

Leon County Courthouse Annex – (BOA) Stair & Elevator Pressurization
Addendum #1 - Amended Table of Contents (for attached specifications dated 5 June 2012)

DIVISION 01 - GENERAL REQUIREMENTS

019113 GENERAL COMMISSIONING REQUIREMENTS

DIVISION 05 - METALS

055000.1 METAL FABRICATIONS FOR MECHANICAL AND ELECTRICAL SYSTEMS

DIVISION 09 - FINISHES

099113.1 EXTERIOR PAINTING FOR MECHANICAL AND ELECTRICAL SYSTEMS

099123.1 INTERIOR PAINTING FOR MECHANICAL AND ELECTRICAL SYSTEMS

Leon County Courthouse Annex – (BOA) Stair & Elevator Pressurization
Addendum #1 - Amended Table of Contents (for attached specifications dated 5 June 2012)

DIVISION 23 - HEATING VENTILATING AND AIR CONDITIONING

230100	GENERAL PROVISIONS FOR HVAC
230120	SUBMITTAL PROCEDURES
230130	QUALITY REQUIREMENTS
230160	EXECUTION
230170	OPERATION AND MAINTENANCE DATA
230180	PROJECT RECORD DOCUMENTS
230190	DEMONSTRATION AND TRAINING
230513	COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
230516	EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
230517	SLEEVES AND SLEEVE SEALS FOR HVAC PIPING
230518	ESCUTCHEONS FOR HVAC PIPING
230519	METERS AND GAGES FOR HVAC PIPING
230523	GENERAL DUTY VALVES FOR HVAC PIPING
230548	VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT
230553	IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
230593	TESTING, ADJUSTING, AND BALANCING FOR HVAC
230713	DUCT INSULATION
230719	HVAC PIPING INSULATION
230800	COMMISSIONING OF HVAC
230900	INSTRUMENTATION AND CONTROL FOR HVAC
230923	CONTROL-VOLTAGE ELECTRICAL POWER CABLES
230928	PATHWAYS FOR CONTROL-VOLTAGE CABLES
232113	HYDRONIC PIPING
232500	HVAC WATER TREATMENT
232923	VARIABLE-FREQUENCY MOTOR CONTROLLERS
233113	METAL DUCTS
233300	AIR DUCT ACCESSORIES
233423	HVAC POWER VENTILATORS
233900	LOUVERS AND VENTS
234100	PARTICULATE AIR FILTRATION
237313	MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

Leon County Courthouse Annex – (BOA) Stair & Elevator Pressurization
Addendum #1 - Amended Table of Contents (for attached specifications dated 5 June 2012)

DIVISION 26 - ELECTRICAL

260100	GENERAL PROVISIONS FOR ELECTRICAL
260105	SUBSTITUTION PROCEDURES
260120	SUBMITTAL PROCEDURES
260130	QUALITY REQUIREMENTS
260150	PRODUCT REQUIREMENTS
260160	EXECUTION
260170	OPERATION AND MAINTENANCE DATA
260180	PROJECT RECORD DOCUMENTS
260190	DEMONSTRATION AND TRAINING
260519	LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
260526	GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
260529	HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
260533	RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
260544	SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING
260553	IDENTIFICATION FOR ELECTRICAL SYSTEMS
260953	DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM
26105120	SUBSTITUTION PROCEDURES" FOR CONDITIONS
262416	PANELBOARDS
262726	WIRING DEVICES
262816	ENCLOSED SWITCHES AND CIRCUIT BREAKERS
264313	TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

END OF TABLE OF CONTENTS

SECTION 019113 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.
- B. Related Sections:
 - 1. Section 230130 "Quality Requirements" for administrative and procedural requirements for quality assurance and quality control.
 - 2. Section 230593 "Testing, Adjusting, and Balancing for HVAC".
 - 3. Section 230800 "Commissioning of HVAC" for commissioning process activities for HVAC&R systems, assemblies, equipment, and components.
 - 4. Section 260953 "Digital, Addressable Fire-Alarm System".

1.3 DEFINITIONS

- A. FPT: Functional Performance Test. Test of dynamic function and operation of equipment and systems. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, life safety conditions, power failure, etc. Systems are run through all specified sequences of operation.
- B. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.
- C. TAB: Testing, Adjusting, and Balancing.

1.4 SPECIAL INSPECTOR

- A. Smoke control systems shall be tested by a special inspector.
- B. Qualifications:
 - 1. Special inspection agencies for smoke control systems shall have expertise in fire protection engineering, mechanical engineering, and certification as air balancers.
 - 2. Special inspection agencies shall be approved by the Engineer. Submit qualifications to Engineer for approval.

- C. Testing shall comply with Florida Building Code, Section 909 requirements.

1.5 COMMISSIONING TEAM

- A. Members Appointed by Contractor(s): Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, representatives of each Contractor, including Project superintendent and subcontractors, installers, suppliers, Special Inspector, and specialists deemed appropriate by the Engineer.
- B. Members Appointed by Owner:
 - 1. Representatives of the facility user and operation and maintenance personnel.
 - 2. Architect and engineering design professionals.

1.6 OWNER'S RESPONSIBILITIES

- A. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.

1.7 CONTRACTOR'S RESPONSIBILITIES

- A. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 - 1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
 - 2. Integrate and coordinate commissioning process activities with construction schedule.
 - 3. Review and accept commissioning process functional performance test (FPT) procedures provided by the Special Inspector.
 - 4. Complete commissioning process functional performance test (FPT) procedures.
 - 5. Coordinate training of Owner's O&M personnel.
 - 6. Ensure that all Sub-Contractors execute their commissioning responsibilities according to the Contract Documents and schedule.
 - 7. Schedule, coordinate, and assist commissioning team in seasonal or deferred testing.

1.8 SUB-CONTRACTOR'S RESPONSIBILITIES

- A. Each Sub-Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 - 1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
 - 2. Review and accept commissioning process functional performance test (FPT) procedures provided by the Engineer.
 - 3. Provide technically capable representative to participate in functional performance test (FPT) procedures for entire duration of testing of system samples for contracted scope of work.

4. Participate in training sessions of Owner's O&M personnel for contracted scope of work.
5. Participate in seasonal or deferred testing, as necessary.

1.9 EQUIPMENT SUPPLIER'S RESPONSIBILITIES

- A. Assist in testing equipment they supplied.
- B. Include all special tools and instruments, except for stand-alone data-logging equipment that may be used by the Special Inspector and Engineer.
 1. Review functional performance test (FPT) procedures provided by the Special Inspector for equipment they supplied for feasibility, safety, equipment, and warranty protection.

1.10 SPECIAL INSPECTOR'S RESPONSIBILITIES

- A. Monitor component and equipment installation and document observations. Record device locations.
- B. Witness duct pressure and leakage tests.
- C. Provide Project-specific commissioning process functional performance test (FPT) procedures.
- D. Conduct functional performance test (FPT) procedures.
- E. Provide a complete report of testing prepared by the special inspector or special inspection agency. The report shall include identification of all devices by manufacturer, nameplate data, design values, measured values, and identification tag or mark. The report shall be reviewed by the responsible registered design professional, and, when satisfied that the design intent has been achieved, the responsible registered design professional shall seal, sign, and date the report.

PART 2 - PRODUCTS (Not Used)

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division Contractor and Sub-Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the mechanical system and controls systems in Division 23, except for equipment specific to and used by TAB in their commissioning responsibilities.
- B. Special equipment, tools, and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment shall be provided and left on site, except for stand-alone data-logging equipment that may be used by the Engineer.
- C. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system

performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the last year and a resolution of + or – 0.1°F. Pressure sensors shall have an accuracy of + or – 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer’s recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

3.1 COMMISSIONING SCOPE

- A. With respect to this section and other related section, the following systems shall be commissioned.
 - 1. HVAC Outside Air and Smoke Management System
 - 2. HVAC Controls (Building Automation System)

3.2 FUNCTIONAL PERFORMANCE TESTS

- A. Functional Performance Tests shall be completed for the following systems:
 - 1. Air Handling Units
 - 2. Smoke Management Systems

3.3 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

- A. NON-CONFORMANCE
 - 1. The Special Inspector shall record the results of the functional performance tests on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the Contractor.
 - 2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the Special Inspector. In such cases the deficiency and resolution shall be documented on the procedure form.
 - 3. Every effort shall be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the Special Inspector and Engineer will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues.
 - 4. Cost of Retesting:
 - a. The cost for the Sub-Contractor to retest a functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the Contractor.

B. FAILURE DUE TO MANUFACTURER DEFECT

1. If 10% (or two, whichever is greater) of identical pieces of equipment fail to perform to the Contract Documents (mechanically or substantively) due to a manufacturer defect, not allowing it to meet its submitted performance specification, all identical units may be considered unacceptable by the A/E, upon recommendation by the Engineer. In such case, the Contractor shall provide the Owner with the following:
 - a. Within one week of notification from the Owner, the applicable Sub-Contractor or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the Contractor within two weeks of the original notice.
 - b. Within two weeks of the original notification, the applicable Sub-Contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc., and all proposed solutions. The proposed solutions shall not significantly exceed the specification requirements of the original installation.
 - c. The A/E shall determine whether a replacement of identical units or a repair is acceptable.
 - d. Two examples, where applicable, of the proposed solution shall be installed by the applicable Sub-Contractor and the A/E shall be allowed to test the installations for up to one week, upon which the A/E shall decide whether to accept the solution.
 - e. Upon acceptance, the applicable Sub-Contractor and/or manufacturer shall replace or repair all identical items, at their expense. The replacement/repair work shall proceed with reasonable speed beginning one week from when parts can be obtained.

C. APPROVAL

1. The Special Inspector documents each satisfactorily function on the test form. Final approval of the performance test by the Owner is made after review by the Engineer, .

END OF SECTION 019113

This Page Left Intentionally Blank

SECTION 230130 - QUALITY REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for quality assurance and quality control.
- B. Testing and inspecting services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with the Contract Document requirements.
 - 1. Specific quality-assurance and -control requirements for individual construction activities are specified in the Sections that specify those activities. Requirements in those Sections may also cover production of standard products.
 - 2. Specified tests, inspections, and related actions do not limit Contractor's other quality-assurance and -control procedures that facilitate compliance with the Contract Document requirements.
 - 3. Requirements for Contractor to provide quality-assurance and -control services required by Engineer, Owner, or authorities having jurisdiction are not limited by provisions of this Section.
 - 4. Specific test and inspection requirements are not specified in this Section.
- C. Related Requirements:
 - 1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements.
 - 2. Section 230593 "Testing, Adjusting, and Balancing for HVAC".
 - 3. Section 230800 "Commissioning of HVAC".

1.3 DEFINITIONS

- A. Quality-Assurance Services: Activities, actions, and procedures performed before and during execution of the Work to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.
- B. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work to evaluate that actual products incorporated into the Work and completed construction comply with requirements. Services do not include contract enforcement activities performed by Engineer.

- C. Source Quality-Control Testing: Tests and inspections that are performed at the source, e.g., plant, mill, factory, or shop.
- D. Field Quality-Control Testing: Tests and inspections that are performed on-site for installation of the Work and for completed Work.
- E. Testing Agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.
- F. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, Subcontractor, or Sub-subcontractor, to perform a particular construction operation, including installation, erection, application, and similar operations.
 - 1. Use of trade-specific terminology in referring to a trade or entity does not require that certain construction activities be performed by accredited or unionized individuals, or that requirements specified apply exclusively to specific trade(s).
- G. Experienced: When used with an entity or individual, "experienced" means having successfully completed a minimum of five previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

1.4 CONFLICTING REQUIREMENTS

- A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to Engineer for a decision before proceeding.
- B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to Engineer for a decision before proceeding.

1.5 QUALITY ASSURANCE

- A. General: Qualifications paragraphs in this article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.
- B. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- C. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

- D. **Installer Qualifications:** A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
- E. **Professional Engineer Qualifications:** A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of the system, assembly, or products that are similar in material, design, and extent to those indicated for this Project.
- F. **Manufacturer's Technical Representative Qualifications:** An authorized representative of manufacturer who is trained and approved by manufacturer to observe and inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- G. **Factory-Authorized Service Representative Qualifications:** An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.

1.6 QUALITY CONTROL

- A. **Manufacturer's Field Services:** Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections.
- B. **Manufacturer's Technical Services:** Where indicated, engage a manufacturer's technical representative to observe and inspect the Work. Manufacturer's technical representative's services include participation in preinstallation conferences, examination of substrates and conditions, verification of materials, observation of Installer activities, inspection of completed portions of the Work, and submittal of written reports.
- C. **Retesting/Reinspecting:** Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and reinspecting, for construction that replaced Work that failed to comply with the Contract Documents.
- D. **Coordination:** Coordinate sequence of activities to accommodate required quality-assurance and -control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.
 - 1. Schedule times for tests, inspections, obtaining samples, and similar activities.
- E. **Schedule of Tests and Inspections:** Prepare a schedule of tests, inspections, and similar quality-control services required by the Contract Documents as a component of Contractor's quality-control plan. Coordinate and submit concurrently with Contractor's construction schedule. Update as the Work progresses.
 - 1. **Distribution:** Distribute schedule to Owner, Engineer, testing agencies, and each party involved in performance of portions of the Work where tests and inspections are required.

1.7 SPECIAL TESTS AND INSPECTIONS

- A. Special Tests and Inspections: Conducted by a qualified special inspector, approved by the Engineer and authorities having jurisdiction, to conduct special tests and inspections required by authorities having jurisdiction as the responsibility of Owner, and as follows:
1. Verifying that manufacturer maintains detailed fabrication and quality-control procedures and reviews the completeness and adequacy of those procedures to perform the Work.
 2. Notifying Engineer, General Contractor, and Contractor promptly of irregularities and deficiencies observed in the Work during performance of its services.
 3. Submitting a certified written report of each test, inspection, and similar quality-control service to Architect, through General Contractor, with copy to Contractor.
 4. Submitting a final report of special tests and inspections at Substantial Completion, which includes a list of unresolved deficiencies.
 5. Interpreting tests and inspections and stating in each report whether tested and inspected work complies with or deviates from the Contract Documents.
 6. Retesting and reinspecting corrected work.
 7. Testing shall comply with Florida Building Code, Section 909 requirements.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TEST AND INSPECTION LOG

- A. Test and Inspection Log: Prepare a record of tests and inspections. Include the following:
1. Date test or inspection was conducted.
 2. Description of the Work tested or inspected.
 3. Date test or inspection results were transmitted to Engineer.
 4. Identification of testing agency or special inspector conducting test or inspection.
- B. Maintain log at Project site. Post changes and revisions as they occur. Provide access to test and inspection log for Engineer's reference during normal working hours.

