air ducts, concealed.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: No.
- C. Service: Round, outside-air ducts, concealed.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: Yes.
- D. Service: Rectangular, supply-air ducts, concealed.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: Yes.
- E. Service: Rectangular, return-air ducts, concealed.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: No.
- F. Service: Rectangular, outside-air ducts, concealed.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: Yes.
- G. Service: Round, supply-air ducts, exposed.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: Yes.
- H. Service: Round, return-air ducts, exposed.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: No.

- I. Service: Round, outside-air ducts, exposed.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: Yes.
- J. Service: Rectangular, supply-air ducts, exposed.
 - 1. Material: Mineral-fiber board.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: Yes.
- K. Service: Rectangular, return-air ducts, exposed.
 - 1. Material: Mineral-fiber board.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: Yes.
- L. Service: Rectangular, outside-air ducts, exposed.
 - 1. Material: Mineral-fiber board.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: Yes.
- M. Service: Rectangular, dishwasher exhaust ducts, concealed.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 1 inch.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: No.
- N. Service: Rectangular, dishwasher exhaust ducts, exposed.
 - 1. Material: Mineral-fiber board.
 - 2. Thickness: 1 inch.
 - 3. Number of Layers: One.
 - 4. Vapor Retarder Required: No.

3.8 OUTDOOR DUCT AND PLENUM APPLICATION SCHEDULE

- A. Service: Round, supply-air ducts.
 - 1. Material: Mineral-fiber board.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: Two.
 - 4. Field-Applied Jacket: Aluminum.

- a. Aluminum Thickness: 0.032 inch.
- 5. Vapor Retarder Required: Yes.
- B. Service: Round, return-air ducts.
 - 1. Material: Mineral-fiber board.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: Two.
 - 4. Field-Applied Jacket: Aluminum.
 - a. Aluminum Thickness: 0.032 inch.
 - 5. Vapor Retarder Required: No.
- C. Service: Rectangular, supply-air ducts.
 - 1. Material: Mineral-fiber board.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: Two.
 - 4. Field-Applied Jacket: Aluminum.
 - a. Aluminum Thickness: 0.032 inch.
 - 5. Vapor Retarder Required: Yes.
- D. Service: Rectangular, return-air ducts.
 - 1. Material: Mineral-fiber board.
 - 2. Thickness: 1-1/2 inches.
 - 3. Number of Layers: Two.
 - 4. Field-Applied Jacket: Aluminum.
 - a. Aluminum Thickness: 0.032 inch.
 - 5. Vapor Retarder Required: No.

END OF SECTION 23 07 13

SECTION 23 07 16 - EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes blanket, board, and block insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.
- B. Related Sections include the following:
 - 1. Division 23 Section "Duct Insulation" for insulation materials and application for ducts and plenums.
 - 2. Division 23 Section "Pipe Insulation" for insulation for piping systems.

1.3 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details for the following:
 - 1. Field application for each equipment type.
 - 2. Removable insulation sections at access panels.
 - 3. Application of field-applied jackets.
 - 4. Special shapes for cellular-glass insulation.
- C. Samples: For each type of insulation and field-applied jacket. Identify each Sample, describing product and intended use. Submit 12-inch-square sections of each sample material.
 - 1. Manufacturer's Color Charts: Show the full range of colors available for each type of field-applied finish material indicated.
- D. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.
- E. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.
- C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups according to the following requirements, using materials indicated for the completed Work:
 - 1. Include the following mockups:
 - a. One chilled-water centrifugal pump.
 - b. One small tank or vessel.
 - 2. Build mockups with cutaway sections to allow observation of application details for insulation materials, mastics, attachments, and jackets.
 - 3. Build mockups in the location indicated or, if not indicated, as directed by Architect.
 - 4. Notify Architect seven days in advance of dates and times when mockups will be constructed.
 - 5. Obtain Architect's approval of mockups before starting insulation application.
 - 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 7. Demolish and remove mockups when directed.
 - 8. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate clearance requirements with equipment Installer for insulation application.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mineral-Fiber Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.
 - 2. Cellular-Glass Insulation:
 - a. Pittsburgh-Corning Corp.
 - 3. Flexible Elastomeric Thermal Insulation:
 - a. Armstrong World Industries, Inc.
 - b. Rubatex Corp.
 - 4. Closed-Cell Phenolic-Foam Insulation:
 - a. Kooltherm Insulation Products, Ltd.
 - 5. Calcium Silicate Insulation:
 - a. Owens-Corning Fiberglas Corp.
 - b. Pabco.
 - c. Schuller International, Inc.

2.2 INSULATION MATERIALS

- A. Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
- B. Mineral-Fiber Blanket Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.

- C. Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.
 - 1. Block Insulation: ASTM C 552, Type I.
 - 2. Special-Shaped Insulation: ASTM C 552, Type III.
 - 3. Board Insulation: ASTM C 552, Type IV.
- D. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.
 - 1. Adhesive: As recommended by insulation material manufacturer.
 - 2. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.
- E. Closed-Cell Phenolic-Foam Insulation: Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
- F. Calcium Silicate Insulation: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a nonasbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

2.3 FIELD-APPLIED JACKETS

- A. General: ASTM C 921, Type 1, unless otherwise indicated.
- B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.
- C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.
 - 1. Adhesive: As recommended by insulation material manufacturer.
 - 2. PVC Jacket Color: White or gray.
 - 3. PVC Jacket Color: Color-code to match connected piping jackets based on materials contained within the piping system.
- D. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209, and having an integrally bonded moisture barrier over entire surface in contact with insulation. Metal thickness and corrugation dimensions are scheduled at the end of this Section.
 - 1. Finish: Smooth finish.
 - 2. Finish: Cross-crimp corrugated finish.
 - 3. Finish: Stucco-embossed finish.
 - 4. Finish: Factory-painted finish.
 - 5. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.
- E. Stainless-Steel Jacket: Deep corrugated sheets of stainless steel complying with ASTM A 666, Type 304 or 316; 0.10 inch thick; and roll stock ready for shop or field cutting and forming to indicated sizes.

- 1. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.
- 2. Moisture Barrier: 3-mil- thick, heat-bonded polyethylene and kraft paper.
- 3. Jacket Bands: Stainless steel, Type 304, 3/4 inch wide.

2.4 ACCESSORIES AND ATTACHMENTS

- A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd..
 - 1. Tape Width: 4 inches.
- B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:
 - 1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch thick.
 - 2. Galvanized Steel: 0.005 inch thick.
 - 3. Aluminum: 0.007 inch thick.
 - 4. Brass: 0.010 inch thick.
 - 5. Nickel-Copper Alloy: 0.005 inch thick.
- C. Wire: 0.080-inch, nickel-copper alloy; 0.062-inch, soft-annealed, stainless steel; or 0.062-inch, soft-annealed, galvanized steel.
- D. Weld-Attached Anchor Pins and Washers: Copper-coated steel pin for capacitor-discharge welding and galvanized speed washer. Pin length sufficient for insulation thickness indicated.
 - 1. Welded Pin Holding Capacity: 100 lb for direct pull perpendicular to the attached surface.
- E. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.
 - 1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of ducts, plenums, and breechings; and to achieve a holding capacity of 100 lb for direct pull perpendicular to the adhered surface.
- F. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

2.5 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

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

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of equipment.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each equipment system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either the wet or dry state.
- D. Apply multiple layers of insulation with longitudinal and end seams staggered.
- E. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- F. Keep insulation materials dry during application and finishing.
- G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- H. Apply insulation with the least number of joints practical.
- I. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
- J. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

- K. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
- L. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
 - 3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges and fittings.
- M. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
- N. Install vapor-retarder mastic on equipment scheduled to receive vapor retarders. Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.
- O. Insulate the following indoor equipment:
 - 1. Chilled-water air separators (small tanks).
 - 2. Chilled-water compression tanks (small tanks).
 - 3. Chilled-water centrifugal pump housings.
 - 4. Aboveground, thermal (ice) storage tanks, not factory insulated.
 - 5. Low-temperature brine tanks.
 - 6. Domestic hot-water storage tanks, not factory insulated.
 - 7. Heating hot-water air separators (small tanks).
 - 8. Heating hot-water compression tanks (small tanks).
 - 9. Heating hot-water heat exchangers.
 - 10. Steam-to-water converters, not factory insulated.
 - 11. Condensate receivers, not factory insulated.
 - 12. Deaerators, not factory insulated.
- P. Insulate the following outdoor equipment:
 - 1. Aboveground water storage tanks.
 - 2. Aboveground fuel storage tanks.
- Q. Omit insulation from 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 INDOOR TANK AND VESSEL INSULATION APPLICATION