3.2 REPAIR AND PROTECTION

- A. General: On completion of testing, inspecting, sample taking, and similar services, repair damaged construction and restore substrates and finishes.
1. Provide materials and comply with installation requirements specified in other Specification Sections or matching existing substrates and finishes. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible. Comply with the Contract Document requirements for cutting and patching in Section 230160 "Execution."
- B. Protect construction exposed by or for quality-control service activities.

- C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

END OF SECTION 230130

This Page Left Intentionally Blank

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Rubber packless expansion joints.
 - 2. Alignment guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Product Certificates: For each type of expansion joint, from manufacturer.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 PACKLESS EXPANSION JOINTS

A. Rubber Packless Expansion Joints:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Twin City Hose, Inc.; MS2 or comparable product by one of the following:
 - a. Mason Industries, Inc.; Mercer Rubber Co.
 - b. Metraflex, Inc TSUC or DSRC series.
2. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
3. Material: Fabric-reinforced rubber complying with FSA-NMEJ-703.
4. Spherical Type: Multiple spheres.
5. Minimum Pressure Rating for **NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 150 psig (1035 kPa) at 220 deg F (104 deg C)** .
6. Minimum Pressure Rating for **NPS 5 and NPS 6 (DN 125 and DN 150): 140 psig (966 kPa) at 200 deg F (93 deg C)** .
7. Material for Water: EPDM .
8. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.2 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is

- to be installed.
- b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
- c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install rubber packless expansion joints according to FSA-NMEJ-702.

3.2 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
- C. Attach guides to pipe and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

3.3 EXPANSION-JOINT SCHEDULE

- A. Air Handling Unit Hydronic Coil Connections: Rubber packless expansion joints.

END OF SECTION 230516

This Page Left Intentionally Blank

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

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

2.2 SLEEVE-SEAL FITTINGS

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

2.3 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: **5000-psi (34.5-MPa)**, 28-day compressive strength.

- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

3.2 SLEEVE-SEAL-FITTING INSTALLATION

- A. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- B. Secure nailing flanges to concrete forms.
- C. Using grout, seal the space around outside of sleeve-seal fittings.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than **NPS 6 (DN 150)** : Galvanized-steel-pipe sleeves.
 - b. Piping **NPS 6 (DN 150)** and Larger: Galvanized-steel-pipe sleeves.
 - 2. Concrete Slabs above Grade:
 - a. Piping Smaller Than **NPS 6 (DN 150)**: Galvanized-steel-pipe sleeves.
 - b. Piping **NPS 6 (DN 150)** and Larger: Galvanized-steel-pipe sleeves.
 - 3. Interior Partitions:
 - a. Piping Smaller Than **NPS 6 (DN 150)**: Galvanized-steel-pipe sleeves.
 - b. Piping **NPS 6 (DN 150)** and Larger: Galvanized-steel-pipe sleeves.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- D. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.
- E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange.
- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Insulated Piping: One-piece, stamped-steel type .
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
 - f. Bare Piping in Equipment Rooms: One-piece, cast-brass type with rough-brass finish.
 - 2. Escutcheons for Existing Piping:
 - a. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
 - d. Bare Piping in Unfinished Service Spaces: Split-casting brass type with rough-brass finish.
 - e. Bare Piping in Equipment Rooms: Split-casting brass type with rough-brass finish.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor-plate type.
 - 2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 230518

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 1. Liquid-in-glass thermometers.
 2. Thermowells.
 3. Dial-type pressure gages.
 4. Gage attachments.
 5. Test plugs.
 6. Test-plug kits.
 7. Turbine flowmeters.
 8. Electromagnetic flowmeters.
 9. Venturi flowmeters.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 FILLED-SYSTEM THERMOMETERS

- A. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:
 1. **Basis-of-Design Product:** Subject to compliance with requirements, provide Terrice, H.O. Co.; V803 or comparable product by one of the following:
 - a. **Ashcroft Inc.**

- b. [Miljoco Corporation.](#)
 - c. [Trerice, H. O. Co.](#)
 - d. [Weiss Instruments, Inc.](#)
2. Standard: ASME B40.200.
 3. Case: Sealed type, cast aluminum or drawn steel ; **4-1/2-inch (114-mm)** nominal diameter with **back** flange and holes for panel mounting; provide weatherproofed case (NEMA 3) for outdoor installations.
 4. Element: Bourdon tube or other type of pressure element.
 5. Movement: Mechanical, with link to pressure element and connection to pointer.
 6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in **deg F (deg C)** .
 7. Pointer: Dark-colored metal.
 8. Window: **Glass** .
 9. Ring: **Stainless steel** .
 10. Connector Type(s): Union joint, back for panel mounted applications, bottom otherwise; with ASME B1.1 screw threads.
 11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: Helical bulb with 3-inche O.D. reversible flange.
 - b. Design for Thermowell Installation: Bare stem.
 12. Accuracy: Plus or minus **1** percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

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

1. **Basis-of-Design Product:** Subject to compliance with requirements, provide Trerice, H.O. Co.; BX9 or comparable product by one of the following:
 - a. [Miljoco Corporation.](#)
 - b. [Weiss Instruments, Inc.](#)
 - c. [Winters Instruments - U.S.](#)
2. Standard: ASME B40.200.
3. Case: Cast aluminum ; **9-inch (229-mm)** nominal size unless otherwise indicated. Provide weatherproofed case (NEMA 3) for outdoor installations.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in **deg F (deg C)** .
7. Window: Glass.
8. Stem: Brass and of length to suit installation.
 - a. Design for Air-Duct Installation: Provide aluminum ventilated air-duct stem with 3-inch O.D. reversible aluminum flange and perforated aluminum guard.
 - b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 DUCT-THERMOMETER MOUNTING BRACKETS

- A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.4 THERMOWELLS

- A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Steel Piping: CRES (stainless steel).
4. Type: Stepped shank unless straight or tapered shank is indicated.
5. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
6. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
7. Bore: Diameter required to match thermometer bulb or stem.
8. Insertion Length: Length required to match thermometer bulb or stem.
9. Lagging Extension: Include on thermowells for insulated piping and tubing.
10. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

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

2.5 PRESSURE GAGES

- A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Terrice, H.O. Co.; 600CB or comparable product by one of the following:
 - a. Ashcroft Inc.
 - b. Miljoco Corporation.
 - c. Weiss Instruments, Inc.
 - d. Winters Instruments - U.S.
2. Standard: ASME B40.100.
3. Case: Solid-front, pressure relief type(s); cast aluminum; 4-1/2-inch (114-mm) nominal diameter; provide weatherproofed case for outdoor installations; provide back flange kit for surface mount applications.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15) , ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.

6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in **psi (kPa)** .
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with **NPS 1/4 or NPS 1/2 (DN 8 or DN 15)** , ASME B1.20.1 pipe threads and porous-metal-type surge-dampening device. Include extension for use on insulated piping.
- B. Valves: Brass ball, with **NPS 1/4 or NPS 1/2 (DN 8 or DN 15)**, ASME B1.20.1 pipe threads.

2.7 TEST PLUGS

- A. **Basis-of-Design Product:** Subject to compliance with requirements, provide Peterson Equipment Co., Inc.; Model 110 XL or comparable product by one of the following:
 1. Sisco Manufacturing Company, Inc.
 2. Trerice, H. O. Co.
 3. Weiss Instruments, Inc.
- B. Description: Test-station fitting made for insertion into piping tee fitting.
- C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- D. Thread Size: **NPS 1/4 (DN 8)** , ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: **500 psig at 200 deg F (3450 kPa at 93 deg C)** .
- F. Core Inserts: EPDM self-sealing rubber.

2.8 TEST-PLUG KITS

- A. **Basis-of-Design Product:** Subject to compliance with requirements, provide Peterson Equipment Co., Inc.; Model 1500XL or comparable product by one of the following:
 1. Miljoco Corporation.
 2. Sisco Manufacturing Company, Inc.
 3. Trerice, H. O. Co.
 4. Weiss Instruments, Inc.
- B. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of

diameter to fit test plugs and of length to project into piping.

- C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F (minus 4 to plus 52 deg C).
- D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F (minus 18 to plus 104 deg C).
- E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be at least 0 to 200 psig (0 to 1380 kPa).
- F. Carrying Case: Metal or plastic, with formed instrument padding.

2.9 FLOWMETERS

A. Venturi Flowmeters:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Griswold Controls; 3Q??0T Metering Station or comparable product by one of the following:
 - a. ABB; Instrumentation and Analytical.
 - b. Gerand Engineering Co.
2. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.
 - a. Design: Differential-pressure-type measurement for water .
 - b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
 - c. Minimum Pressure Rating: 240 psig (1656 kPa).
 - d. Minimum Temperature Rating: 250 deg F (121 deg C).
 - e. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
 - f. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged or welded.
 - g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.
5. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- (152-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
 - a. Scale: Gallons per minute (Liters per second).
 - b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.
6. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected flowmeter element and having two 12-foot (3.7-m) hoses, with carrying case.

- a. Scale: Gallons per minute (Liters per second).
 - b. Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.
7. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
 8. Conversion Chart: Flow rate data compatible with sensor.
 9. Operating Instructions: Include complete instructions with each flowmeter.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- H. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- I. Install test plugs in piping tees.
- J. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
- K. Install flowmeter elements in accessible positions in piping systems.
- L. Install flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
- M. Install permanent indicators on walls or brackets in accessible and readable positions.
- N. Install connection fittings in accessible locations for attachment to portable indicators.
- O. Install thermometers in the following locations:
 1. Inlet and outlet of each hydronic coil in air-handling units.
 2. Air handler supply air ducts with an airflow of 2000 cfm or greater.
- P. Install pressure gages in the following locations:

1. Inlet and outlet of each air handling unit hydronic coil.

Q. Install test plugs in the following locations:

1. Inlet and outlet of each hydronic coil.
2. Inlet and outlet of each pressure independent control valve.

3.2 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.
- B. Connect flowmeter-system elements to meters.

3.3 ADJUSTING

- A. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

- A. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be the following:
 1. Remote-mounted, metal -case, vapor-actuated type where indicated on plans.
 2. Industrial-style, liquid-in-glass type otherwise.
 3. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial or remote mounted thermometers.
- B. Thermometers at supply -air ducts shall be the following:
 1. Remote-mounted, metal -case, vapor-actuated type where indicated on plans.
 2. Industrial-style, liquid-in-glass type otherwise.
- C. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C).
- B. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F (0 to 150 deg C).
- C. Scale Range for Air Ducts: 0 to 150 deg F (Minus 20 to plus 70 deg C).

3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be the following:
 - 1. Solid-front, pressure-relief, remote mounted where indicated on plans, direct mounted otherwise, metal case.
 - 2. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to direct or remote mounted gages.
- B. Pressure gages at suction and discharge of each pump shall be the following:
 - 1. Solid-front, pressure-relief, remote mounted where indicated on plans, direct mounted otherwise, metal case.
 - 2. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to direct or remote mounted gages.
- C. Pressure gages at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be the following:
 - 1. Solid-front, pressure-relief, remote mounted where indicated on plans, direct mounted otherwise, metal case.
 - 2. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to direct or remote mounted gages.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: 0 to 160 psi (0 to 1100 kPa).
- B. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi (0 to 1100 kPa).

3.8 FLOWMETER SCHEDULE

- A. Flowmeters for Chilled-Water Piping: Provide Venturi type as indicated on plans for testing, adjusting and balancing.

END OF SECTION 230519

SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze ball valves.
2. Iron, single-flange butterfly valves.

B. Related Sections:

1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
2. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. RS: Rising stem.
- D. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of valve indicated.

1.5 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 2. ASME B31.1 for power piping valves.

3. ASME B31.9 for building services piping valves.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set ball and plug valves open to minimize exposure of functional surfaces.
4. Set butterfly valves closed or slightly open.

B. Use the following precautions during storage:

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves **NPS 8 (DN 200)** and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves **NPS 6 (DN 150)** and smaller except plug valves.

E. Valves in Insulated Piping: With **2-inch (50-mm)** stem extensions and the following features:

1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
2. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.

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

2.2 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
 - a. Conbraco Industries, Inc.; Apollo Valves.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig (1035 kPa).
 - c. CWP Rating: 600 psig (4140 kPa).
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE or TFE.
 - h. Stem: Stainless steel.
 - i. Ball: Stainless steel, vented.
 - j. Port: Full.

2.3 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - e. Seat: EPDM.
 - f. Stem: One- or two-piece stainless steel.
 - g. Disc: Aluminum bronze.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball, butterfly valves.
 - 2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
 - 3. Throttling Service except Steam: Globe or angle valves.
 - 4. Throttling Service, Steam: Globe or angle valves.

5. Pump-Discharge Check Valves:

- a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with nonmetallic disc.
- b. NPS 2-1/2 (DN 65) and Larger: Center-guided, metal -seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
2. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Ball Valves: Two piece, full port, bronze with stainless-steel trim.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM seat, aluminum-bronze disc.

3.6 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Ball Valves: Two piece, full port, bronze with stainless-steel trim.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM seat, aluminum-bronze disc.

END OF SECTION 230523

This Page Left Intentionally Blank

SECTION 230548 - VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Isolation pads.
 - 2. Freestanding spring isolators.
 - 3. Spring hangers.
 - 4.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
- B. Delegated-Design Submittal: For attaching and securing stairwell shaft and elevator hoistway pressurization fans to isolate vibration and resist wind forces to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, and wind forces required to select vibration isolators, and wind restraints, and for designing vibration isolation.
 - a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - 2. Vibration Isolation & Curb Details: Detail overall dimensions, including anchorages and

attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

3. Operation- and Wind-Restraint Details:

- a. Design Analysis: To support selection and arrangement of operation and wind restraints. Include calculations of combined tensile and shear loads.
- b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
- c. Coordinate vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of seismic bracing for HVAC equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.
- B. Qualification Data: For professional engineer .