- A. Blankets, Board, and Block Applications for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of tank and vessel surfaces.
 - 2. Groove and score insulation materials to fit as closely as possible to the equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joint. Stagger end joints.
 - 3. Protect exposed corners with secured corner angles.
 - 4. Install adhesive-attached or self-adhesive anchor pins and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. On tank and vessel, 3 inches maximum from insulation end joints, and 16 inches o.c. in both directions.
 - c. Do not overcompress insulation during installation.
 - d. Cut and miter insulation segments to fit curved sides and dome heads of tanks and vessels.
 - 5. Impale insulation over anchor pins and attach speed washers.
 - 6. 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
 - 7. Secure each layer of insulation with stainless-steel bands.
 - 8. Stagger joints between insulation layers at least 3 inches.
 - 9. Apply insulation in removable segments on equipment access doors and other elements that require frequent removal for service.
 - 10. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
 - 11. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.
- B. Flexible Elastomeric Thermal Insulation Applications for Tanks and Vessels: Apply insulation over entire surface of tanks and vessels according to the manufacturer's written instructions.
 - 1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 - 2. Seal longitudinal seams and end joints.

3.5 FIELD-APPLIED JACKET APPLICATION

- A. Apply glass-cloth jacket where indicated, directly over bare insulation or insulation with factory-applied jackets.
 - 1. Apply jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062-inch- thick coats of jacket manufacturer's recommended adhesive.
 - 3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

- B. Foil and Paper Jackets: Apply foil and paper jackets where indicated.
 - 1. Draw jacket material smooth and tight.
 - 2. Apply lap or joint strips with the same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Apply jackets with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-retarder mastic.
- C. PVC Jackets: Apply jacket with longitudinal seams along top and bottom of tanks and vessels for horizontal applications. Secure and seal seams and end joints with manufacturer's welding adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along the seam and joint edge.
- D. Aluminum Jackets: Secure jackets according to jacket manufacturer's written instructions.
- E. Stainless-Steel Jackets: Secure jackets according to jacket manufacturer's written instructions.

3.6 FINISHES

- A. Glass-Cloth Jacketed Insulation: Paint insulation finished with glass-cloth jacket as specified in Division 9 Section "Painting."
- 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.

3.7 FIELD QUALITY CONTROL

- A. Inspection: Owner will engage a qualified inspection agency to perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:
- B. Inspection: Engage a qualified inspection agency to perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:
- C. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:
 - 1. Inspect pumps and tanks randomly selected by Architect.

- 2. Remove insulation and covers from two chilled-water pumps or one percent of chilledwater pumps, whichever is greater.
- 3. Remove insulation and covers from two small tanks or one percent of small tanks, whichever is greater.
- D. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.
- E. Reinstall insulation and covers on pumps and tanks uncovered for inspection according to these Specifications.

3.8 EQUIPMENT APPLICATIONS

- A. Insulation materials and thicknesses are specified in schedules at the end of this Section.
- B. Materials and thicknesses for systems listed below are specified in schedules at the end of this Section.

3.9 INTERIOR TANK AND VESSEL INSULATION APPLICATION SCHEDULE

- A. Equipment: Chilled-water air separators and compression tanks.
 - 1. Operating Temperature: 35 to 75 deg F.
 - 2. Insulation Material: Fiberglass, with jacket.
 - 3. Insulation Thickness: 1.5"
 - 4. Field-Applied Jacket: Glass cloth.
 - 5. Field-Applied Jacket: Foil and paper.
 - 6. Field-Applied Jacket: Aluminum.
 - a. Aluminum Thickness: 0.024 inch.
 - 8. Field-Applied Jacket: Stainless steel.
 - 9. Vapor Retarder Required: Yes
 - 10. Finish: None.

END OF SECTION 23 07 16

SECTION 23 23 00 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications. Provide a complete refrigerant piping system sized and installed in accordance with all manufacturers recommendations.

1.3 SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for thermostatic expansion valves, solenoid valves, and pressure-regulating valves.
- B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and equipment.
 - 1. Refrigerant piping indicated is schematic only. Size piping and design the actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes, to ensure proper operation and compliance with warranties of connected equipment.
- C. Field Test Reports:
- D. Maintenance Data:

1.4 QUALITY ASSURANCE

- A. ASHRAE Standard: Comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
- B. ASME Standard: Comply with ASME B31.5, "Refrigeration Piping."
- C. UL Standard: Provide products complying with UL 207, "Refrigerant-Containing Components and Accessories, Nonelectrical"; or UL 429, "Electrically Operated Valves."
- 1.5 COORDINATION

- A. Coordinate layout and installation of refrigerant piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate pipe sleeve installations for foundation wall penetrations.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.
- D. Coordinate pipe sleeve installations for penetrations in exterior walls and floor assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Refrigerant Valves and Specialties:
 - a. Climate & Industrial Controls Group; Parker-Hannifin Corp.; Refrigeration & Air Conditioning Division.
 - b. Danfoss Electronics, Inc.
 - c. Emerson Electric Company; Alco Controls Div.
 - d. Henry Valve Company.
 - e. Sporlan Valve Company.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: ASTM B 280, Type ACR.
- B. Annealed-Temper Copper Tube: ASTM B 280, Type ACR .
- C. Wrought-Copper Fittings: ASME B16.22.
- D. Wrought-Copper Unions: ASME B16.22.
- E. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver), BAg-2 (silver)

2.3 REFRIGERANT PIPING SPECIALITIES

- A. Straight- or Angle-Type Strainers: 500-psig working pressure; forged-brass or steel body with stainless-steel wire or brass-reinforced Monel screen of 80 to 100 mesh in liquid lines up to 1-1/8 inches, 60 mesh in larger liquid lines, and 40 mesh in suction lines; with screwed cleanout plug and solder-end connections.
- B. Moisture/Liquid Indicators: 500-psig maximum working pressure and 200 deg F operating temperature; all-brass body with replaceable, polished, optical viewing window with color-coded moisture indicator; with solder-end connections.

- C. Replaceable-Core Filter-Dryers: 500-psig maximum working pressure; heavy gage protected with corrosion-resistant-painted steel shell, flanged ring and spring, ductile-iron cover plate with steel cap screws; wrought-copper fittings for solder-end connections; with replaceable-core kit, including gaskets and the following:
 - 1. Filter-Dryer Cartridge: Pleated media with solid-core sieve with activated alumina, ARI 730 rated for capacity.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Aboveground, within Building: Type ACR drawn-copper tubing .
- B. Belowground for NPS 2 and Smaller: Type K annealed-copper tubing.

3.2 PIPING INSTALLATION

- A. Install refrigerant piping according to ASHRAE 15.
- B. Basic piping installation requirements are specified in Division 23 Section "Basic Mechanical Materials and Methods."
- C. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- D. Arrange piping to allow inspection and service of compressor and other equipment. Install valves and specialties in accessible locations to allow for service and inspection.
- E. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- F. Belowground, install copper tubing in protective conduit. Vent conduit outdoors.
- G. Install copper tubing in rigid or flexible conduit in locations where copper tubing will be exposed to mechanical injury.
- H. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.
- I. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
 - 4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 - 5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.

- 6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
- 7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
- 8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
- 9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.
- J. Support vertical runs at each floor.

3.3 PIPE JOINT CONSTRUCTION

- A. Braze joints according to Division 23 Section "Basic Mechanical Materials and Methods."
- B. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide) during brazing to prevent scale formation.

3.4 FIELD QUALITY CONTROL

- A. Test and inspect refrigerant piping according to ASME B31.5, Chapter VI.
 - 1. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure.
 - 2. Test high- and low-pressure side piping of each system at not less than the lower of the design pressure or the setting of pressure relief device protecting high and low side of system.
 - a. System shall maintain test pressure at the manifold gage throughout duration of test.
 - b. Test joints and fittings by brushing a small amount of soap and glycerine solution over joint.
 - c. Fill system with nitrogen to raise a test pressure of 150 psig or higher as required by authorities having jurisdiction.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.5 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of the conditioned air controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Open shutoff valves in condenser water circuit.
 - 2. Check compressor oil level above center of sight glass.
 - 3. Open compressor suction and discharge valves.

- 4. Open refrigerant valves, except bypass valves that are used for other purposes.
- 5. Check compressor-motor alignment, and lubricate motors and bearings.

3.6 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Install core in filter-dryer after leak test but before evacuation.
 - 2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 - 4. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

END OF SECTION 23 23 00

SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes rectangular, round, and flat-oval metal ducts and plenums for heating, ventilating, and air-conditioning systems in pressure classes from minus 2- to plus 10-inch wg.
- B. Related Sections include the following:
 - 1. Division 7 Section "Joint Sealants" for fire-resistant sealants for use around duct penetrations and fire-damper installations in fire-rated floors, partitions, and walls.
 - 2. Division 8 Section "Access Doors" for wall- and ceiling-mounted access doors for access to concealed ducts.
 - 3. Division 10 Section "Louvers and Vents" for intake and relief louvers and vents connected to ducts and installed in exterior walls.
 - 4. Division 23 Section "Mechanical Insulation" for duct insulation.
 - 5. Division 23 Section "Fibrous-Glass Ducts."
 - 6. Division 23 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
 - 7. Division 23 Section "Duct Accessories" for dampers, sound-control devices, ductmounted access doors and panels, turning vanes, and flexible ducts.
 - 8. Division 23 Section "Air Terminals" for constant-volume and variable-air-volume control boxes, and reheat boxes.
 - 9. Division 23 Section "Diffusers, Registers, and Grilles."
 - 10. Division 23 Section "Control Systems Equipment" for automatic volume-control dampers and operators.
 - 11. Division 23 Section "Testing, Adjusting, and Balancing" for air balancing and final adjusting of manual-volume dampers.

1.3 DEFINITIONS

- A. Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C 168. In this Section, these values are the result of the formula Btu x in./h x sq. ft. x deg F or W/m x K at the temperature differences specified. Values are expressed as Btu or W.
 - 1. Example: Apparent Thermal Conductivity (k-Value): 0.26 or 0.037.

1.4 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select and size air-moving and -distribution equipment and other components of air system. Changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.5 SUBMITTALS

- A. Product Data: For duct liner and sealing materials.
- B. Shop Drawings: Show details of the following:
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 2. Duct layout indicating pressure classifications and sizes on plans.
 - 3. Fittings.
 - 4. Reinforcement and spacing.
 - 5. Seam and joint construction.
 - 6. Penetrations through fire-rated and other partitions.
 - 7. Terminal unit, coil, and humidifier installations.
 - 8. Hangers and supports, including methods for building attachment, vibration isolation, seismic restraints, and duct attachment.
- C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
 - 1. Ceiling suspension assembly members.
 - 2. Other systems installed in same space as ducts.
 - 3. Ceiling- and wall-mounted access doors and panels required to provide access to dampers and other operating devices.
 - 4. Coordination with ceiling-mounted items, including lighting fixtures, diffusers, grilles, speakers, sprinkler heads, access panels, and special moldings.
- D. Welding Certificates: Copies of certificates indicating welding procedures and personnel comply with requirements in "Quality Assurance" Article.
- E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- F. Record Drawings: Indicate actual routing, fitting details, reinforcement, support, and installed accessories and devices.

1.6 QUALITY ASSURANCE

A. Welding Standards: Qualify welding procedures and welding personnel to perform welding processes for this Project according to AWS D1.1, "Structural Welding Code--Steel," for

hangers and supports; AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members; and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

- B. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," unless otherwise indicated.
- C. Comply with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems," unless otherwise indicated.
- D. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Chapter 3, "Duct System," for range hood ducts, unless otherwise indicated.
- E. Mockups: Before installing duct systems, erect mockups representing system pressure classifications higher than 2-inch wg. Build mockups to comply with the following requirements, using materials indicated for completed Work:
 - 1. Locate mockups in the locations and of the size indicated or, if not indicated, as directed by Architect. Mockup may be a representative section of the actual duct system.
 - 2. Include the minimum number of each of the following features and fittings:
 - a. Five transverse joints.
 - b. One access door.
 - c. Two typical branch connections, each with at least one elbow.
 - d. Two typical flexible duct or flexible connector connections for each duct and apparatus.
 - 3. Perform tests specified in "Field Quality Control" Article. Modify mockup construction and perform additional tests as required to achieve specified minimum acceptable results.
 - 4. Obtain Architect's approval of mockups before starting Work.
 - 5. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 6. When directed, demolish and remove mockups from Project site.
 - 7. Approved mockups in an undisturbed condition at the time of Substantial Completion may become part of the completed Work.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver sealant and firestopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multicomponent materials.
- B. Store and handle sealant and firestopping materials according to manufacturer's written recommendations.
- C. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

- A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653/A 653M, G90 coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.
- B. PVC-Coated Galvanized Steel: UL 181, Class 1 listing. Lock-forming-quality, galvanized, sheet steel with ASTM A 653/A 653M, G90 coating designation; factory-applied, 4-mil PVC coating on exposed surfaces of ducts and fittings (exterior of ducts and fittings for underground applications and interior of ducts and fittings for fume-handling applications) and with factory-applied, 2-mil PVC coating on reverse side of ducts and fittings.
- C. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, exposed matte finish.
- D. Stainless Steel: ASTM A 480/A 480M, Type 316, sheet form with No. 4 finish for surfaces of ducts exposed to view; and Type 304, sheet form with No. 1 finish for concealed ducts.
- E. Aluminum Sheets: ASTM B 209, Alloy 3003, Temper H14, sheet form with standard, one-side bright finish for ducts exposed to view and with mill finish for concealed ducts.
- F. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 DUCT LINER

- A. General: Comply with NFPA 90A or NFPA 90B and NAIMA's "Fibrous Glass Duct Liner Standard."
- B. Materials: ASTM C 1071 with coated surface exposed to airstream to prevent erosion of glass fibers.
 - 1. Thickness: 1/2 inch.
 - 2. Thickness: 1 inch.
 - 3. Thickness: 1-1/2 inches.
 - 4. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 - 5. Fire-Hazard Classification: Maximum flame-spread rating of 25 and smoke-developed rating of 50, when tested according to ASTM C 411.
 - 6. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and ASTM C 916.
 - 7. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.

- a. Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.
- b. Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
- c. Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

2.3 SEALANT MATERIALS

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
 - 1. Joint and Seam Tape: 2 inches wide; glass-fiber fabric reinforced.
 - 2. Tape Sealing System: Woven-fiber tape impregnated with a gypsum mineral compound and a modified acrylic/silicone activator to react exothermically with tape to form a hard, durable, airtight seal.
 - 3. Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant, formulated with a minimum of 75 percent solids.
 - 4. Flanged Joint Mastics: One-part, acid-curing, silicone, elastomeric joint sealants, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

2.4 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for building materials.
 - 1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- B. Hanger Materials: Galvanized, sheet steel or round, threaded steel rod.
 - 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rod or galvanized rods with threads painted after installation.
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
 - 1. Supports for Galvanized-Steel Ducts: Galvanized steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
 - 3. Supports for Aluminum Ducts: Aluminum support materials, unless materials are electrolytically separated from ductwork.
2.5 RECTANGULAR DUCT FABRICATION

- A. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction with galvanized, sheet steel, according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Comply with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.
 - 2. Materials: Free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.
- B. Fabricate range hood exhaust ducts with 0.0598-inch- thick, carbon-steel sheet for concealed ducts and 0.0500-inch- thick stainless steel for exposed ducts. Weld and flange seams and joints. Comply with NFPA 96.
- C. Fabricate dishwasher hood exhaust ducts with 0.0500-inch- thick stainless steel. Weld and flange seams and joints.
- D. Acid-Resistant Ducts: PVC-coated galvanized steel.
- E. Static-Pressure Classifications: Unless otherwise indicated, construct ducts to the following:
 - 1. Supply Ducts: 3-inch wg.
 - 2. Return Ducts: 2-inch wg, negative pressure.
 - 3. Exhaust Ducts: 2-inch wg, negative pressure.
- F. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of unbraced panel area, unless ducts are lined.