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- 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. [Amber/Booth Company, Inc.](#)
 2. [Kinetics Noise Control.](#)
 3. [Mason Industries.](#)
- B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 1. Resilient Material: Oil- and water-resistant neoprene.
- C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- D. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.2 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
1. Powder coating on springs and housings.
 2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
 3. Baked enamel or powder coat for metal components on isolators for interior use.
 4. Color-code or otherwise mark vibration isolation-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

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

- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 VIBRATION-CONTROL DEVICE INSTALLATION

- A. Comply with requirements in Section 233500 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- B. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- C. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ADJUSTING

- A. Adjust active height of spring isolators.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- C. Valve numbering scheme.
- D. 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. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/8 inch (3.2 mm)** thick, and having predrilled holes for attachment hardware.
 2. Letter Color: White.
 3. Background Color: Black.
 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. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. 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.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/8 inch (3.2 mm)** thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White.
- C. Background Color: Red.
- 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. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- H. 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. 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)] 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. 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.
- B. Pipe Label Color Schedule:
 - 1. Chilled-Water Piping:
 - a. Background Color: **Blue** .
 - b. Letter Color: **White** .
 - 2. Heating Water Piping:
 - a. Background Color: **Red** .
 - b. Letter Color: **White** .

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 HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Chilled Water: **1-1/2 inches (38 mm)** , round .
 - b. Hot Water: **1-1/2 inches (38 mm)** , round .
 - 2. Valve-Tag Color:
 - a. Chilled Water: **Natural** .

b. Hot Water: Natural .

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION 230553

This Page Left Intentionally Blank

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:
 - a. Air systems.
2. Balancing Hydronic Piping Systems:
 - a. Variable-flow hydronic systems.
3. Smoke Control Systems:
 - a. Elevator shaft systems.
 - b. Stairwell shaft systems.

B. Related Sections:

1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements.
2. Section 230800 "Commissioning of HVAC" for commissioning process activities for HVAC&R systems, assemblies, equipment, and components.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. Special Inspector: An entity engaged to inspect smoke control systems.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An entity engaged to perform TAB Work.

1.4 ACTION SUBMITTALS

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 45 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 90 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- D. Certified TAB reports.
- E. Sample report forms.
- F. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration.

1.6 QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Conducted by a TAB entity certified by AABC NEBB or TABB, approved by the Engineer, as the responsibility of the Owner.
 - 1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC NEBB or TABB.
 - 2. TAB Technician: Employee of the TAB contractor and who is certified by AABC NEBB or TABB as a TAB technician.
- B. TAB Conference: Meet with Engineer, Owner, Construction Manager, and Special Inspector on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.
 - 1. Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Coordination and cooperation of trades and subcontractors.
 - d. Coordination of documentation and communication flow.
- C. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- D. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer and Special Inspector.
- E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."
- F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.7 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.

1.8 COORDINATION

- A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- B. Perform TAB after leakage and pressure tests on air distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
- B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.

- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- J. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- K. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- L. Examine operating safety interlocks and controls on HVAC equipment.
- M. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system-readiness checks and prepare reports. Verify the following:
 - 1. Permanent electrical-power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.
 - 3. Automatic 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. 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 ASHRAE 111 SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 1. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- D. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- E. Verify that motor starters are equipped with properly sized thermal protection.
- F. Check dampers for proper position to achieve desired airflow path.
- G. Check for airflow blockages.
- H. Check condensate drains for proper connections and functioning.
- I. Check for proper sealing of air-handling-unit components.
- J. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 1. Measure total airflow.

- a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
2. Measure fan static pressures as follows to determine actual static pressure:
 - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Report the cleanliness status of filters and the time static pressures are measured.
 4. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 5. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 23 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 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 mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
1. Measure airflow of submain and branch ducts.
 - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
 3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure air outlets and inlets without making adjustments.
1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

- D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
 - 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Pressure-Dependent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - 1. Balance variable-air-volume systems the same as described for constant-volume air systems.
 - 2. Set terminal units and supply fan at full-airflow condition.
 - 3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the airflow controller.
 - 4. Readjust fan airflow for final maximum readings.
 - 5. Measure operating airflow at each sensor that controls the supply fan, and verify operation of the airflow controller.
 - 6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure airflow to verify that it is being maintained by the controller.
 - 7. Set terminal units at minimum airflow and adjust controller to deliver the designed minimum airflow.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

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

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:
1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from [Engineer] [**Owner**] [**Construction Manager**] [**Commissioning Authority**] and comply with requirements in Division 23 Section "Hydronic Pumps."
 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved
 - a. Monitor motor performance during procedures and do not operate motors in overload conditions.
 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 4. Report flow rates that are not within plus or minus 10 percent of design.
- B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.
- C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.
- D. Set calibrated balancing valves, if installed, at calculated presettings.
- E. Measure flow at all stations and adjust, where necessary, to obtain first balance.
1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
1. Determine the balancing station with the highest percentage over indicated flow.
 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 3. Record settings and mark balancing devices.

- H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.
- J. Check settings and operation of each safety valve. Record settings.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.
- B. Adjust discharge valve from the open position only if required to avoid motor overload, otherwise valve shall remain open and variable frequency controller shall control pump discharge pressure.
- C. Compensating for diversity. When the total flow rate of all valves is more than the indicated flow of the pump(s), close a selected number of valves with the remainder at design flow (100% control point, not necessarily 100% open) condition until the total flow rate equals the indicated flow of the pump(s). Select the closed valves so they are distributed evenly among the branch pipes.

3.10 PROCEDURES FOR MOTORS

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

3.11 GENERAL PROCEDURES FOR SMOKE CONTROL PRESSURIZATION SYSTEMS

- A. Prepare test reports for fans, outlets, and doors. 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" layouts.

- C. Balance air volume systems the same as described for constant-volume air systems.
- D. Conduct tests for each system individually and again for all systems working concurrently.

3.12 PROCEDURES FOR STAIRWELL SHAFTS

- A. Record door locations and dimensions.
- B. Set stairwell doors to minimum design condition (all stairwell doors closed, except for Exterior Door on Level P2).
 - 1. Set system at design indicated airflow.
 - 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller.
 - 3. Measure and record supply airflow.
 - 4. Measure and record pressure difference across each stairwell door.
 - 5. Measure operating pressure difference at each sensor that controls the supply fan, and verify operation of the pressure controller.
 - 6. Adjust supply fan airflow to achieve design pressure differences.
 - 7. Measure and record final supply airflow.
 - 8. Measure and record final pressure differences across each stairwell door.
 - 9. Measure and record final static pressure across the fan.
- C. Set stairwell doors to maximum design condition (design stairwell doors open).
 - 1. Set system at design indicated airflow.
 - 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller.
 - 3. Measure and record supply airflow.
 - 4. Measure and record pressure difference across each stairwell door.
 - 5. Measure operating pressure difference at each sensor that controls the supply fan, and verify operation of the pressure controller.
 - 6. Adjust supply fan airflow to achieve design pressure differences.
 - 7. Measure and record final supply airflow.
 - 8. Measure and record final pressure differences across each stairwell door.

3.13 PROCEDURES FOR ELEVATOR HOISTWAYS

- A. Record door locations and dimensions.
- B. Set elevator hoistway doors to minimum design condition (all elevator hoistway doors closed; elevator lobby doors open on Levels P1 & P2).
 - 1. Set system at design indicated airflow.
 - 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller.
 - 3. Measure and record supply airflow.
 - 4. Measure and record pressure difference across the midpoint of each hoistway door.
 - 5. Measure operating pressure difference at each sensor that controls the supply fan, and verify operation of the pressure controller.
 - 6. Adjust supply fan airflow to achieve design pressure differences.
 - 7. Measure and record final supply airflow.

8. Measure and record final pressure differences across the midpoint of each hoistway door.
- C. Set elevator hoistway doors to maximum design condition (all elevator hoistway doors closed, except for doors on Level P1; elevator lobby doors open on Levels P1 & P2).
1. Set system at design indicated airflow.
 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller.
 3. Measure and record supply airflow.
 4. Measure and record pressure difference across the midpoint of each hoistway door.
 5. Measure operating pressure difference at each sensor that controls the supply fan, and verify operation of the pressure controller.
 6. Adjust supply fan airflow to achieve design pressure differences.
 7. Measure and record final supply airflow.
 8. Measure and record final pressure differences across the midpoint of each hoistway door.

3.14 TOLERANCES

- A. Set HVAC system's air flow rates within the following tolerances:
1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent .
 2. Air Outlets and Inlets: Plus or minus 10 percent.
 3. Smoke Control Systems: Plus or minus 5 percent

3.15 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.16 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 2. Include a list of instruments used for procedures, along with proof of calibration.
- B. Final Report Contents: In addition to certified field-report data, include the following:
1. Fan curves.

2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Fan drive settings including settings and percentage of maximum pitch diameter.
 - e. Settings for supply-air, static-pressure controller.
 - f. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Balancing stations.
6. Position of balancing devices.
7. Quantities and sizes of doors in smoke control systems.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

- a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches (mm), and bore.
 - i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
2. Motor Data:
- a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
3. Test Data (Indicated and Actual Values):
- a. Total air flow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Filter static-pressure differential in inches wg (Pa).
 - f. Preheat-coil static-pressure differential in inches wg (Pa).
 - g. Cooling-coil static-pressure differential in inches wg (Pa).

F. Apparatus-Coil Test Reports:

1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch (mm) o.c.
 - f. Make and model number.
 - g. Face area in sq. ft. (sq. m).
 - h. Tube size in NPS (DN).
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm (L/s).
 - b. Average face velocity in fpm (m/s).
 - c. Air pressure drop in inches wg (Pa).

- d. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
- e. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
- f. Water flow rate in gpm (L/s).
- g. Water pressure differential in feet of head or psig (kPa).
- h. Entering-water temperature in deg F (deg C).
- i. Leaving-water temperature in deg F (deg C).

G. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

- a. System identification.
- b. Location.
- c. Make and type.
- d. Model number and size.
- e. Manufacturer's serial number.
- f. Arrangement and class.
- g. Sheave make, size in inches (mm), and bore.
- h. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

2. Motor Data:

- a. Motor make, and frame type and size.
- b. Horsepower and rpm.
- c. Volts, phase, and hertz.
- d. Full-load amperage and service factor.
- e. Sheave make, size in inches (mm), and bore.
- f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
- g. Number, make, and size of belts.
- h. Belt tension in lbs.

3. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm (L/s).
- b. Total system static pressure in inches wg (Pa).
- c. Fan rpm.
- d. Discharge static pressure in inches wg (Pa).
- e. Suction static pressure in inches wg (Pa).

H. Shaft Reports: For stairwell and elevator shafts, include the following:

1. Shaft Data:

- a. System identification.
- b. Location.

2. Door Data:

- a. Number of doors adjacent to building interior.
- b. Number of doors adjacent to building exterior.
- c. Dimensions of doors in inches (mm).

- d. Door closing force in **lbs.**
3. Test Data at Each Condition (Indicated and Actual Values):
 - a. Total airflow rate in **cfm (L/s)**.
 - b. Total system static pressure in **inches wg (Pa)**.
 - c. Fan rpm.
 - d. Discharge static pressure in **inches wg (Pa)**.
 - e. Suction static pressure in **inches wg (Pa)**.
 - f. Differential pressure across each shaft door in **inches wg (Pa)**.
- I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in **deg F (deg C)**.
 - d. Duct static pressure in **inches wg (Pa)**.
 - e. Duct size in **inches (mm)**.
 - f. Duct area in **sq. ft. (sq. m)**.
 - g. Indicated air flow rate in **cfm (L/s)**.
 - h. Indicated velocity in **fpm (m/s)**.
 - i. Actual air flow rate in **cfm (L/s)**.
 - j. Actual average velocity in **fpm (m/s)**.
- J. Instrument Calibration Reports:
 1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

END OF SECTION 230593

This Page Left Intentionally Blank

SECTION 230719 - HVAC 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 HVAC piping systems:
 - 1. Condensate drain piping, outdoors.
 - 2. Chilled-water piping, indoors and outdoors.
 - 3. Heating hot-water piping, indoors and outdoors.
 - 4. Storm-water piping exposed to below ambient temperatures.
 - 5. Roof drains and rainwater leaders.
- B. Related Sections:
 - 1. Section 230713 "Duct 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.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors (Except Polyurethane Foam): Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Indoors (Polyurethane Foam): Flame-spread index of 75 or less, and smoke-developed index of 450 or less.
 - 3. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," and "Outdoor, Aboveground 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. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
 - 1. **Products:** Subject to compliance with requirements, provide one of the following :
 - a. [Aeroflex USA, Inc.; Aerocel.](#)
 - b. [Armacell LLC; AP Armaflex.](#)
 - c. [K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.](#)
- G. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. **Products:** Subject to compliance with requirements, provide one of the following :
 - a. [Johns Manville; Micro-Lok.](#)
 - b. [Knauf Insulation; 1000-Degree Pipe Insulation.](#)
 - c. [Owens Corning; Fiberglas Pipe Insulation.](#)
 - 2. Type I, **850 deg F (454 deg C)** Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- H. Phenolic:
 - 1. **Products:** Subject to compliance with requirements, provide one of the following :
 - a. [Kingspan Tarec Industrial Insulation NV; Koolphen K.](#)
 - b. [Resolco International BV; Insul-phen.](#)
 - 2. Preformed pipe insulation of rigid, expanded, closed-cell structure with factory applied ASJ-SSL. Comply with ASTM C 1126, Type III, Grade 1.
 - 3. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
 - 4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
 - 5. Nominal Density: 3.75 pcf per ASTM 1622.
- I. Polyurethane Foam Spray: Closed cell, spray applied, rigid polyurethane foam.
 - 1. Nominal Density: 2.0 pcf.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. 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. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
 - b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-33.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aeroseal.
 - b. Armacell LLC; Armaflex 520 Adhesive.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. K-Flex USA; R-373 Contact Adhesive.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. **Childers Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. **Eagle Bridges** - Marathon Industries; 225.
 - c. **Foster Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. **Mon-Eco Industries, Inc.**; 22-25.
 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- E. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. **Childers Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. **Eagle Bridges** - Marathon Industries; 225.
 - c. **Foster Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
 - d. **Mon-Eco Industries, Inc.**; 22-25.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
 1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. **Foster Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.

- b. [Vimasco Corporation](#); 749.
 - 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, **0.013 perm** (0.009 metric perm) at **43-mil (1.09-mm)** dry film thickness.
 - 3. Service Temperature Range: **Minus 20 to plus 180 deg F** (Minus 29 to plus 82 deg C).
 - 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 5. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
- 1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. [Childers Brand](#), Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
 - b. [Eagle Bridges](#) - Marathon Industries; 570.
 - c. [Foster Brand](#), Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
 - 2. Water-Vapor Permeance: ASTM F 1249, **0.05 perm** (0.033 metric perm) at **30-mil (0.8-mm)** dry film thickness.
 - 3. Service Temperature Range: **Minus 50 to plus 220 deg F** (Minus 46 to plus 104 deg C).
 - 4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - 5. Color: White.
- D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
- 1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. [Childers Brand](#), Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
 - b. [Eagle Bridges](#) - Marathon Industries; 550.
 - c. [Foster Brand](#), Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
 - d. [Mon-Eco Industries, Inc.](#); 55-50.
 - e. [Vimasco Corporation](#); WC-1/WC-5.
 - 2. Water-Vapor Permeance: ASTM F 1249, **1.8 perms** (1.2 metric perms) at **0.0625-inch (1.6-mm)** dry film thickness.
 - 3. Service Temperature Range: **Minus 20 to plus 180 deg F** (Minus 29 to plus 82 deg C).
 - 4. Solids Content: 60 percent by volume and 66 percent by weight.
 - 5. Color: White.