2.6 SHOP APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. Adhere a single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness are prohibited.
- B. Apply adhesive to liner facing in direction of airflow not receiving metal nosing.
- C. Butt transverse joints without gaps and coat joint with adhesive.
- D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- E. Do not apply liners in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.

- G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profile or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - 1. Fan discharge.
 - 2. Intervals of lined duct preceding unlined duct.
 - 3. Upstream edges of transverse joints in ducts.
- I. Secure insulation liner with perforated sheet metal liner of same metal thickness as specified for duct, secured to ducts with mechanical fasteners that maintain metal liner distance from duct without compressing insulation.
 - 1. Sheet Metal Liner Perforations: 3/32-inch diameter, with an overall open area of 23 percent.
- J. Terminate liner with duct buildouts installed in ducts to attach dampers, turning vane assemblies, and other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct wall with bolts, screws, rivets, or welds. Terminate liner at fire dampers at connection to fire-damper sleeve.

2.7 ROUND AND FLAT-OVAL DUCT FABRICATION

- A. General: Diameter as applied to flat-oval ducts in this Article is the diameter of the size of round duct that has a circumference equal to perimeter of a given size of flat-oval duct.
- B. Round Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- C. Flat-Oval Ducts: Fabricate supply ducts with standard spiral lock seams or with butt-welded longitudinal seams according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- D. Double-Wall (Insulated) Ducts: Fabricate double-wall (insulated) ducts with an outer shell and an inner liner. Dimensions indicated on internally insulated ducts are inside dimensions.
 - 1. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 - 2. Outer Shell: Base outer-shell metal thickness on actual outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner shell and insulation, and in metal thickness specified for single-wall duct.
 - 3. Insulation: 1-inch- thick fibrous-glass insulation, unless otherwise indicated. Terminate insulation where internally insulated duct connects to single-wall duct or uninsulated components. Terminate insulation and reduce outer duct diameter to inner liner diameter.
 - 4. Solid Inner Liner: Fabricate round and flat-oval inner liners with solid sheet metal of thickness listed below:

- 5. Perforated Inner Liner: Fabricate round and flat-oval inner liners with sheet metal having 3/32-inch- diameter perforations, with an overall open area of 23 percent. Use the following sheet metal thicknesses and seam construction:
 - a. Ducts 3 to 8 Inches in Diameter: 0.019 inch with standard spiral seam construction.
 - b. Ducts 9 to 42 Inches in Diameter: 0.019 inch with single-rib spiral seam construction.
 - c. Ducts 44 to 60 Inches in Diameter: 0.022 inch with single-rib spiral seam construction.
 - d. Ducts 62 to 88 Inches in Diameter: 0.034 inch with standard spiral seam construction.
- 6. Maintain concentricity of liner to outer shell by mechanical means. Retain insulation from dislocation by mechanical means.

2.8 ROUND AND FLAT-OVAL SUPPLY AND EXHAUST FITTING FABRICATION

- A. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal seam straight duct.
- B. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.
- C. Elbows: Fabricate in die-formed, gored, pleated, or mitered construction. Fabricate bend radius of die-formed, gored, and pleated elbows one and one-half times elbow diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
 - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
 - 2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg:
 - a. Ducts 3 to 26 Inches in Diameter: 0.028 inch.
 - b. Ducts 27 to 36 Inches in Diameter: 0.034 inch.
 - c. Ducts 37 to 50 Inches in Diameter: 0.040 inch.
 - d. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
 - e. Ducts 62 to 84 Inches in Diameter: 0.064 inch.
 - 3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:
 - a. Ducts 3 to 14 Inches in Diameter: 0.028 inch.
 - b. Ducts 15 to 26 Inches in Diameter: 0.034 inch.
 - c. Ducts 27 to 50 Inches in Diameter: 0.040 inch.
 - d. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
 - e. Ducts 62 to 84 Inches in Diameter: 0.064 inch.

- 4. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal seam flat-oval duct.
- 5. 90-Degree, Two-Piece, Mitered Elbows: Use only for supply systems, or exhaust systems for material-handling classes A and B; and only where space restrictions do not permit using 1.5 bend radius elbows. Fabricate with single-thickness turning vanes.
- 6. Round Elbows, 8 Inches and Smaller: Fabricate die-formed elbows for 45- and 90degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with gored construction.
- 7. Round Elbows, 9 through 14 Inches: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees, unless space restrictions require a mitered elbow. Fabricate nonstandard bend-angle configuration or nonstandard diameter elbows with gored construction.
- 8. Round Elbows, Larger Than 14 Inches, and All Flat-Oval Elbows: Fabricate gored elbows, unless space restrictions require a mitered elbow.
- 9. Die-Formed Elbows for Sizes through 8 Inches and All Pressures: 0.040 inch thick with two-piece welded construction.
- 10. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
- 11. Flat-Oval Elbow Metal Thickness: Same as longitudinal seam flat-oval duct specified above.
- 12. Pleated Elbows for Sizes through 14 Inches and Pressures through 10-Inch wg: 0.022 inch.
- D. Double-Wall (Insulated) Fittings: Fabricate double-wall (insulated) fittings with an outer shell and an inner liner. Dimensions indicated on internally insulated ducts are inside dimensions.
 - 1. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 - 2. Outer Shell: Base outer-shell metal thickness on actual outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner shell and insulation. Use the same metal thicknesses for outer duct as for uninsulated fittings.
 - 3. Insulation: 1-inch- thick fibrous-glass insulation, unless otherwise indicated. Terminate insulation where internally insulated duct connects to single-wall duct or uninsulated components. Terminate insulation and reduce outer duct diameter to nominal single-wall size.
 - 4. Solid Inner Liner: Fabricate round and flat-oval inner liners with solid sheet metal of thickness listed below:
 - 5. Perforated Inner Liner: Fabricate round and flat-oval inner liners with sheet metal having 3/32-inch- diameter perforations, with an overall open area of 23 percent. Use the following sheet metal thicknesses:
 - a. Ducts 3 to 34 Inches in Diameter: 0.028 inch.
 - b. Ducts 35 to 58 Inches in Diameter: 0.034 inch.
 - c. Ducts 60 to 88 Inches in Diameter: 0.040 inch.
 - 6. Maintain concentricity of liner to outer shell by mechanical means. Retain insulation from dislocation by mechanical means.
- E. PVC-Coated Elbows and Fittings: Fabricate elbows and fittings as follows:

- 1. Round Elbows 4 to 8 Inches in Diameter: Two piece, die stamped, with longitudinal seams spot welded, bonded, and painted with a PVC aerosol spray.
- 2. Round Elbows 9 to 26 Inches in Diameter: Standing seam construction.
- 3. Round Elbows 28 to 60 Inches in Diameter: Standard gore construction, riveted and bonded.
- 4. Other Fittings: Riveted and bonded joints.
- 5. Couplings: Slip-joint construction with a minimum 2-inch insertion length.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION, GENERAL

- A. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts, fittings, and accessories.
- B. Construct and install each duct system for the specific duct pressure classification indicated.
- C. Install round and flat-oval ducts in lengths not less than 12 feet, unless interrupted by fittings.
- D. Install ducts with fewest possible joints.
- E. Install fabricated fittings for changes in directions, changes in size and shape, and connections.
- F. Install couplings tight to duct wall surface with a minimum of projections into duct.
- G. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs.
- H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- J. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.
- K. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- L. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches.

N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire damper, sleeve, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Firestopping."

3.2 PVC-COATED DUCT INSTALLATION

- A. Install PVC-coated duct and fittings according to manufacturer's written instructions.
- B. Seal all joints and seams. Apply sealer to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- C. Secure couplings with sheet metal screws. Install screws at an interval of 12 inches, with a minimum of three screws in each coupling.
- D. Repair damage to PVC coating with manufacturer's recommended materials.

3.3 UNDERSLAB DUCT INSTALLATIONS

- A. Verify undamaged conditions of duct before enclosure with fill or encasement.
- B. Install underslab ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and as indicated.
- C. Protect ducts from damage by equipment used in placing concrete on or around ducts.
- D. Protect duct openings.

3.4 RANGE HOOD EXHAUST DUCT INSTALLATIONS

- A. Install ducts to allow for thermal expansion of ductwork through 2000 deg F temperature range.
- B. Install ducts without dips or traps that may collect residues, unless traps have continuous or automatic residue removal.
- C. Install access openings at each change in direction and at 50-foot intervals; locate on sides of duct a minimum of 1-1/2 inches from bottom; and fit with grease-tight covers of same material as duct.
- D. Do not penetrate fire-rated assemblies.

3.5 DISHWASHER EXHAUST DUCT INSTALLATIONS

A. Install dishwasher exhaust ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

3.6 SEAM AND JOINT SEALING

- A. General: Seal duct seams and joints according to the duct pressure class indicated and as described in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Pressure Classification Less Than 2-Inch wg: Transverse joints.
- C. Seal externally insulated ducts before insulation installation.

3.7 HANGING AND SUPPORTING

- A. Install rigid round, rectangular, and flat-oval metal duct with support systems indicated in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
- C. Support vertical ducts at a maximum interval of 16 feet and at each floor.
- D. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- E. Install concrete inserts before placing concrete.
- F. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3.8 CONNECTIONS

- A. Connect equipment with flexible connectors according to Division 23 Section "Duct Accessories."
- B. For branch, outlet and inlet, and terminal unit connections, comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

3.9 FIELD QUALITY CONTROL

- A. Disassemble, reassemble, and seal segments of systems as required to accommodate leakage testing and as required for compliance with test requirements.
- B. Conduct tests, in presence of Architect, at static pressures equal to maximum design pressure of system or section being tested. If pressure classifications are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
- C. Determine leakage from entire system or section of system by relating leakage to surface area of test section.

- D. Maximum Allowable Leakage: Comply with requirements for Leakage Classification 3 for round and flat-oval ducts, Leakage Classification 12 for rectangular ducts in pressure classifications less than and equal to 2-inch wg (both positive and negative pressures), and Leakage Classification 6 for pressure classifications from 2- to 10-inch wg.
- E. Remake leaking joints and retest until leakage is less than maximum allowable.
- F. Leakage Test: Perform tests according to SMACNA's "HVAC Air Duct Leakage Test Manual."

3.10 ADJUSTING

- A. Adjust volume-control dampers in ducts, outlets, and inlets to achieve design airflow.
- B. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed procedures.

3.11 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect the system. Vacuum ducts before final acceptance to remove dust and debris.

END OF SECTION 23 31 13

SECTION 23 33 00 - DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Backdraft dampers.
 - 2. Volume dampers.
 - 3. Motorized control dampers.
 - 4. Fire dampers.
 - 5. Ceiling fire dampers.
 - 6. Smoke dampers.
 - 7. Combination fire and smoke dampers.
 - 8. Turning vanes.
 - 9. Duct-mounting access doors.
 - 10. Flexible connectors.
 - 11. Flexible ducts.
 - 12. Duct accessory hardware.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Backdraft dampers.
 - 2. Volume dampers.
 - 3. Motorized control dampers.
 - 4. Fire dampers.
 - 5. Ceiling fire dampers.
 - 6. Smoke dampers.
 - 7. Combination fire and smoke dampers.
 - 8. Duct silencers.
 - 9. Turning vanes.
 - 10. Duct-mounting access doors.
 - 11. Flexible connectors.
 - 12. Flexible ducts.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 BACKDRAFT DAMPERS

- A. Description: Multiple-blade, parallel action gravity balanced, with [center-pivoted] blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.
- B. Frame: 0.052-inch- thick, galvanized sheet steel, with welded corners.
- C. Blades: 0.025-inch- thick, roll-formed aluminum.
- D. Blade Seals: Neoprene.
- E. Blade Axles: Galvanized steel.
- F. Tie Bars and Brackets: Galvanized steel.
- G. Return Spring: Adjustable tension.

2.2 VOLUME DAMPERS

- A. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
- B. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
 - 1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 - 2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized sheet steel.
 - 3. Blade Axles: Galvanized steel .
 - 4. Bearings: Molded synthetic.
 - 5. Tie Bars and Brackets: Galvanized steel.

2.3 MOTORIZED CONTROL DAMPERS

A. General Description: AMCA-rated, opposed-blade design; minimum of 0.1084-inch- thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch- thick, galvanized-steel damper blades with maximum blade width of 8 inches.

- 1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
- 2. Operating Temperature Range: From minus 40 to plus 200 deg F.
- 3. Provide closed-cell neoprene edging.

2.4 FIRE DAMPERS

- A. Fire dampers shall be labeled according to UL 555 for dynamic application.
- B. Fire Rating: 1-1/2 hours.
- C. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- D. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 - 1. Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.
 - 2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.
- E. Mounting Orientation: Vertical or horizontal as indicated.
- F. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- G. Fusible Links: Replaceable, 212 deg F rated.

2.5 CEILING FIRE DAMPERS

- A. General Description: Labeled according to UL 555C; comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."
- B. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.
- C. Blades: Galvanized sheet steel with refractory insulation.
- D. Fusible Links: Replaceable, 285 deg F rated.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

- A. General Description: Labeled according to UL 555S. Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating.
- B. Fusible Links: Replaceable, 212 deg F rated.

- C. Frame and Blades: 0.064-inch- thick, galvanized sheet steel.
- D. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.
- E. Damper Motors: Provide for modulating or two-position action.
 - 1. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 2. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 - 3. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 - 4. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 - 5. Electrical Connection: 115 V, single phase, 60 Hz.

2.7 TURNING VANES

- A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.
- B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- wide, single -vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

2.8 DUCT-MOUNTING ACCESS DOORS

- A. General Description: Fabricate doors airtight and suitable for duct pressure class.
- B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.
 - 1. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 2. Provide number of hinges and locks as follows:
 - a. Less Than 12 Inches Square: Secure with two sash locks.
 - b. Up to 18 Inches Square: Two hinges and two sash locks.
 - c. Up to 24 by 48 Inches: Three hinges and two compression latches.
 - d. Sizes 24 by 48 Inches and Larger: One additional hinge.

2.9 FLEXIBLE CONNECTORS

- A. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- B. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel. Select metal compatible with ducts.
- C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd..
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.
- D. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd..
 - 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F.

2.10 FLEXIBLE DUCTS

- A. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor barrier film.
 - 1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 10 to plus 160 deg F.
- B. Flexible Duct Clamps: Nylon strap, in sizes 3 through 18 inches to suit duct size.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- D. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

- E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.
- F. Provide test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.
- H. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
 - 1. On both sides of duct coils.
 - 2. Downstream from volume dampers and equipment.
 - 3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
 - 4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
 - 5. On sides of ducts where adequate clearance is available.
- I. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
- J. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- K. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- L. Connect diffusers or light troffer boots to low pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- M. Connect flexible ducts to metal ducts with draw bands.
- N. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

- A. Adjust duct accessories for proper settings.
- B. Adjust fire and smoke dampers for proper action.

END OF SECTION 23 33 00

SECTION 23 24 23 - POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Centrifugal roof ventilators.
 - 2. Centrifugal wall ventilators.
 - 3. Ceiling-mounting ventilators.
 - 4. In-line centrifugal fans.

1.2 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material gages and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
 - 2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
- C. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

1.4 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraphs titles below introduce lists, the following requirements apply for product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 CENTRIFUGAL ROOF VENTILATORS

- A. Description: Belt-driven or direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
 - 1. Manufacturers
 - a. Acme Fan Company
 - b. Cook, Loren Company.
 - c. Greenheck Fan Corp.
- B. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
- C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- D. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
 - 1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - 4. Fan and motor isolated from exhaust airstream.
- E. Accessories:
 - 1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
 - 2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.

- 3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
- 4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
- F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
 - 1. Configuration: Self-flashing without a cant strip, with mounting flange.
 - 2. Overall Height: 12 inches.
 - 3. Sound Curb: Curb with sound-absorbing insulation matrix.
 - 4. Pitch Mounting: Manufacture curb for roof slope.
 - 5. Metal Liner: Galvanized steel.
 - 6. Burglar Bars: 1/2-inch-thick steel bars welded in place to form 6-inch squares.
 - 7. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
 - 8. Mounting Pedestal: Galvanized steel with removable access panel.
 - 9. Vented Curb: Unlined with louvered vents in vertical sides.