2.5 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 - 1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less

when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. **Childers Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
 - b. **Foster Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
 - c. **Vimasco Corporation**; 713 and 714.
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: **0 to plus 180 deg F (Minus 18 to plus 82 deg C)**.
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

1. **Joint Sealants for Cellular-Glass and Phenolic Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. **Childers Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. **Eagle Bridges** - Marathon Industries; 405.
 - c. **Foster Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
 - d. **Mon-Eco Industries, Inc.**; 44-05.
 - e. **Pittsburgh Corning Corporation**; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: **Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C)**.
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Metal Jacket Flashing Sealants:

1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. **Childers Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. **Eagle Bridges** - Marathon Industries; 405.
 - c. **Foster Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller

Company; 95-44.

d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C)**.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.8 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.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas Number 10.

2.9 FIELD-APPLIED JACKETS

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

B. Metal Jacket:

1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. **Childers Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
 - b. **ITW Insulation Systems**; Aluminum and Stainless Steel Jacketing.
 - c. **RPR Products, Inc.**; Insul-Mate.
2. 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: **2.5-mil- (0.063-mm-)** thick polysurlyn.
 - d. Moisture Barrier for Outdoor Applications: **2.5-mil- (0.063-mm-)** thick polysurlyn.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.10 TAPES

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

1. Width: **3 inches (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.

2.11 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 ; **0.015 inch (0.38 mm)** thick, **1/2 inch (13 mm)** wide with wing 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, **1/2 inch (13 mm)** wide with wing seal .

- B. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel .

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.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. On below ambient systems provide continuous vapor barrier.
- B. 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.
- C. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- D. 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.
- E. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- F. Install multiple layers of insulation with longitudinal and end seams staggered.
- G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- H. Keep insulation materials dry during application and finishing.
- I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

- J. Install insulation with least number of joints practical.
- K. 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.
- L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- M. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 3. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- N. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- 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. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.

- B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
- D. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies.

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. 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 field fabricated removable insulation covers at unions, control valves, valves and other locations indicated for below ambient systems. Installation shall maintain continuous vapor barrier and 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. Finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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

eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

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

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. 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.

B. 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.
3. Install field applied glass cloth jacket; where metal jacket is specified install over glass cloth jacket.

C. Insulation Installation on Valves and Pipe Specialties:

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

3.8 INSTALLATION OF PHENOLIC INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Create a water stop between insulation and pipe by brushing vapor barrier mastic on pipe around circumference of pipe every 3 feet.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint 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 block insulation of same material and 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 insulation sections of same material as straight segments of pipe insulation. 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.
3. Install field applied glass cloth jacket; where metal jacket is specified install over glass cloth jacket.

D. 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.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with **2-inch (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.
4. Finish to achieve smooth, uniform finish.

B. 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.

3.10 FINISHES

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- B. Color: White. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless-steel jackets.

3.11 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.

3.12 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 3/4 inch (19 mm) thick.
- B. Chilled Water, above 40 Deg F (5 Deg C):
 - 1. NPS 12 (DN 300) and Smaller (Exposed Piping): Insulation shall be one of the following:
 - a. Phenolic: 1-1/2 inches (38 mm) thick.
 - 2. NPS 12 (DN 300) and Smaller (Existing Floor Penetrations): Insulation shall be one of the following:
 - a. Polyurethane Foam: 1 inches (25 mm) thick. Insulation shall be covered with galvanized steel or stainless steel having a base thickness of note less than 0.1060 inches.
- C. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:
 - 1. NPS 12 (DN 300) and Smaller: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches (50 mm) thick.
- D. Stormwater and Overflow:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
- E. Roof Drain and Overflow Drain Bodies:
 - 1. All Pipe Sizes: Insulation shall be the following:

- a. Flexible Elastomeric: 1 inch (25 mm) thick.

3.13 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 3/4 inch (19 mm) thick.
- B. Chilled Water and Brine:
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Phenolic: 1 1/2 inches (38 mm) thick.
- C. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Phenolic: 1 1/2 inches (38 mm) thick.

3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 - 1. None.
- D. Piping, Exposed (Except Storm Water Piping):
 - 1. Aluminum, Corrugated: 0.016 inch (0.41 mm) thick.

3.15 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 - 1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.
- D. Piping, Exposed:
 - 1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements.
 - 2. Section 230593 "Testing, Adjusting, and Balancing for HVAC".
 - 3. Section 260953 "Digital, Addressable Fire-Alarm System".

1.3 DEFINITIONS

- A. FPT: Functional Performance Test. Test of dynamic function and operation of equipment and systems. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, life safety conditions, power failure, etc. Systems are run through all specified sequences of operation.
- B. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.
- C. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.
- D. TAB: Testing, Adjusting, and Balancing.

1.4 APPROVAL SUBMITTALS

- A. Functional performance tests.
- B. Final report by special inspector or special inspection agency.

1.5 INFORMATIONAL SUBMITTALS

- A. Certificate of proper controls hardware specification to permit functional performance testing.

- B. Certificates of readiness.
- C. Certificates of completion of controls point-to-point checkout.

1.6 HVAC CONTRACTOR'S RESPONSIBILITIES

- A. Ensure that all Division 23 sub-contractors execute their commissioning responsibilities according to the Contract Documents and schedule.
- B. Participate in commissioning functional performance tests at the direction of the Special Inspector and Engineer.
- C. Attend construction phase controls coordination meeting.
- D. Attend testing, adjusting, and balancing review and coordination meeting.
- E. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the Engineer.
- F. Provide information requested by the Special Inspector and Engineer for final commissioning documentation.
- G. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.7 TAB CONTRACTOR'S RESPONSIBILITIES

- A. Attend coordination meeting for testing, adjusting, and balancing review, controls, and functional performance testing.
- B. Participate in verification of the TAB report by the Engineer and Special Inspector for verification and diagnostic purposes.
- C. Participate in commissioning functional performance tests at the direction of the Special Inspector and Engineer.

1.8 BUILDING AUTOMATION CONTRACTOR'S RESPONSIBILITIES

- A. Review design for controllability with respect to equipment selected for the project. Review and confirm in writing that a proper hardware specification exists to permit functional performance testing as required by specification and sequence of operation.
- B. Attend coordination meeting for testing, adjusting, and balancing review, controls, and functional performance testing.
- C. Inspect, check, and confirm the correct installation and operation of input and output field points and devices through documented and signed off point-to-point checkouts.

- D. Provide support and coordination with TAB Contractor on all interfaces between controls and TAB scopes of work. Provide, at no additional cost to the TAB and commissioning agencies, all devices, such as portable operator's terminals and all software for the TAB agency to use in completing TAB procedures.
- E. Provide Engineer with full access to Building Automation System (BAS) during commissioning process. Provide control technician responsible for system programming during construction, to assist the Engineer for the duration of the commissioning process.

1.9 SPECIAL INSPECTOR'S RESPONSIBILITIES

- A. Provide Project-specific functional test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
- B. Conduct coordination meeting for TAB, controls, and functional testing.
- C. Witness duct pressure and leakage tests.
- D. Conduct commissioning testing.
- E. Verify testing, adjusting, and balancing of Work are complete.
- F. Provide test data, inspection reports, and certificates in final report.

1.10 ENGINEER'S RESPONSIBILITIES

- A. Participate in coordination meeting for TAB, controls, and functional testing.
- B. Review and approve project-specific functional test procedures provided by Special Inspector.
- C. Review final report by special inspector or special inspection agency. When satisfied that the design intent has been achieved, the Engineer shall seal, sign, and date the report.

1.11 COMMISSIONING DOCUMENTATION

- A. Provide the following information to the Engineer :
 - 1.
 - 2. Certificate of completion certifying that installation , and startup procedures have been completed.
 - 3. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
 - 4. Test and inspection reports and certificates.
 - 5. Corrective action documents.
 - 6. Verification of testing, adjusting, and balancing reports.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

- A. Certify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the Engineer.

3.2 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the Engineer and Special Inspector.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The Special Inspector along with the HVAC&R Contractor , testing and balancing Contractor , and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment. Provide plans, procedures, and checklists to Engineer for review and approval.
- E. Tests will be performed using design conditions whenever possible.

- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the Special Inspector or Engineer and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The Special Inspector or Engineer may direct that set points be altered when simulating conditions is not practical.
- H. The Special Inspector or Engineer may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. Short-term diagnostic testing, using data acquisition equipment or Building Automation System trends to record system operation over a two to three week period, may be used to investigate dynamic interactions between components in the building system.
- J. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- K. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.3 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Section 230900 "Instrumentation and Control for HVAC". Assist the Engineer with preparation of testing plans.
- B. Duct pressure and leakage tests are specified in HVAC duct Sections.
- C. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air distribution systems; smoke control systems; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

END OF SECTION 230800

This Page Left Intentionally Blank

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- B. Related Sections include the following:
 - 1. Section 230519 "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.
 - 2. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for coordination requirements that relate to this Section.
 - 3. Section 230800 "Commissioning of HVAC" for coordination requirements that relate to this Section.
 - 4. Section 230923 "Control-Voltage Electrical Power Cables" for requirements that relate to this Section.
 - 5. Section 230928 "Pathways for Control-Voltage Cables" for requirements that relate to this Section.
 - 6. Section 233300 "Air Duct Accessories" for dampers that relate to this Section.
 - 7. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for requirements that relate to this Section.
 - 8. Section 260533 "Raceways and Boxes for Electrical Systems" for requirements that relate to this Section.
 - 9. Section 260953 "Digital, Addressable Fire-Alarm System" for coordination requirements that relate to this Section.

1.3 DEFINITIONS

- A. AAC: Advanced Application Controller; Programmable controller serving single piece of equipment and residing on peer to peer or high level building network.
- B. ASC: Application Specific Controller; Pre-programmed controller with specific routines for applicable equipment and residing on lower level or sub-LAN network connected to a BC.
- C. BACnet: A control network technology platform for designing and implementing interoperable control devices and networks.
- D. BAS: Building Automation System.

- E. BC: Building Controller; Programmable controller with input/output points residing on peer-to-peer or high level building network.
- F. DDC: Direct digital control.
- G. I/O: Input/output.
- H. Gateway: Device connecting two or more communication networks utilizing different application protocols.
- I. LAN: Local Area Network.
- J. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- K. MS/TP: Master slave/token passing.
- L. PC: Personal computer.
- M. PID: Proportional plus integral plus derivative.
- N. Router: Device connecting two or more communication networks utilizing the same application protocol.
- O. RTD: Resistance temperature detector.
- P. SPD: Surge Protection Device
- Q. VPN: Virtual Private Network

1.4 SCOPE

- A. The intent of this specification is to provide a complete and operational BAS designed to accomplish the intent of the sequences of operation.
- B. Electrical Work: Furnish all control wiring, conduit, relays, contactors and electrical work required as integral part of the instrumentation and control system or indicated on drawings.
 - 1. Control contractor shall provide relays and/or contactors required for operation of single phase motors, 1 hp and smaller. Motor starters for three phase motors and single phase motors larger than 1 hp shall be furnished and installed by Division 26 contractor.
- C. Mechanical Work: Furnish all wells for water monitoring devices, flow switches and alarms, sensors, etc. to mechanical contractor for installation.
- D. BAS System: The BAS manufacturer shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.

1. Compatibility: The BAS system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network. Compatibility shall be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers or protocol converters.
2. Architecture: System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
3. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall also be able to send alarm to multiple operator workstations without dependence upon a central or intermediate processing device.
4. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.
5. Spare Capacity: Building Controllers and Advanced Application Controllers shall be selected to provide a minimum of 10% spare I/O point capacity for each point type found at each location. If input points are not universal, 10% of each type is required. If outputs are not universal, 10% of each type is required. A minimum of one spare is required for each type of point used. DDC controllers shall have sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25% of available memory free for future use. Future use of spare capacity shall require providing the field device, field wiring, points database definition, and custom software. No additional Controller boards or point modules shall be required to implement use of these spare points.
6. All real time clocks and data file RAM shall battery back-up for a minimum 72 hours and include local and system low battery indication.
7. Provide an uninterruptable power supply (UPS) capable of powering the end device for a minimum of four hours, for workstation(s) and building controllers.
8. Provide surge transient protection for all DDC controllers and operator workstations.
9. Provide static, transient and short-circuit protection on all inputs and outputs. Protect communication lines against incorrect wiring, static transients and induced magnetic interference.
10. Provide satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3 Hertz variation in line frequency.
11. The existing operator interface is a Metasys product manufactured by Johnson Controls .
12. The BAS system specified herein is an expansion of an existing BAS system manufactured by Johnson Controls . The existing system does not utilize BACnet network protocols.
13. Communications:
 - a. Communication between building controllers and all operator/server workstations shall be over a high-speed Ethernet network using standard TCP/IP, IEEE 802.3 protocol. All nodes on this network shall be peers. The operator shall not have to

identify the panel or address to view or control an object. AACs and ASCs shall be constantly scanned by their respective BC to update point and alarm information. .

- b. .
 - c. Building Level Networks shall be connected to the existing server workstation located at the district office via the owner's Ethernet backbone network as specified herein.
 - d. Provide system capable of interoperability with the existing operator interface as specified herein.
- E. Abbreviations, Symbols and Definitions: All letter symbols and engineering unit abbreviations utilized in information displays and printouts shall be fully explained and documented in the documentation provided.
- F. System Commissioning: The Control Contractor shall include within his bid price an allowance for 8 hours of time to meet with the Engineer for the purpose of commissioning the system, as described in "Commissioning" of this section. Time for the Engineer shall be charged at \$160.00 per hour and billed directly to the Controls Contractor from the Engineer.

1.5 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
- 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds. System shall be capable of displaying up to 400 dynamic points per graphic.
 - 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds. Automatically refresh every 15 seconds.
 - 3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
 - 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
 - 5. Alarm Response Time: Annunciate alarm at workstation within 15 seconds. Multiple workstations must receive alarms within five seconds of each other.
 - 6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
 - 7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
 - 8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - a. Water Pressure (Absolute & Differential): Plus or minus 2 percent of full scale.
 - b. Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
 - c. Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
 - d. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
 - e. Air Pressure (Ducts): Plus or minus 0.01-inch wg (25 Pa).