2.3 CENTRIFUGAL WALL VENTILATORS

- A. Description: Belt-driven or direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
 - 1. Available Manufacturers:
 - a. Acme Fan Company
 - b. Cook, Loren Company.
 - c. Greenheck Fan Corp.
- B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.
- C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.
- D. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
 - 1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - 4. Fan and motor isolated from exhaust airstream.
- E. Accessories:
 - 1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
 - 2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
 - 3. Wall Grille: Ring type for flush mounting.

- 4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
- 5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

2.4 CEILING-MOUNTING VENTILATORS

- A. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.
 - 1. Available Manufacturers:
 - a. Acme Fan Company
 - b. Cook, Loren Company.
 - c. Greenheck Fan Corp.
- B. Housing: Steel, lined with acoustical insulation.
- C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
- D. Grille: Aluminum or Stainless steel, louvered grille with flange on intake and thumbscrew attachment to fan housing.
- E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
- F. Accessories:
 - 1. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
 - 2. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
 - 3. Motion Sensor: Motion detector with adjustable shutoff timer.
 - 4. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless steel springs, and fusible link.
 - 5. Filter: Washable aluminum to fit between fan and grille.
 - 6. Isolation: Rubber-in-shear vibration isolators.
 - 7. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.5 IN-LINE CENTRIFUGAL FANS

- A. Description: In-line, belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
 - 1. Manufacturers:
 - a. Acme Fan Company
 - b. Cook, Loren Company.

- c. Greenheck Fan Corp.
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Driven Units: Motor encased in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.
- D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:

- 1. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
- 2. Companion Flanges: For inlet and outlet duct connections.
- 3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
- 4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.6 MOTORS

- A. For motors larger than ¹/₄ horsepower, refer to Division 23 Section "Motors" for general requirements for factory-installed motors.
- B. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B.
- C. Enclosure Type: Open drip-proof.

2.7 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Support units using spring isolators having a static deflection of 1 inch: Vibration- and seismiccontrol devices are specified in Division 23 Section "Mechanical Vibration and Seismic Controls."

- 1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
- B. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."
- C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. Refer to Section "Roof Accessories" for installation of roof curbs.
- D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- E. Support suspended units from structure using threaded steel rods and spring hangers. Vibrationcontrol devices are specified in Division 23 Section "Mechanical Vibration and Seismic Controls."
 - 1. In seismic zones, restrain support units.
- F. Install units with clearances for service and maintenance.
- G. Label units according to requirements specified in Division 23 Section "Mechanical Identification."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

- A. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Shut unit down and reconnect automatic temperature-control operators.
- D. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.
- E. Replace fan and motor pulleys as required to achieve design airflow.
- F. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

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END OF SECTION 23 24 23

SECTION 23 36 00 - AIR TERMINALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Single-duct air terminals.
 - 2. Dual-duct air terminals.
 - 3. Fan-powered air terminals.
 - 4. Mechanical air terminals.
 - 5. System-powered air terminals.
 - 6. Diffuser air terminals.
- B. Related Sections include the following:
 - 1. Division 23 Section "Duct Insulation" for external insulation of air terminals.
 - 2. Division 23 Section "Control Systems Equipment" for control devices installed on air terminals.

1.3 SUBMITTALS

- A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each model indicated. Include a schedule showing drawing designation, room location, number furnished, model number, size, and accessories furnished.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.
- C. Coordination Drawings: Reflected ceiling plans drawn to scale and coordinating air outlets with other items installed in ceilings.
- D. Maintenance Data: List of parts for each type of air terminal and troubleshooting maintenance guide to include in the maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings and schedules indicate requirements of air terminals and are based on specific systems indicated. Other manufacturers' systems with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."
- B. Listing and Labeling: Provide electrically operated air terminals specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.
- C. NFPA Compliance: Install air terminals according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- D. Comply with NFPA 70 for electrical components and installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering air terminals that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide air terminals by one of the following:
 - 1. Nailor
 - 2. Trane
 - 3. Carrier
 - 4. Titus
 - 5. Enviro-Tech
 - 6. Acutherm

2.2 SINGLE-DUCT AIR TERMINALS

- A. Configuration: Volume-damper assembly inside unit casing. Locate control components inside protective metal shroud.
- B. Casings: Steel or aluminum sheet metal of the following minimum thicknesses:
 - 1. Upstream Pressure Side: 0.0239-inch steel.
 - 2. Downstream Pressure Side: 0.0179-inch steel.
 - 3. Upstream Pressure Side: 0.032-inch aluminum.
 - 4. Downstream Pressure Side: 0.025-inch aluminum.

- C. Casing Lining: Minimum of 1/2-inch-thick, neoprene- or vinyl-coated, fibrous-glass insulation; 1.5-lb/cu. ft. density, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent delamination, sagging, or settling.
 - 1. Coat liner surfaces and edges with erosion-resistant coating or cover with perforated metal.
 - 2. Cover liner with perforated metal.
 - 3. Cover liner with Mylar film.
 - 4. Cover liner with Tedlar film.
- D. Plenum Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
- E. Plenum Air Outlets: S-slip and drive connections.
- F. Access: Removable panels to permit access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
- G. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: 2 percent of nominal airflow at 1-inch wg inlet static pressure.
 - 2. Maximum Damper Leakage: 2 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 3. Maximum Damper Leakage: 3 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 4. Maximum Damper Leakage: 3 percent of nominal airflow at 6-inch wg inlet static pressure.
 - 5. Damper Position: Normally open.
 - 6. Damper Position: Normally closed.
- H. Attenuator Section: Line with 2-inch-thick, neoprene- or vinyl-coated, fibrous-glass insulation.
- I. Multi-outlet Attenuator Section: With 6-inch-diameter collars; each with locking butterfly balancing damper.
- J. Multi-outlet Attenuator Section: With 8-inch-diameter collars; each with locking butterfly balancing damper.
- K. Round Outlet: Discharge collar matching inlet size.
- L. Hot-Water Heating Coil: 1/2-inch copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.
- M. Electric Heating Coil: Slip-in type, open-coil design with integral control box factory wired and installed. Include the following features:
 - 1. Primary and secondary over-temperature protection.
 - 2. Minimum airflow switch.
 - 3. Pneumatic-electric switches and relays.

- 4. Magnetic contactor for each step of control.
- N. Controls: Damper operator, thermostat, and other devices compatible with temperature controls specified in other Division 23 Sections.
- O. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.
- P. Pneumatic Controls: Damper operator, velocity controller, and thermostat.
 - 1. Pneumatic Damper Operator: 8- to 13-psig spring range.
 - 2. Velocity Controller: Factory calibrated to minimum and maximum air volumes, field adjustable; maintains constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4 inches wg.
 - 3. Thermostat: Wall-mounted, pneumatic type with appropriate mounting hardware.
- Q. Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor provide control with the following features:
 - 1. Proportional plus integral control of room temperature.
 - 2. Time-proportional reheat-coil control.
 - 3. Occupied/unoccupied operating mode.
 - 4. Remote reset of airflow or temperature set points.
 - 5. Adjusting and monitoring with portable terminal.
 - 6. Communication with temperature-control system specified in other Division 23 Sections.

2.3 DUAL-DUCT AIR TERMINALS

- A. Configuration: 2 volume dampers inside unit casing with mixing attenuator section. Locate control components inside protective metal shroud.
- B. Casings: Steel or aluminum sheet metal of the following minimum thicknesses:
 - 1. Upstream Pressure Side: 0.0239-inch steel.
 - 2. Downstream Pressure Side: 0.0179-inch steel.
 - 3. Upstream Pressure Side: 0.032-inch aluminum.
 - 4. Downstream Pressure Side: 0.025-inch aluminum.
- C. Casing Lining: Minimum of 1/2-inch-thick, neoprene- or vinyl-coated, fibrous-glass insulation; 1.5-lb/cu. ft. density, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent delamination, sagging, or settling.
 - 1. Coat liner surfaces and edges with erosion-resistant coating or cover with perforated metal.
 - 2. Cover liner with perforated metal.
 - 3. Cover liner with Mylar film.
 - 4. Cover liner with Tedlar film.
- D. Plenum Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.