1.6 ACTION SUBMITTALS

- A. Provide the following in a submittal booklet. Each booklet shall be an 8-1/2" X 11" loose-leaf

3-ring binder with identification inserts in clear vinyl on the front cover and the back spine. Identification insert shall include building name, owner, controls contractor, design engineer and submittal date. Provide separate sections with the following tabbed dividers.

1. TAB 1 "System Schematics" – Provide sequence of operations, schematic flow diagrams, wiring diagrams, object names, point addresses, interface wiring diagrams, panel layouts, and system riser diagrams (architecture). Schematics shall be submitted in 11" X 17" format.
2. TAB 2 "Object List" – Provide object lists in 8 ½" x 11" format. Object list shall include for each physical or logical point, the name, description, display units, BACnet object description, object ID, associated device ID, address, object type (AO, AI, DI, DO), initial value, default value, reset limits, alarm high and low limits. Coordinate object names and addresses with system schematics. Also provide in Excel file format on optical disk in binder pocket.
3. Tab 3 "HVAC Plans" – HVAC plans in 11"x17" format indicating controlled equipment, control panel and sensor locations.
4. Tab 4 "Object Naming Convention" - Indicate the format, structure and standards of typical point names. Provide a list of point names for typical equipment and functions with specific coordinated examples. The addressing scheme shall be coordinated and approved by the owner and engineer.
5. Tab 5 "Valve & Damper Schedule" – Provide valve and damper schedules showing size, configuration, CV, system pressures, capacity and location of all equipment.
6. TAB 6 "TAB Data" – Empty
7. TAB 7 "System Verification Checklists" – Include forms that will be used for point-to-point checkout and calibration verification.
8. TAB 8 "Functional Performance Tests" – Empty
9. TAB 9 "Bill of Materials" – Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
10. TAB 10 "Data Sheets" – Provide for all control system components. When manufacturer has cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is being submitted to cover.
11. TAB 11 "Control System Software" - Include technical data for operating system software, operator interface, color graphics, and other third-party applications. List color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
12. TAB 12 "O&M" – Operation and maintenance manuals for each controller, valve, damper, meter or any other device or piece of equipment. O&M manuals shall be specific to the product used for this project and shall specifically identifying the actual product and options used and only contain O&M information pertaining to said product. Submittal of a general series of products is not acceptable. In addition to O&M manuals, the BAS contractor shall provide an executive summary at the front end of the tabbed section. The executive summary should outline the type and location of specific items that require routine maintenance or calibration (i.e., CO₂ sensors) and the general procedure for performing said work.
13. TAB 13 "Training" – Description of process, report formats and checklists to be used in Part 3: "Control System Demonstration and Acceptance."

14. TAB 14 "Service Contacts" - Names, addresses, and 24-hour telephone numbers of local factory direct service representatives for equipment and control systems.

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and manufacturer.
- B. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
- C. Field quality-control test reports.
- D. Commissioning: For Engineer to use to verify compliance prior to the commissioning demonstration. Refer to this section "Commissioning".
 1. Printout of each graphic screen in 8-1/2" x 11" format.
 2. Printout of software programming, including comment statements, for each system in 8-1/2" x 11" format.

1.8 CLOSEOUT SUBMITTALS

- A. The contractor shall provide three copies of the following included in an operation and maintenance manual for the use of the owner's operating personnel. Each manual shall be an 8-1/2" X 11" loose-leaf 3-ring binder with identification inserts in clear vinyl on the front cover and the back spine. Identification insert shall include building name, owner, controls contractor, design engineer, commissioning authority and commissioning date. Provide separate sections with the following tabbed dividers. Each of the following shall incorporate as-built data derived from the commissioning process.
 1. TAB 1 "System Schematics" – Approved submittals indicating as-built conditions. Also provide in AutoCAD v2004 drawing format on optical disk in binder pocket.
 2. TAB 2 "Object List" – Approved submittals Indicating final object names, setpoints, reset limits, alarm high and low limits, default values, etc. Object list shall also identify. Also provide in Excel file format on optical disk in binder pocket.
 3. Tab 3 "HVAC Plans" – As-built version of submitted HVAC plans in 11"x17" format indicating controlled equipment, control panel and sensor locations.
 4. TAB 4 "Valve & Damper Schedule" – Approved submittals
 5. Tab 5 "Object Naming Convention" – Approved submittals
 6. TAB 6 "TAB Data" – Spread sheet format indicating final flow coefficients for each air flow monitoring station and water meter.
 7. TAB 7 "System Verification Checklists" – Signed and dated by the installing contractor. This documentation shall include point-to-point verification specified herein and test measurements and system calibrations specified herein. A certification report shall be provided listing the test.
 8. TAB 8 "Functional Performance Tests" – Copies of FPT forms completed and approved by the commissioning authority and as required to meet requirements of Part 3: "Control System Verification, Demonstration and Acceptance."
 9. TAB 9 "Bill of Materials – Approved submittals
 10. TAB 10 "Data Sheets" – Approved submittals

11. TAB 11 "Control System Software" - Include technical data for operating system software, operator interface, color graphics, and other third-party applications. List color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations. Include the following:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 - c. Device address list.
 - d. Printout of final software programming and graphic screens.
 - e. Software license required by and installed for DDC workstations and control systems.

12. TAB 12 "O&M" – Operation and maintenance manuals for each controller, valve, damper, meter or any other device or piece of equipment. O&M manuals shall be specific to the product used for this project and shall specifically identifying the actual product and options used and only contain O&M information pertaining to said product. Submittal of a general series of products is not acceptable. At minimum, provide the following.
 - a. An executive summary at the front end of the tabbed section. The executive summary should outline the type and location of specific items that require routine maintenance or calibration (i.e., CO₂ sensors) and the general procedure for performing said work.
 - b. Operator's Manual with procedures for operating control systems, logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 - c. Programming manual or set of manuals with description of programming language and of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - d. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
 - e. Documentation of all programs created using custom programming language, including set points, tuning parameters, and object database.
 - f. Programs and database on optical media.
 - g. List of recommended spare parts with part numbers and suppliers.
 - h. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.
 - i. Interconnection wiring diagrams with identified and numbered system components and devices.
 - j. Calibration records and list of set points.

13. TAB 13 "Training" – Training videos specified herein on DVD format.
14. TAB 14 "Service Contacts" - Names, addresses, and 24-hour telephone numbers of local factory direct service representatives for equipment and control systems.
15. Tab 15 "Warranty" - Licenses, guarantees, and warranty documents for equipment and systems.

1.9 QUALITY ASSURANCE

- A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements. All systems and components shall have been thoroughly tested and proven in actual use for at least two years or as approved by the Engineer.
- B. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer. The installing manufacturer shall certify in writing that the shop drawings have been prepared by the equipment manufacturer and that the equipment manufacturer has supervised their installation. In addition, the equipment manufacturer shall certify in writing that the shop drawings were prepared by their company and that all temperature control equipment was installed under their direct supervision.
- C. Installer Qualifications: The control system shall be designed and installed, commissioned and serviced by manufacturer employed, factory trained personnel.
 - 1. Controls Contractor shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. Distributors or licensed installing contractors are not acceptable.
 - 2. Controls Contractor shall provide full time, on site, experienced project manager for this work, responsible for direct supervision of the design, installation, start up, and commissioning of the BAS system.
- 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. The control system shall comply with the most restrictive requirements of all applicable standards and codes (including those listed below), except when more detailed or stringent requirements are indicated by the Contract Documents.
 - 1. ASHRAE/ANSI 135 - 2004 , BACnet – A Data Communication
 - 2. IEEE 802.3 – Ethernet Standard

1.10 DELIVERY, STORAGE, AND HANDLINGSystem Software: Update to latest version of software at Project completion.COORDINATION

- A. Products furnished by Control Contractor but installed by Mechanical Contractor:
 - 1. Control Valves.
 - 2. Electronic Actuators.
 - 3. Air Flow Stations.
 - 4. Thermal Wells and Sockets.
 - 5. Taps and Tap Isolation Valves.

- B. Products furnished and installed by Mechanical Contractor but wired by Electrical Contractor:
 - 1. Variable Frequency Drives.

- C. Products furnished and installed by Mechanical or Electrical Contractor, but integrated to by Control Contractor. Unless noted otherwise, wiring shall be by Control Contractor.:
 - 1. Fire Alarm System via BACnet/IP.
 - 2. Variable Frequency Drives via LAN.
 - 3. Control Dampers via Hardwire. Smoke and Fire/Smoke Dampers complete with actuators and end switches via Hardwire.
 - 4. Automatic Doors via Hardwire.

- D. Electrical Contractor:
 - 1. Wiring of power feeds through all disconnects or starters to electrical motors.
 - 2. Wiring of any remote start/stop and manual or automatic motor speed control devices not furnished by Control Contractor.

- E. Coordinate equipment with Section 283111 "Digital, Addressable Fire-Alarm System" to achieve compatibility with equipment that interfaces with that system. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

1.11 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer warrants instrumentation and control system free from defects within specified warranty period.
 - 1. Warranties include, but are not limited to, the following:
 - a. Recalibration of sensors.
 - b. Tuning of PID control loops.
 - c. Labor & materials.
 - d. Update of operator workstation software, project specific software, graphics, database, and firmware.
 - 2. System failures during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the Owner.
 - 3. The Contractor shall respond to the Owner's request for warranty service within 24 hours during customary business hours.
 - 4. Written authorization by Owner must be granted prior to the installation of updates to software, graphics, database, or firmware.
 - 5. Warranty Period: One year from date of Final Completion.

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

- A. All project developed hardware and software shall become the property of the Owner. These include but are not limited to:
1. Project specific graphic images
 2. Record drawings
 3. Project specific database
 4. Project specific application programming code
 5. All project documentation

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. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONTROL SYSTEM

- A. **Manufacturers:** The following list of approved manufacturers applies to controller software, custom application programming language, building controllers, advanced application controllers, and application specific controllers. All other products specified herein and elsewhere in Division 23 specifications are not required to be manufactured by the below manufacturers.
1. **Johnson Controls, Inc.; Controls Group.**
- B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.3 COMMUNICATIONS

- A. Network Topology: The network topology (architecture) shall consist of the following levels:
1. Management Level Network: Ethernet based high speed data link between standard client and server workstations.
 2. Peer-to-Peer Primary Building Level Network: Ethernet based high speed data link between building controllers, advanced application controllers, servers and operator workstations.
 3. Master-Slave Secondary Sub-Networks: Moderate speed data link between application

specific controllers and associated building controller.

B. Management Level Network: Devices on the Management Level Network shall communicate over Ethernet utilizing standard TCP/IP, IEEE 802.3.

1. Client workstations shall direct connect to the Ethernet Management Level Network without the use of an interposing device. Servers and Operator Workstations shall be capable of simultaneous direct connection and communication with TCP/IP level networks without the use of interposing devices. The Management Level Network shall not impose a maximum constraint on the number of connected workstations.
2. Any workstation on the Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet.
3. Any break in Ethernet communication from a workstation to the controllers on the building level networks shall result in a notification at the workstation. Any break in Ethernet communication between the standard client workstations and servers on the Management Level Network shall result in a notification at each workstation.
4. System software applications will run as a service to allow communication with Building Level Network Controllers without the need for user log in. Closing the application or logging off shall not prevent the processing of alarms, network status, panel failures, and trend information.
5. Access to the system database shall be available from any standard client workstation on the Management Level Network.
6. Client access to client-server workstation configurations over the Internet network shall be available via Web browser interface.
7. Thin Client access to client-server workstation configurations via Windows Terminal Services shall provide multiple, independent sessions of the workstations software. Terminal Services clients shall have full functionality, without the need to install the workstation software on the local hard drive.

C. Primary Building Level Network: Devices on the Building Level Network shall communicate using over Ethernet.

1. Operator Workstations, Server Workstations, All Building Controllers and Advanced Application Controllers shall directly reside on the building level Ethernet network such that communications may be executed directly between Building Controllers and directly between server, Building Controllers and Advanced Application Controllers on a peer-to-peer basis. Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel-to-panel or device-to-device communications shall not be acceptable.
2. This Building Level Network shall be connected to the owner's backbone network (Management Level Network). Unless otherwise specified, the connection shall be via a 10/100BASE-T port provided by the Owner. The location of the jack shall be coordinated with the owner's IT department. The Contractor shall also provide any additional data communication hardware, such as hubs and repeaters, which may be needed to interconnect the supplied BAS equipment and to connect to the Owner's backbone network.
3. All operator interfaces shall have the ability to access all point status and application report data or execute control functions for any and all other devices. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.

4. All devices on the building level network shall:
 - a. Auto-sense 10/100 Mbps networks.
 - b. Receive an IP Address from a Dynamic Host Configuration Protocol (DHCP) Server or be configured with a Fixed IP Address.
 - c. Resolve Name to IP Addresses for devices using a Domain Name Service (DNS) Server on the Ethernet network.

5. The building level network shall provide the following minimum performance:
 - a. Provide high-speed data transfer rates for alarm reporting, report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any controller is displayed at any PC workstations, all Building controllers, and other alarm printers within 15 seconds.
 - b. Message and alarm buffering to prevent information from being lost.
 - c. Error detection, correction, and re-transmission to guarantee data integrity.
 - d. The building level network shall allow the Building Controllers to access any data from, or send control commands and alarm reports directly to, any other Building Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. Building Controllers shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The network shall also allow any Building controller to access, edit, modify, add, delete, back up, restore all system point database and all programs.
 - e. The building level network shall allow the Building Controllers to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (e.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.
 - f. Devices containing custom programming must reside on the Building Level Network and shall be provided with non-volatile memory.

D. Secondary Sub-Network:

1. Sub-networks shall support a family of application specific controllers for terminal equipment.
2. The Application Specific Controllers shall communicate bi-directionally with the building level network through Building Controllers for transmission of global data.
3. A maximum of 30 terminal equipment controllers shall be configured on individual sub-network trunks to insure adequate global data and alarm response times.
4. Where indicated communication over the secondary sub-network may utilize wireless MESH topology based on IEEE 802.15.4 network. Point to point communication shall be acceptable.

E. Provide all communication media, connectors, repeaters, hubs, routers and gateways necessary for the internetwork and as necessary for communication with third party equipment control

systems.