- E. Plenum Air Outlets: S-slip and drive connections.
- F. Access: Removable panels to permit access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
- G. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: 2 percent of nominal airflow at 1-inch wg inlet static pressure.
 - 2. Maximum Damper Leakage: 2 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 3. Maximum Damper Leakage: 3 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 4. Maximum Damper Leakage: 3 percent of nominal airflow at 6-inch wg inlet static pressure.
 - 5. Damper Position: Normally open.
 - 6. Damper Position: Normally closed.
- H. Attenuator Section: Line with 2-inch-thick, neoprene- or vinyl-coated, fibrous-glass insulation.
- I. Multi-outlet Attenuator Section: With 6-inch-diameter collars; each with locking butterfly balancing damper.
- J. Multi-outlet Attenuator Section: With 8-inch-diameter collars; each with locking butterfly balancing damper.
- K. Controls: Damper operator, thermostat, and other devices compatible with temperature controls specified in other Division 23 Sections.
- L. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.
- M. Pneumatic Controls: Damper operator, velocity controller, and thermostat.
 - 1. Pneumatic Damper Operator: 8- to 13-psig spring range.
 - 2. Velocity Controller: Factory calibrated to minimum and maximum air volumes, field adjustable; maintains constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4 inches wg.
 - 3. Thermostat: Wall-mounted, pneumatic type with appropriate mounting hardware.
- N. Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor provide control with the following features:
 - 1. Proportional plus integral control of room temperature.
 - 2. Time-proportional reheat-coil control.
 - 3. Occupied/unoccupied operating mode.
 - 4. Remote reset of airflow or temperature set points.
 - 5. Adjusting and monitoring with portable terminal.

- 6. Communication with temperature-control system specified in other Division 23 Sections.
- O. Control Sequence: Provide the following:
 - 1. Modulate cold-air damper closed as warm-air damper opens.
 - 2. Field-adjustable actuator for warm-air damper allows a choice between simultaneously opening warm-air damper as cold-air damper closes and delaying opening warm-air damper until cold-air damper is closed.

2.4 FAN-POWERED AIR TERMINALS

- A. Configuration: Volume-damper assembly and fan in series or in parallel arrangement inside unit casing. Locate control components inside protective metal shroud.
- B. Casings: Steel or aluminum sheet metal of the following minimum thicknesses:
 - 1. Upstream Pressure Side: 0.0239-inch steel.
 - 2. Downstream Pressure Side: 0.0179-inch steel.
 - 3. Upstream Pressure Side: 0.032-inch aluminum.
 - 4. Downstream Pressure Side: 0.025-inch aluminum.
- C. Casing Lining: Minimum of 1/2-inch-thick, neoprene- or vinyl-coated, fibrous-glass insulation; 1.5-lb/cu. ft. density, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent delamination, sagging, or settling.
 - 1. Coat liner surfaces and edges with erosion-resistant coating or cover with perforated metal.
 - 2. Cover liner with perforated metal.
 - 3. Cover liner with Mylar film.
 - 4. Cover liner with Tedlar film.
- D. Plenum Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
- E. Plenum Air Outlets: S-slip and drive connections.
- F. Access: Removable panels to permit access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
- G. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: 2 percent of nominal airflow at 1-inch wg inlet static pressure.
 - 2. Maximum Damper Leakage: 2 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 3. Maximum Damper Leakage: 3 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 4. Maximum Damper Leakage: 3 percent of nominal airflow at 6-inch wg inlet static pressure.

- 5. Damper Position: Normally open.
- 6. Damper Position: Normally closed.
- H. Fan Section: Galvanized-steel plenum, acoustically lined, housing direct-drive, forward-curved fan with permanent split-capacitor motor, air filter, and backdraft damper.
 - 1. Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.
 - 2. Isolation: Fan-motor assembly on rubber isolators.
- I. Attenuator Section: Line with 2-inch-thick, neoprene- or vinyl-coated, fibrous-glass insulation.
- J. Hot-Water Heating Coil: 1/2-inch copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.
- K. Electric Heating Coil: Slip-in type, open-coil design with integral control box factory wired and installed. Include the following features:
 - 1. Primary and secondary over-temperature protection.
 - 2. Minimum airflow switch.
 - 3. Pneumatic-electric switches and relays.
 - 4. Magnetic contactor for each step of control.
- L. Factory-mounted and -wired controls: Mount electrical components in control box with removable cover. Incorporate single-point electrical connection to power source.
 - 1. Factory-mounted transformer for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
 - 2. Wiring Terminations: Fan and controls to terminal strip, and terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box sized according to NFPA 70.
 - 3. Disconnect Switch: Factory-mounted, fused, disconnect switch.
- M. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
- N. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.
- O. Pneumatic Controls: Damper operator, velocity controller, and thermostat.
 - 1. Pneumatic Damper Operator: 8- to 13-psig spring range.
 - 2. Velocity Controller: Factory calibrated to minimum and maximum air volumes, field adjustable; maintains constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4 inches wg.
 - 3. Thermostat: Wall-mounted, pneumatic type with appropriate mounting hardware.
- P. Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor provide control with the following features:
 - 1. Proportional plus integral control of room temperature.

- 2. Time-proportional reheat-coil control.
- 3. Occupied/unoccupied operating mode.
- 4. Remote reset of airflow or temperature set points.
- 5. Adjusting and monitoring with portable terminal.
- 6. Communication with temperature-control system specified in other Division 23 Sections.
- Q. Factory-mounted electronic controls to accomplish the following sequence of operation:
 - 1. With central system fan operating in occupied mode, sequence the controls as follows:
 - a. When primary duct pressure is sensed, thermostat and volume damper proportion airflow from central system.
 - b. On reduced cooling demand, volume damper closes. At a field-adjustable point, fan is energized.
 - c. As cooling demand increases, fan speed increases.
 - d. If central duct system pressure varies, volume damper maintains constant primary airflow.
 - e. If no cooling or heating demand, control enters field-adjustable, no-load band.
 - f. On heating demand, heating coil is energized.
 - 2. With central system fan operating in unoccupied mode, sequence the controls as follows:
 - a. Field-adjustable temperature setback.
 - b. On heating demand, terminal unit fan and heating coil are energized.
 - c. Volume damper is closed.
 - 3. With central system fan operating in occupied mode, sequence the controls as follows:
 - a. On cooling demand, volume damper proportions airflow from central system.
 - b. On reduced cooling demand, volume damper closes. Pneumatic-electric or damper-position switch energizes fan.
 - c. Speed control adjusts fan speed to match downstream resistance.
 - d. On heating demand, heating coil is energized.
 - 4. With central system fan operating in unoccupied mode, sequence the controls as follows:
 - a. Thermostat cycles fan.

2.5 MECHANICAL AIR TERMINALS

- A. Configuration: Volume-damper assembly and control components inside unit casing.
- B. Casings: Steel or aluminum sheet metal of the following minimum thicknesses:
 - 1. Upstream Pressure Side: 0.0239-inch steel.
 - 2. Downstream Pressure Side: 0.0179-inch steel.
 - 3. Upstream Pressure Side: 0.032-inch aluminum.
 - 4. Downstream Pressure Side: 0.025-inch aluminum.

- C. Casing Lining: Minimum of 1/2-inch-thick, neoprene- or vinyl-coated, fibrous-glass insulation; 1.5-lb/cu. ft. density, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent delamination, sagging, or settling.
 - 1. Coat liner surfaces and edges with erosion-resistant coating or cover with perforated metal.
 - 2. Cover liner with perforated metal.
 - 3. Cover liner with Mylar film.
 - 4. Cover liner with Tedlar film.
- D. Plenum Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
- E. Plenum Air Outlets: S-slip and drive connections.
- F. Access: Removable panels to permit access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
- G. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: 2 percent of nominal airflow at 1-inch wg inlet static pressure.
 - 2. Maximum Damper Leakage: 2 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 3. Maximum Damper Leakage: 3 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 4. Maximum Damper Leakage: 3 percent of nominal airflow at 6-inch wg inlet static pressure.
 - 5. Damper Position: Normally open.
 - 6. Damper Position: Normally closed.
- H. Regulator Assembly: Extruded-aluminum or 20-gage galvanized-steel components; key damper blades into shaft with nylon-fitted pivot points located inside unit casing.
 - 1. Automatic Flow-Control Assembly: Combine spring rates matched for each volume-regulator size with machined dashpot for stable operation.
 - 2. Factory calibrate assembly with shaft extension for connection to externally mounted control actuator.
- I. Multi-outlet Attenuator Section: With 6-inch-diameter collars; each with locking butterfly balancing damper.
- J. Multi-outlet Attenuator Section: With 8-inch-diameter collars; each with locking butterfly balancing damper.
- K. Hot-Water Heating Coil: 1/2-inch copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.
- L. Electric Heating Coil: Slip-in type, open-coil design with integral control box factory wired and installed. Include the following features:

- 1. Primary and secondary over-temperature protection.
- 2. Minimum airflow switch.
- 3. Pneumatic-electric switches and relays.
- 4. Magnetic contactor for each step of control.
- M. Controls: Damper operator, thermostat, and other devices compatible with temperature controls specified in other Division 23 Sections.
- N. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.
- O. Pneumatic Controls: Damper operator, velocity controller, and thermostat.
 - 1. Pneumatic Damper Operator: 8- to 13-psig spring range.
 - 2. Thermostat: Wall-mounted, pneumatic type with appropriate mounting hardware.

2.6 SYSTEM-POWERED AIR TERMINALS

- A. Configuration: Volume-damper and automatic flow-control assemblies inside unit casing.
- B. Casings: Steel or aluminum sheet metal of the following minimum thicknesses:
 - 1. Upstream Pressure Side: 0.0239-inch steel.
 - 2. Downstream Pressure Side: 0.0179-inch steel.
 - 3. Upstream Pressure Side: 0.032-inch aluminum.
 - 4. Downstream Pressure Side: 0.025-inch aluminum.
- C. Casing Lining: Minimum of 1/2-inch-thick, neoprene- or vinyl-coated, fibrous-glass insulation; 1.5-lb/cu. ft. density, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent delamination, sagging, or settling.
 - 1. Coat liner surfaces and edges with erosion-resistant coating or cover with perforated metal.
 - 2. Cover liner with perforated metal.
 - 3. Cover liner with Mylar film.
 - 4. Cover liner with Tedlar film.
- D. Plenum Air Inlets: Round or oval stub connections for duct attachment.
- E. Plenum Air Outlets: S-slip and drive connections.
- F. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings.
- G. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Design bellows to operate at temperatures of 0 to 140 deg F; to be impervious to moisture and fungus; and to be suitable for 10-inch wg static pressure. Factory test for leaks.

- H. Multi-outlet Attenuator Section: With 6-inch-diameter collars; each with locking butterfly balancing damper.
- I. Multi-outlet Attenuator Section: With 8-inch-diameter collars; each with locking butterfly balancing damper.
- J. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
 - 1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.
 - 2. Factory-mounted and -piped, 5-micron filter; velocity-resetting, adjustable, high-limit control; and amplifying relay.
 - 3. System-powered, wall-mounted thermostat.

2.7 DIFFUSER AIR TERMINALS

- A. Configuration: Volume-damper assembly inside unit casing. Locate control components inside protective metal shroud.
- B. Casings: Steel or aluminum sheet metal.
- C. Plenum Air Inlets: Round stub connections for duct attachment.
- D. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Damper Position: Normally open.
 - 2. Damper Position: Normally closed.
- E. Diffuser: Galvanized-steel, insulated plenum with extruded-aluminum or sheet-steel diffuser, having fixed or variable geometry designed to operate from 100 percent to minimum airflow, manual adjustment of airflow direction, and white baked-enamel finish.
- F. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.
- G. Pneumatic Controls: Damper operator, velocity controller, and thermostat.
 - 1. Pneumatic Damper Operator: 8- to 13-psig spring range.
 - 2. Thermostat: Wall-mounted, pneumatic type with appropriate mounting hardware.

2.8 SOURCE QUALITY CONTROL

A. Testing Requirements: Test and rate air terminals according to ARI 880, "Industry Standard for Air Terminals."

B. Identification: Label each air terminal with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air terminals level and plumb, according to manufacturer's written instructions, rough-in drawings, original design, and referenced standards; and maintain sufficient clearance for normal service and maintenance.
- B. Connect ductwork to air terminals according to Division 23 ductwork Sections.

3.2 CONNECTIONS

- A. Install piping adjacent to air terminals to allow service and maintenance.
- B. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- C. Steam Piping: In addition to requirements in Division 23 Section "Steam and Condensate Piping," connect heating coils to steam supply with shutoff valve, strainer, and control valve; and to condensate return piping with shutoff valve, strainer, steam trap, and shutoff valve.
- D. Electrical: Comply with applicable requirements in Division 16 Sections.
- E. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torquetightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.
- 3.5 COMMISSIONING

- A. Verify that installation of each air terminal is according to the Contract Documents.
- B. Check that inlet duct connections are as recommended by air terminal manufacturer to achieve proper performance.
- C. Check that controls and control enclosure are accessible.
- D. Verify that control connections are complete.
- E. Check that nameplate and identification tag are visible.
- F. Verify that controls respond to inputs as specified.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:
 - 1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
 - 2. Review data in the maintenance manuals. Refer to Division 1 Section "Contract Closeout."
 - 3. Review data in the maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
 - 4. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

END OF SECTION 23 36 00

SECTION 23 37 13 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.2 SUBMITTALS

- A. Product Data: For each product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
 - 2. Products: Subject to compliance with requirements, provide one of the products specified.
 - 3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 4. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 GRILLES AND REGISTERS

- A. Adjustable Bar Grille:
 - 1. Products:
 - a. Nailor Industries of Texas Inc.
 - b. Price Industries.
 - c. Titus.

- 2. Manufacturers:
 - a. Nailor Industries of Texas Inc.
 - b. Price Industries.
 - c. Titus.
- 3. Material: Steel.
- 4. Finish: Baked enamel, color selected by Architect.
- 5. See drawings for additional specifications.
- B. Fixed Face Grille:
 - 1. Products:
 - a. Nailor Industries of Texas Inc.
 - b. Price Industries.
 - c. Titus.
 - 2. Manufacturers:
 - a. Nailor Industries of Texas Inc.
 - b. Price Industries.
 - c. Titus.
 - 3. Material: Steel.
 - 4. Finish: Baked enamel, color selected by Architect.
 - 5. See drawings for additional specifications.

2.3 CEILING DIFFUSER OUTLETS

- A. Round Ceiling Diffuser:
 - 1. Products:
 - a. Nailor Industries of Texas Inc.; < Insert product name or designation>.
 - b. Price Industries; < Insert product name or designation>.
 - c. Titus; < Insert product name or designation>.
 - 2. Manufacturers:
 - a. Nailor Industries of Texas Inc.
 - b. Price Industries.
 - c. Titus.
- 3. Material: Steel.
- 4. Finish: Baked enamel, color selected by Architect.
- 5. See drawings for additional specifications.
- B. Rectangular and Square Ceiling Diffusers:
 - 1. Products:
 - 2.
- a. Nailor Industries of Texas Inc.
- b. Price Industries.
- c. Titus.
- 3. Manufacturers:
 - a. Nailor Industries of Texas Inc.
 - b. Price Industries.
 - c. Titus.
- 4. Material: Steel.
- 5. Finish: Baked enamel, color selected by Architect.
- 6. See drawings for additional specifications.
- C. Perforated Diffuser:
 - 1. Products:
 - a. Nailor Industries of Texas Inc.
 - b. Price Industries.
 - c. Titus.
 - 2. Manufacturers:
 - a. Nailor Industries of Texas Inc.
 - b. Price Industries.
 - c. Titus.
 - 3. Material: Steel backpan and pattern controllers, with steel face.
 - 4. Finish: Baked enamel, color selected by Architect.
 - 5. See drawings for additional specifications.
- D. Louver Face Diffuser:
 - 1. Products:
 - a. Nailor Industries of Texas Inc.

- b. Price Industries.
- c. Titus.
- 2. Manufacturers:
 - a. Nailor Industries of Texas Inc.
 - b. Price Industries.
 - c. Titus.
- 3. Material: Steel.
- 4. Finish: Baked enamel, color selected by Architect.
- 5. See drawings for additional specifications.

2.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 37 13