1. Router Requirements: In the event that devices are provided that do not use BACnet/IP over Ethernet or BACnet MS/TP as their communication technology, BACnet routers shall be provided that route between BACnet/IP or BACnet MS/TP and the other BACnet LAN type(s). These routers shall conform to the specifications of BACnet, Clause 6. The use of BACnet LAN types other than those specified herein for each network requires the specific approval of the Owner and Engineer.
 2. Gateways: Devices that use BACnet as their native protocol are preferred. The use of gateways, in circumstances where no native BACnet device is available, requires the specific approval of the Owner and Engineer.
- F. Communication services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture as follows:
1. Connection of an operator interface device to any one controller on the internetwork will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the internetwork.
 2. All database values (e.g., objects, software, variables, custom program variables) of any one controller shall be readable by any other controller on the internetwork. This value passing shall be automatically performed by a controller when a reference to an object name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communication services to perform internetwork value passing.
- G. The time clocks in all controllers shall be automatically synchronized daily via the internetwork. An operator change to the time clock in any controller shall be automatically broadcast to all controllers on the internetwork. System shall automatically adjust for daylight saving and standard time.
- H. Portable Operator Interface: All controllers shall have a communication port for connections with a portable operator interface. Communication shall support memory downloads and other commissioning and troubleshooting operations.

2.4 DDC CONTROLLERS

- A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-

access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
 - d. Software applications, scheduling, and alarm processing.
 - e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

- a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
- b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
- c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
- d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
- e. Remote communications.
- f. Maintenance management.
- g. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

- C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting of the point to itself, another point, or ground will cause no damage to controllers. Protect points so that contact with a voltage up to 24-V of any duration will cause no damage to controllers.
1. Binary Inputs: Allow monitoring of on-off signals from remote devices and sensing “dry contact” closure without external power. Provide a wetting current of at least 12 mA to be compatible with commonly available control devices. Protect against effects of contact bounce and noise.
 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second. Conform to all requirements of Binary Inputs.
 3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals. Analog Inputs shall be compatible with and field configurable to commonly available sensing devices.
 4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
 5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with two-position (auto-manual) override switches, manually adjustable potentiometer for manual override, and status lights. Analog Outputs shall not exhibit a drift greater than 0.4% of range per year.
 6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators. Use of three-point, floating-type devices shall be limited to zone control and terminal unit control applications.
 7. Universal I/Os: Provide software selectable binary or analog outputs. Conform to the provisions of this section that are appropriate to their designated use.
 8. System Object Capacity: The system size shall be expandable to at least twice the number of input / output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interface installed for this project shall not require any hardware additions in order to expand this system.
- D. Power Supplies: UL listed transformers with Class 2 current-limiting type or overcurrent protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
1. Output ripple of 5.0 mV maximum peak to peak.
 2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
 3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- E. Power Line Filtering:
1. Isolation for all network and field point terminations to suppress induced voltage transients consistent with the following:
 - a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3V
 - b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8

- kV air discharge, 4 kV contactA
 - c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
 - d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
- 2. All electric wiring that serves as power for the computer system, microprocessors, or other field panels shall have surge protective devices installed to suppress induced voltage transients consistent with IEEE standard 587-1980.
 - a. Unit shall provide continuous non-interrupting protection with no degradation in protection capabilities.
 - b. Unit shall have instant automatic reset after safely eliminating transient surges from switching or other forms of transient overvoltages.
 - c. Voltage clamping level shall be 120 percent of nominal line voltage.
- 3. Internal or external transient voltage and surge suppression for workstations or controllers with the following:
 - a. Minimum dielectric strength of 1000 V.
 - b. Maximum response time of 10 nanoseconds.
 - c. Minimum transverse-mode noise attenuation of 65 dB.
 - d. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

F. Transient Voltage Surge Suppression:

- 1. General:
 - a. All SPDs shall be provided by the same manufacturer.
- 2. Control Power SPD:
 - a. **Basis-of-Design Product:** Subject to compliance with requirements, provide Surge Suppression, Inc.; S-SPT###-30 or a comparable product by one of the following:
 - 1) Liebert Corporation.
 - 2) Current Technology.
 - b. Description: Series connected type 2 SPD, Type 1 and Type 4 SPDs not permitted, listed to ANSI/UL 1449-2006 (UL 1449 3rd Edition).
 - c. Peak Surge Current: 120 kA per phase.
 - d. Enclosure: Plastic with mounting feet or DIN rail.
 - e. Connections: 3-position screw terminal strips.
 - f. Diagnostics: LED indicator lights for power and protection status.
 - g. Circuit Design: Series wired design incorporating all mode protection and "True" sine-wave tracking based on the results of the Category A (2kV) Ring Wave Measured Limiting Voltages.
 - h. Current Rating: 30 amps.
- 3. BAS Hardwired Points SPD:
 - a. **Basis-of-Design Product:** Subject to compliance with requirements, provide Surge

Suppression, Inc.; CLP24Ax-B or a comparable product by one of the following:

- 1) [Liebert Corporation.](#)
- 2) [Current Technology.](#)

- b. Description: Series connected SPD.
- c. Peak Surge Current: 10 kA per phase.
- d. Enclosure: Plastic with mounting feet or DIN rail.
- e. Connections: Screw terminal strips.
- f. Circuit Design: Series wired design incorporating all mode protection.
- g. Current Rating: 500 mA.
- h. Maximum Data Rate: 2 Mbps.

4. BAS Communication Interface SPD:

- a. [Basis-of-Design Product](#): Subject to compliance with requirements, provide Surge Suppression, Inc.; DRJ45##C8-B or a comparable product by one of the following:

- 1) [Liebert Corporation.](#)
- 2) [Current Technology.](#)

- b. Description: Series connected SPD.
- c. Peak Surge Current: 10 kA per phase.
- d. Enclosure: Plastic with mounting feet or DIN rail.
- e. Connections: RJ45 modular connectors.
- f. Circuit Design: Series wired design incorporating all mode protection.
- g. Current Rating: 500 mA.
- h. Maximum Data Rate: 100 Mbps.

2.5 ELECTRONIC SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

- B. RTDs and Transmitters:

1. [Manufacturers](#):

- a. [BEC Controls Corporation.](#)
- b. [MAMAC Systems, Inc.](#)
- c. [RDF Corporation.](#)
- d.

2. Accuracy: Plus or minus 0.2 percent at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Element Material: Platinum.
5. Insertion Elements in Ducts: Single point, long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m). Sensor shall extend into middle third of duct.
6. Averaging Elements in Ducts: 5 ft. long per 10 sq. ft. of duct cross section, flexible; use

- where prone to temperature stratification or where ducts are larger than **9 sq. ft. (1 sq. m)**.
7. Insertion Elements for Liquids: Stainless-steel socket with minimum insertion length of **2-1/2 inches (64 mm)**.
 8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. Pressure Transmitters/Transducers:

1. Manufacturers:
 - a. BEC Controls Corporation.
 - b. General Eastern Instruments.
 - c. MAMAC Systems, Inc.
 - d. Setra.
 - e. TCS/Basys Controls.
 - f. Vaisala.
2. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum **150-psig (1034-kPa)** operating pressure and tested to **300-psig (2070-kPa)**; linear output 4 to 20 mA. Provide suitable mounting provisions and 3-valve manifold.
3. Thermistor Type Airflow/Pressure Measurement Station:
 - a. Manufacturers:
 - 1) Ebtron, Inc.
 - b. Accuracy (Airflow): Plus or minus **2%** of reading with repeatability of 0.25 percent. Flow measurement drift shall not exceed manufacturer's repeatability statement for the life of the equipment.
 - c. Accuracy (Temperature): Plus or minus **0.15 deg F (0.08 deg C)**.
 - d. Construction: Three glass encapsulated thermistor for each sensing point.
 - e. Electronics: Microprocessor based, solid-state in aluminum enclosure with LCD display. Use NEMA 4 enclosure for exterior installation. Provide transmitter with 4-20 mA analog output signals.
 - f. Sensor probes shall be "Plug and Play" type and shall not require matching to transmitter.
 - g. Series: Gold Series
 - h. Mounting Options: Through-wall, Ducted damper, Plenum damper.
4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.6 STATUS SENSORS

- A. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements, and tested to provide positive indication of belt failure.

2.7 RELAYS

- A. Control Relays: UL listed, with dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

2.8 FLOW MEASURING STATIONS

- A. Thermistor Type Airflow Station:

1. Manufacturers:

a. Ebtron, Inc.

2. Accuracy (Airflow): Plus or minus **2%** of reading with repeatability of 0.25 percent. Flow measurement drift shall not exceed manufacturer’s repeatability statement for the life of the equipment.
3. Accuracy (Temperature): Plus or minus **0.15 deg F (0.08 deg C)**.
4. Construction: One glass encapsulated self-heated thermistor and one glass encapsulated thermistor temperature sensor for each sensing point. Support struts and brackets shall be tubular aluminum extrusion.
5. Electronics: Microprocessor based, solid-state in aluminum enclosure with LCD display. Use NEMA 4 enclosure for exterior installation. Provide transmitter with 4-20 mA analog output signals.
6. Sensor probes shall be “Plug and Play” type and shall not require matching to transmitter.
7. Duct & Plenum Installations: Gold Series
8. Fan Inlet: Hybrid Series

2.9 ACTUATORS

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Nonspring-Return Motors for Valves Larger Than **NPS 2-1/2 (DN 65)**: Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
4. Spring-Return Motors for Valves Larger Than **NPS 2-1/2 (DN 65)**: Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
5. Nonspring-Return Motors for Dampers Larger Than **25 Sq. Ft. (2.3 sq. m)**: Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
6. Spring-Return Motors for Dampers Larger Than **25 Sq. Ft. (2.3 sq. m)**: Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.

- B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at

rated torque.

1. Manufacturers:
 - a. Belimo Aircontrols (USA), Inc.
2. Dampers: Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - b. Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - c. Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft (49.6 kg-cm/sq. m)** of damper.
 - d. Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
 - e. Dampers with **2- to 3-Inch wg (500 to 750 Pa)** of Pressure Drop or Face Velocities of **1000 to 2500 fpm (5 to 13 m/s)**: Increase running torque by 1.5.
 - f. Dampers with **3- to 4-Inch wg (750 to 1000 Pa)** of Pressure Drop or Face Velocities of **2500 to 3000 fpm (13 to 15 m/s)**: Increase running torque by 2.0.
3. Coupling: V-bolt and V-shaped, toothed cradle.
4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
6. Provide auxiliary switch for feedback.
7. Power Requirements (Two-Position Spring Return): 24 -V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
10. Actuators shall be provided with a conduit fitting and a minimum of three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
11. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
12. Temperature Rating: **Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C).**
13. Temperature Rating (Smoke Dampers): **Minus 22 to plus 250 deg F (Minus 30 to plus 121 deg C).**

2.10 CONTROL VALVES

- A. Manufacturers:
 1. Belimo.
 2. Danfoss Inc.; Air Conditioning & Refrigeration Div.
 3. <Insert manufacturer's name.>
- B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

- C. Butterfly Valves: ASME/ANSI Class 125 body pressure rating, ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM sleeve and stem seals.
1. Body Style: Lug .
 2. Disc Type: 304 stainless steel .
 3. End Fitting: ANSI 125/150 flanges.
 - 4.
- D. Pressure Independent Actuated Ball Valves:
1. The modulating control valves shall be pressure independent and shall include a Self-Balancing Cartridge and Actuated Ball Valve in a single valve housing. Valve housing shall consist of forged brass, rated at no less than 360 psi at 250°F. Valve shall have a fixed end or union end connection.
 2. The control valve shall accurately control the flow from 0 to 100% full rated flow. A flow tag shall be furnished with each valve.
 3. Self-Balancing Cartridge (SBC):
 - a. SBC shall automatically control flow rates with +/-5% accuracy over an operating range at least 10 times the minimum required for control.
 - b. The operating pressure range shall be available with the minimum range requiring less than 5.8 PSID to actuate the mechanism.
 - c. Valve internal control mechanism shall include a diaphragm and full travel linear coil spring.
 - d. Valves shall include an accessible/ replaceable cartridge.
 4. Actuated Ball Valve:
 - a. Ball valve shall consist of chemically plated nickel brass or stainless steel.
 - b. Actuator stem shall be removable/replaceable without removing valve from line.
 - c. Manufacturer shall be able to provide ball insert to make flow control equal percentage.
 - d. Valve shall have EPDM O-rings behind the seals to allow for a minimum close-off pressure of 100 psi with 35 in-lbs of torque for 1/2" – 2" sizes.
 - e. Actuator shall provide minimum torque required for full valve shutoff position.
- E. Valve Selection:
1. Two Position Control of Water: Select valve for a maximum pressure drop of 1 psi when full open.
 2. Two-way and Three-way Modulating Control of Flow: Select valve for a nominal pressure drop of 5 psi when full open. When the calculated Cv falls between valves, select the next smaller valve for heating and the next larger valve for cooling.

2.11 CONTROL CABLE

- A. Electronic and fiber-optic cables for control wiring are specified in Section 271500 "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the project plans thoroughly for control device and equipment locations. Report any discrepancies, conflicts, or omissions to the Architect/Engineer for resolution before starting rough-in work.
- B. Inspect the site to verify that equipment is installable as shown. Report any discrepancies, conflicts, or omissions to the Architect/Engineer for resolution before starting rough-in work.
- C. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to the Engineer and obtain written instructions for changes necessary to accommodate work of this section with work of others. The Controls Contractor shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.
- D. Verify that conditioned power supply is available to control units and operator workstation.
- E. Verify that duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 PROTECTION

- A. Control Contractor shall protect against and be liable for damage to work and to material caused by Contractor's work or employees.
- B. Control Contractor shall be responsible for work and equipment until inspected, tested, and accepted.
- C. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 INSTALLATION

- A. Connect and configure equipment and software to achieve sequence of operation specified.
- B. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices **60 inches (1530 mm)** above the floor.
- C. Install automatic dampers according to Section 233300 "Air Duct Accessories."
- D. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- E. Install labels and nameplates to identify control components according to Section 230553 "Identification for HVAC Piping and Equipment."

- F. Install hydronic instrument wells, valves, and other accessories according to Section 232113 "Hydronic Piping."
- G. Install duct volume-control dampers according to Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts."
- H. Install electronic and fiber-optic cables according to Section 271500 "Communications Horizontal Cabling."

3.4 INSTALLATION OF SENSORS

- A. Install sensors according to manufacturer's recommendations.
- B. Sensors shall be readily accessible and installed in such a manner as to allow for easy replacement.
- C. Sensors must be installed in such a manner that prevents condensation from making direct contact with the sensor's electronic components.
- D. Mount sensors rigidly and adequately for operating environment.
- E. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.
- F. Install averaging sensors in a serpentine manner vertically across the duct. Support each bend with a capillary clip.
- G. Install low-limit sensors in a serpentine manner horizontally across the duct. Support each bend with a capillary clip.
- H. Install outdoor air temperature sensors on north wall at designated location with sun shield.
- I. Differential Air Static Pressure:
 - 1. Supply Duct Static Pressure: Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to the manufacturer's recommendations.
 - 2. Building Static Pressure: Pipe pressure sensor's low-pressure to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.
- J. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to the transducer.
- K. Pressure transducers, except those controlling individual room controllers, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without the use of ladders or special equipment.
- L. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

3.5 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Provide all electrical work required as an integral part of the digital control work. Install a complete wiring system for the control system including wire and miscellaneous materials as required for mounting and connecting control devices.
- B. Electrical control and power wiring, contactors, and relays required for BAS equipment, damper and valve actuators, and local control panels, not specifically identified in the Division 26 sections as electrical work or shown on the electrical drawings, is work of this section. If additional circuits need to be designated for this equipment, the Control Contractor shall include the cost to add these circuits.
- C. Control panels serving equipment fed by emergency power shall also be served by emergency power.
- D. Install raceways, boxes, and cabinets for low-voltage conductors according to Section 260533 "Raceways and Boxes for Electrical Systems."
- E. Install building wire and cable according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- F. Install pathways, boxes, and cabinets for control-voltage cabling according to Section 230928 "Pathways for Control-Voltage Cables."
- G. Install signal and communication cable according to Section 230923 "Control-Voltage Electrical Power Cables."
 - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install exposed cable in raceway.
 - 3. Install concealed cable in raceway.
 - 4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 - 7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- H. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- I. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.6 SURGE PROTECTIVE DEVICES INSTALLATION

- A. Install surge protective devices as close as practical to the electrical panel or dedicated electronic equipment to be protected. The SPD shall be close connected to the panel in a

position near the panel board neutral bus bar or positioned so that the overall lead length will be minimal.

- B. Install surge protection devices in a manner consistent with proper and acceptable industry wiring practice. Install connection leads as short and straight as possible while avoiding sharp bends. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
- C. Surge protective devices shall be installed at the following locations:
 - 1. DDC panel communication interfaces.
 - 2. VFD communication interfaces.
 - 3. Exterior BAS hardwired terminations. Provide multiple SPDs to accommodate quantity of hardwired terminations specified.
 - 4. Control transformers.

3.7 PROGRAMMING

- A. Provide software programming for the system as per specifications and adhere to the sequences of operation provided.
- B. Provide all other system programming necessary for the operation of the system but not specified in the sequences of operation.
- C. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operation.
- D. Provide a separate program for each major HVAC system.

3.8 CONTROLLERS

- A. Provide a separate controller for each major HVAC system. Controller shall be located within the same room as equipment. All points associated with a single system shall reside in a single controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.
- B. Route all controllers for terminal units through the controller for the air handling unit associated with the terminal units.
- C. Motors in motor control centers (MCC) shall be controlled from the DDC controller associated with the HVAC system. It shall not be acceptable to control all motors in a MCC from one DDC controller dedicated to the MCC. The intent of this specification is that the loss of one DDC controller shall not affect the operation of other HVAC system, but only for the points connected to the DDC controller.
- D. Install software in controllers.

3.9 OPERATOR INTERFACE

- A. Provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface database, and any third party software installation and integration required for successful operation of the operator interface.
- B. Install software in existing server(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- C. Upgrade and otherwise modify existing system software to integrate new control sequences into existing system as appropriate to sequence of operation.
- D. Dynamic Data Display:
 - 1. Point lists shall be organized on a per field device basis.
 - 2. If the software provides for the sub-division of point data within a field device, the data shall be organized by physical sub-system as a minimum (fan section, mixed air section, etc.)
 - 3. The workstation shall be configured to automatically update values without any action by the operator.
 - 4. Value updates in points lists shall be configured to update at least once every 5 seconds.
 - 5. Binary data shall be configured to display state descriptors (OFF, ON, OPEN, CLOSED, etc.) and not the states of 0 and 1.
 - 6. Analog data displays shall include engineering units and shall not report values more accurate than the device can measure. Values shall be reported consistent with the following:
 - a. Temperatures shall be reported to 1 decimal place.
 - b. Percentages shall be reported as integers.
 - c. Velocities shall be reported as integers.
 - d. Flow volumes shall be reported as integers.
 - e. Pressures shall be reported to 1 or 2 decimal places, as determined by the control setpoint.
 - f. Consumptions shall be reported as integers.
 - g. Dampers and valve positions shall be reported as "% OPEN".
 - 7. All temporary points used for debugging or tuning, such as PID loop outputs, shall be removed from the display.
 - 8. All text fields associated with a specific element of data shall be programmed to provide the maximum amount to the operator.
- E. Graphic Pages:
 - 1. Hierarchy:
 - a. The organization of graphic pages shall be from a global level down to a very detailed level through a series of links.
 - b. Linking shall allow the operator to move down the hierarchy, up the hierarchy, and laterally within the hierarchy.

2. Hierarchy Outline:
 - a. Site Plan Page
 - b. Building Graphic Page
 - c. Floor Plan Page
 - d. Delivery System Page
 - e. Delivery System Configuration Page
3. For all points on a graphic page that are subject to being under manual or test mode, the display shall indicate when test mode or manual mode has been applied to the point.
4. Graphic Page Requirements:
 - a. The sequence of operations and points lists define the buildings and all of the equipment items for which graphic pages shall be constructed as described above.
 - b. The Contractor shall develop similar additional graphic pages to be defined during the construction period as follows:
 - 1) Up to 5 additional pages.

F. Alarm Processing:

1. All alarms required by the sequence of operation shall be fully configured for delivery to the operator workstations and the alarm files.
2. A common alarm file shall be established to receive alarms from all of the field devices.
3. A separate alarm file shall be established on a per building basis to receive just the alarms from that building.
4. The alarm messages shall be descriptive and include as a minimum:
 - a. System identification.
 - b. Date.
 - c. Time to the second.
 - d. Nature of the alarm, such as high value, low value, or failure.
5. The system shall be configured to send an alarm message on return to normal.
6. All users shall receive all alarms.

G. Reports:

1. All reports and trends required by the sequence of operation shall be fully configured for delivery to the operator workstations.
2. All trends shall be configured to retain all historical data samples for a minimum of one week prior to the current date and time.

3.10 BACNET CONFIGURATIONS

A. BACnet Interoperability by Area:

1. Data Sharing: Data Sharing requirements apply to the exchange of information between BACnet devices for archival storage, generating graphics and reports, the sharing of common sensor or calculated values, carrying out interlocked control strategies, and the

modification of setpoints or other operational parameters. All such data to be exchanged shall be represented as BACnet objects and conveyed using BACnet messages. Only standard BACnet objects and messages may be used to implement data sharing requirements unless the Owner explicitly approves the non-standard extensions. Any extensions to BACnet shall be fully documented in the manner used within the BACnet standard. Submission of such documentation is a prerequisite for obtaining approval of an extension.

- a. Points List: The Contractor shall provide devices installed and configured with all points indicated in the BAS points list. For the sequence of operations and other functionality described in this specification to be fully implemented, the Contractor shall provide any additional points needed.
 - b. Data Presentation: In the event that workstation/web server capabilities have been specified, the following characteristics shall apply to graphic displays:
 - 1) The graphic displays shall include schematic diagrams of the systems being displayed.
 - 2) When a graphic display is being viewed all values displayed shall be updated when a change of value (COV) notification is received or, if COV is not implemented, within five seconds.
 - 3) Any data value from any networked device shall be available for plotting at a workstation in real time. The operator shall be able to select binary and analog data concurrently and to plot multiple instances of each data type on the same screen. The operator shall be able to select sampling intervals from 1 second to 60 seconds. For devices that implement COV reporting, the operator shall be able to select this as the means to update the plot. It shall be possible to save such real-time plots for subsequent recall.
 - c. Monitoring of Any Property: The operator shall be able to display any value of any property of any object from any networked device including all properties required by BACnet, all supported optional properties, and any proprietary extensions.
 - d. Global Object Definitions: The control system shall be configured with system-wide unique BACnet objects as needed to convey all globally significant information necessary to implement the control strategy.
 - e. Setpoint and Parameter Modifications: Operators with appropriate authority shall be able to modify all control loop setpoints and tuning parameters via BACnet messages initiated through operator interaction with graphics displays.
 - f. Peer-to-Peer Dependencies: All BACnet devices shall be installed and configured to exchange data values directly, without the need for operator or workstation intervention, to implement the sequence of operations specified in the mechanical system drawings and to share global data values.
2. Alarm and Event Management:
- a. Alarm and Event Management is the exchange of data between BACnet devices

related to the occurrence of predefined conditions that meet specific criteria. Such conditions are called “events” and may be the basis for the initiation of a particular control action in response or the simple logging of the event’s occurrence. The event may also be deemed to represent a condition that constitutes an “alarm” requiring human acknowledgment and intervention.

- b. All alarms and events shall be implemented using standard BACnet event detection and notification mechanisms. Either intrinsic reporting or algorithmic change reporting may be used but the intrinsic reporting method is preferred. See BACnet, Clause 13.
- c. Alarm Lists:
 - 1) The Contractor shall provide devices installed and configured to detect alarms and events for the points indicated in the system drawings. Software logic shall be provided to avoid nuisance alarms, e.g., no temperature or status alarms shall be generated when fan systems are not running or during start-up and shut-down transitions. It shall be possible to configure a delay between the occurrence of an alarm condition and its enunciation.
 - 2) Alarms shall appear at the BAS and any local operator workstation(s) within five seconds of their occurrence. The workstations shall display an alarm message window that appears on top of any other open windows. The alarm message window shall have a distinctive color and appearance to attract the operator's attention. Operators with sufficient privilege shall be able to configure the workstation to emit an audible signal (or not) when an alarm message is received.
 - 3) Alarms that require operator acknowledgement shall cause the alarm window to remain active until such an acknowledgement is received. If multiple alarms are received, unacknowledged alarms shall be displayed on a first come first served basis grouped by priority, with the highest priority alarms displayed first.
 - 4) Alarms shall be distributed using the BACnet notification class mechanism. Assignment of classes and destinations shall be configured according to details provided by the Owner. One destination shall, in all cases, be the BAS.
 - 5) BACnet provides a mechanism for prioritizing alarm and event notification messages using a numerical range of 0-255 with 0 being the highest priority and 255 being the lowest priority. Priorities shall be consistent with the safety requirements of UL 864 (applies to fire systems) and UL 1076 (applies to security systems).
- d. Alarm Acknowledgment: Alarms shall be acknowledged through the BAS alarm acknowledgement process.
- e. Alarm Summarization: Alarm summarization shall be handled through the BAS alarm summarization process.

- f. Alarm Parameter Adjustment: Operators with sufficient privilege shall be able to change alarm parameters for all standard BACnet event types.
 - g. Alarm Routing Adjustment: Operators with sufficient privilege shall be able to change alarm routing (BACnet notification classes) for each alarm including the destination for each type of alarm and alarm priority, the day of week and time of day, and the type of transition involved (TO-OFFNORMAL, TO-NORMAL, etc.).
3. Scheduling: Scheduling is the exchange of data between BACnet devices related to the establishment and maintenance of dates and time at which specified output actions are to be taken. All schedules shall be implemented using BACnet objects and messages.
- a. Schedule Lists:
 - 1) The Contractor shall provide devices installed and configured with start/stop, mode change, and night setback schedules as defined in the sequence of operations. As part of the installation process, the Contractor shall configure vacation, holiday, and any special event schedules as provided by the Owner.
 - 2) The system shall have the ability to program alterations to programmed operating schedules based on the priority of events and shall include the following scenario:
 - a) Based on operator privileges, the operator shall have the ability to temporarily override the programmed schedule of equipment. Operational override of a programmed schedule shall be for a specific duration following which the schedule shall revert back to the preprogrammed schedule.
 - b. Display of Start and Stop Times and Actions: An operator shall be able to inspect the content of any schedule and determine the specific control actions that will occur at any time, on any date. For any particular device or system parameter that is the subject of a schedule, an operator shall be able to determine the schedule of actions related to that particular device or parameter.
 - c. Modification of Schedules: All calendar entries and schedules shall be modifiable from the BAS or local workstation by an operator with sufficient privilege.
4. Trending: Trending is the accumulation of (time, value) data pairs at specified rates for a specified duration. Trends are distinguished from real-time plotting of data by the fact that the data are destined for long-term storage.
- a. Archival Storage of Data: Archival storage of data will be handled by the BAS. However, the Owner may specify local trend archiving and display through the use of BACnet Trend Log objects.
 - b. Modification of Trend Log Parameters: An operator with sufficient privilege shall be able to change the data points to be logged, the sampling rate, and the duration

of a trend log.

5. Device and Network Management: Device and network management is the exchange of data between BACnet devices concerning the operation and status of specific devices. If local workstation capabilities are provided, the following functions shall be available:
 - a. Display of Device Status Information: Operators shall be able to display at any time the operational status of any device on the BACnet internetwork.
 - b. Display of BACnet Object Information: Operators shall be able to display, at any time, any property of any BACnet object. Operators shall be able to display property values of objects grouped by object type, object location, and building system.
 - c. Silencing Devices that are Transmitting Erroneous Data: Operators shall be able to direct a field device to stop transmitting event, alarm or COV notifications until a subsequent command to resume transmissions is received.
 - d. Time Synchronization: Operators shall be able to set the time and date in any device on the network that supports time-of-day functionality. The operator shall be able to select to set the time and date for an individual device, or all devices on a single local network.
 - e. Remote Device Reinitialization: Operators shall have the ability to issue reinitialization commands to any device that supports remote reinitialization.
 - f. Backup and Restore: Operators shall have the ability to backup and restore all BACnet devices on the network that support this capability.
 - g. Configuration Management of Half-Routers, Routers and BBMDs: Operators shall have the ability to display and modify the routing table entries in all supplied BACnet half-routers and routers and the broadcast distribution and foreign device registration tables in all BBMDs.

B. BACnet Objects:

1. The naming convention shall be reviewed and coordinated with the Owner, Commissioning Authority, and Engineer prior to implementation.
2. Device Object Names:
 - a. System point names shall be modular in design, allowing easy operator interface without the use of a written point index. The naming convention shall be based on facility name, location within a facility, the system or systems that the device monitors and/or controls, or the area served. Names can be up to 254 characters in length, without embedded spaces. Only the characters A-Z, 0-9, ".", and "-" may be used. The goal is the shortest descriptive, but unambiguous, name. For example, if there is only one chilled water pump, "CHW-P1", a valid name would be "FSU.SMITH-HALL.CHW-P1.STATUS".

- b. These names should be used for the value of the "Object Name" property of the BACnet Device objects of the controllers involved so that the BACnet name and the BAS name are the same.
3. Device Instance Numbers:
 - a. BACnet allows 4194305 device instances per BACnet internetwork, each of which must be unique. Coordinate with the owner, engineer and commissioning agent to develop or expand on a unique naming convention. The following is an example of a naming convention that may be used as a starting point.
 - b. Device Instance = "FFFFNDD" where:
 - FFFF = Facility Code (see below)
 - N = 0-9 This allows up to 10 networks per facility or building.
 - DD = 00-99 This allows up to 100 devices per network.
 - c. Facility codes could be building numbers, address numbers, etc. Note however that four digit numbers above 4193 our out of range; therefore, it may make sense to provide a range of numbers to use as an open "wildcard" range.
4. Non-Device Object Names: Objects other than Device objects shall be named in a manner analogous to Device objects.
5. Non-Device Instance Numbers: The instance numbers for objects other than Device objects may be assigned at the Contractor's discretion subject only to the constraint that they be unique for a given object type within a given device.
6. Issues Relating to Specific BACnet Object Types:
 - a. Analog Input, Output, and Value: All Analog Input, Analog Output, and Analog Value objects shall have the capability of using the Change of Value (COV) reporting mechanism and the COV Increment property shall be writable using BACnet services.
 - b. Binary Input: The Inactive Text and Active Text properties of Binary Input objects shall be configured with text string values as indicated on the points list. Binary Input objects shall support COV reporting.
 - c. Binary Output: The Inactive Text and Active Text properties of Binary Output objects shall be configured with text string values as indicated on the points list. All Binary Output objects associated with motor on/off status shall track changes of state and runtime. Binary Output objects shall support COV reporting.
 - d. Binary Value: The Inactive Text and Active Text properties of Binary Value objects shall be configured with text string values as indicated on the points list. Binary Value objects shall support COV reporting.
7. Calendar:

- a. Devices providing scheduling capability shall also provide at least one Calendar object with a capacity of at least ten entries. Operators shall be able to view the calendar object and make modifications from any BACnet workstation on the network.
 - b. If the Calendar's Date List property is writable using BACnet services, all calendar entry data types shall be supported.
8. Loop: All control loops using any combination of proportional, integral, and/or derivative control shall be represented by BACnet Loop objects. Operators with sufficient authority shall be able to adjust at least the Update Interval, Setpoint, Proportional Constant, Integral Constant, and Derivative Constant using BACnet services. Loop objects shall support COV reporting.
 9. Multi-state Input, Output, and Value: The text to be used for the Multi-state object types shall be determined from the points list. Feedback Value shall be determined by sensing the actual condition or mode of the device. All Multi-state objects shall support COV reporting.
 10. Schedule: All building systems with date and time scheduling requirements shall have schedules represented by BACnet Schedule objects. All operators shall be able to view the entries for a schedule. Operators with sufficient privilege shall be able to modify schedule entries from any BACnet workstation. Required schedules are shown on the drawings as part of the occupied and unoccupied modes.
 11. Dynamic Object Creation: BACnet Building Controllers shall be configured to allow the dynamic creation of Trend Log, Calendar, and Schedule objects by means of the BACnet Create Object service. This shall be possible from any supplied BACnet workstation by operators with appropriate authority.

C. Local Area Networks:

1. These following requirements are specific to the integration of multiple BACnet networks, possibly on different LAN types, into a single BACnet internetwork.
2. Network Numbering:
 - a. The naming convention shall be reviewed and coordinated with the owner, commissioning agent and engineer prior to implementation.
 - b. BACnet network numbers shall be based on a "facility code, network" concept. The "facility code" is an owner assigned numeric value assigned to a specific facility or building. The "network" typically corresponds to a "floor" or other logical configuration within the building. BACnet allows 65535 network numbers per BACnet internetwork.
 - c. Network numbers are thus formed as follows: Network Number = "FFFFN" where:
 FFFF = Facility Code

N = 0-9 Allows up to 10 networks per facility or building.

N = 0 will generally be assigned to the Building Level Network. Normally, this network is connected to the owner's management level network. The additional N-numbers will be assigned to any MS/TP networks as required.

3. IP Address Assignments: The Contractor shall contact the owner's IT department for assignment of IP addresses prior to beginning device configuration.

3.11 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 2. Test and adjust controls and safeties.
 3. Test calibration of electronic controllers by disconnecting input sensors and simulating operation with compatible signal generator.
 4. Test each point through its full operating range to verify that safety and operating control set points are as required.
 5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Adjust PID actions. Use Ziegler-Nichols rules for tuning PID controllers to achieve a 25% maximum overshoot in a step response for PI actions. Test each system for compliance with sequence of operation.
 6. Test software and hardware interlocks.
- C. DDC Verification:
 1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 2. Check instruments for proper location and accessibility.
 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 4. Check instrument tubing for proper fittings, slope, material, and support.
 5. Check installation of air supply for each instrument.
 6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
 7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 8. Check temperature instruments and material and length of sensing elements.
 9. Check control valves. Verify that they are in correct direction.
 10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
 11. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.

- b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.
- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.12 ADJUSTING

A. Calibrating and Adjusting:

1. Completely adjust or calibrate, ready for use, all thermostats, sensors, transducers, valves, damper operators, relays, etc., provided under this specification.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
 - b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.

10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.13 COMMISSIONING

A. Provide at least two persons equipped with two-way communication, including the control technician responsible for system programming during construction, to assist the Engineer for the duration of the commissioning process.

B. Provide Engineer with full access, including remote login capabilities and temporary administrative privileges, to Building Automation System (BAS) during commissioning process.

1. Provide Engineer with any additional third-party software required for remote login capabilities.
2. The Control Contractor shall be responsible for all costs associated with the Engineer connecting to the Owner's VPN.

C. Demonstration:

1. Engineer will be present to observe and review system demonstration. Notify Engineer at least 10 days before system demonstration begins.
2. Demonstration shall follow process submitted and approved under ...
3. Demonstrate actual field operation of each sequence of operation as specified.
4. Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.
5. Demonstrate compliance with Article "System Performance".
6. Demonstrate compliance with sequences of operation through each operational mode.
7. Demonstrate complete operation of operator interface.
8. Demonstrate each of the following:

- a. DDC Loop Response: Supply graphical trend data output showing each DDC loop's response to a set point change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show set point, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.
- b. Demand Limiting: Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand-limiting set point, and status of set points and other affected equipment parameters.
- c. Building fire alarm system interface.
- d. Trend logs for each system: Trend data shall indicate set points, operating points,

valve positions, and other data as specified in the points list provided with each sequence of operation. Each log shall cover three 48-hour periods and shall have a sample frequency not less than every 10 minutes or as specified on its points lists. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs as specified.

9. Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

D. Cost of Re-Testing:

1. The cost for the Sub-Contractor to retest a start-up check, calibration, or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the Contractor.
2. For a deficiency identified, not related to any start-up fault, the following shall apply: The Engineer, Contractor and any applicable Sub-Contractors will retest the equipment once at no "charge". However, the time and expenses for the Engineer to direct a second retest shall be charged to the Contractor. The Contractor shall be responsible for any cost recovery for retesting costs from the party responsible.
3. The time and expenses for the Engineer to direct any retesting required because a specific start-up or checkout test item, reported to have been successfully completed, but determined during functional testing to be faulty, shall be charged to the Contractor. The Contractor shall be responsible for any cost recovery for retesting costs from the party responsible for executing the faulty start-up or checkout test item.

- E. Refer to Section 019113 "General Commissioning Requirements" for additional requirements.

3.14 ACCEPTANCE

- A. After tests described in this specification are performed to the satisfaction of both the Engineer and the Owner, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Engineer will provide a written statement of each exempted test. Exempted tests shall be performed as part of the warranty.
- B. Control system shall not be accepted until completed demonstration forms and checklists are submitted and approved. Refer to this section "Submittals."

3.15 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Section 017900 "Demonstration and Training" and Section 230100 "General Provisions for HVAC".

3.16 TRAINING

- A. Engage a factory-trained representative to provide full instruction to designated personnel in the

operation and maintenance of the building automation system. Orient the training specifically to the system installed. Instructors shall be thoroughly familiar with the subject matter they are to teach.

- B. Provide a training manual for each student at each training phase that describes in detail the data included in each training program. Provide one additional copy for archiving
- C. Conduct training at the site at a time mutually agreeable between the Owner, Commissioning Authority and Contractor and the contractor prior to final acceptance.
- D. Provide course outline and materials according to Article "Submittals." Provide one copy of training material per student.

END OF SECTION 230900

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 1. Hot-water heating piping.
 2. Chilled-water piping.
 3. Condensate-drain piping.

1.3 DEFINITIONS

- A. PTFE: Polytetrafluoroethylene.

1.4 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
 1. Hot-Water Heating Piping: 150 psig (1034 kPa) at 200 deg F (93 deg C) .
 2. Chilled-Water Piping: 150 psig (1034 kPa) at 200 deg F (93 deg C) .

1.5 Condensate-Drain Piping: 150 deg F (66 deg C) ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 2. Air control devices.
 3. Chemical treatment.
 4. Hydronic specialties.
- B. Shop Drawings: Detail, at 1/8 (1:100) scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Welding certificates.
- C. Field quality-control test reports.
- D. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.
- B. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.9 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: **ASTM B 88, Type L (ASTM B 88M, Type B)** .

- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Wrought-Copper Fittings: ASME B16.22.
- E. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.
- B. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.
- C. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.
- D. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.
- E. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- F. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- G. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

- D. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- E. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C) .
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric-Flange Insulating Kits:
 - 1. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: 150 psig (1035 kPa) .
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.

2.5 VALVES

- A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping."
- B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230900 "Instrumentation and Control for HVAC."
- C. Bronze, Calibrated-Orifice, Balancing Valves:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO; INC.; 1710 or a comparable product by one of the following:
 - a. Flow Design Inc.
 - b. Griswold Controls.
 - c. Taco.
 - 2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 - 3. Ball: Brass or stainless steel.
 - 4. Plug: Resin.
 - 5. Seat: PTFE.

6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig (860 kPa).
10. Maximum Operating Temperature: 250 deg F (121 deg C).

D. Cast-Iron, Calibrated-Orifice, Balancing Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide NIBCO, INC; F737A or a comparable product by one of the following:
 - a. Watts; CSM-81-F.
 - b. Wheatley; PSV
2. Body: Cast-iron , plug, or globe pattern with calibrated orifice or venturi.
3. Plug Seal: Isobutene-Isoprene
4. Bearings: Stainless Steel
5. Packing: Buna
6. Disc: EPDM coated cast-iron.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Non-rising stem hand wheel or square nut, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig (860 kPa).
11. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flow Design Inc.
 - b. Griswold Controls.
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel , tamper proof, self cleaning, and removable.
4. Dual pressure/temperature test plugs across flow control cartridge.
5. Combination Assemblies: Include bronze ball valve.
6. Identification Tag: Marked with zone identification, valve number, and flow rate.
7. Size: Same as pipe in which installed.
8. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
9. Minimum CWP Rating: 175 psig (1207 kPa) .
10. Maximum Operating Temperature: 250 deg F (121 deg C).

F. Combination Strainer / Isolation Ball Valve:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flow Design Inc.

b. Griswold Controls.

2. Body: Forged or cast brass.
3. Connections: Threaded with union inlet.
4. Combination Assemblies: Include bronze ball valve, union and strainer.
5. Strainer: 20 mesh stainless steel; provide drain valve with hose bibb adaptor and cap on strainer port. Provide a pressure/temperature test plug at the strainer inlet and outlet.
6. Valve: Nickel-plated brass ball with EPDM O-rings behind the seals.
7. Size: NPS 2" and smaller.
8. Minimum CWP Rating: 275 psig.
9. Maximum Operating Temperature: 250 deg F.

G. Combination Union / Isolation Ball Valve:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flow Design Inc.
 - b. Griswold Controls.
2. Body: Forged or cast brass.
3. Connections: Threaded with union inlet.
4. Combination Assemblies: Include bronze ball valve and union.
5. Union: Provide union with four ¼" body tappings with brass end connections. Union seal shall be EPDM O-rings. Provide an automatic air vent in the top tapping and a pressure/temperature test plug.
6. Valve: Nickel-plated brass ball with EPDM O-rings behind the seals.
7. Size: NPS 2" and smaller.
8. Minimum CWP Rating: 275 psig.
9. Maximum Operating Temperature: 250 deg F.

H. Isolation Union:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flow Design Inc.
 - b. Griswold Controls.
2. Body: Forged or cast brass.
3. Connections: Threaded.
4. Union: Provide union with four ¼" body tappings with brass end connections. Union seal shall be EPDM O-rings. Provide a pressure/temperature test plug.
5. Size: NPS 2" and smaller.
6. Minimum CWP Rating: 275 psig.
7. Maximum Operating Temperature: 250 deg F.

2.6 HYDRONIC COIL PACKAGES

- A. Provide the following arrangements for individual coil connections 2" NPS and smaller where indicated on the drawings.
 - 1. Supply Side: Provide Combination Strainer / Isolation Ball Valve.
 - 2. Return Side:
 - a. Modulating Control (Two Way): Provide combination union / isolation ball valve on leaving side of control valve and isolation union on inlet side of control valve. Provide pressure independent control valve specified in section 230900.
- B. Provide hose kits complete with flame retardant hose.

2.7 AIR CONTROL DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Amtrol, Inc.
 - 2. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - 3. Taco.
- B. Automatic Air Vents:
 - 1. Body: Bronze or cast iron.
 - 2. Internal Parts: Nonferrous.
 - 3. Operator: Noncorrosive metal float.
 - 4. Inlet Connection: **NPS 1/2 (DN 15)**.
 - 5. Discharge Connection: **NPS 1/4 (DN 8)**.
 - 6. CWP Rating: **150 psig (1035 kPa)**.
 - 7. Maximum Operating Temperature: **240 deg F (116 deg C)**.

2.8 HYDRONIC PIPING SPECIALTIES

- A. Y-Pattern Strainers:
 - 1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
 - 2. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
 - 3. Strainer Screen: 40 -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 - 4. CWP Rating: **125 psig (860 kPa)**.
- B. Expansion fittings are specified in Section 230516 "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-water heating piping, aboveground, **NPS 2 (DN 50)** and smaller, shall be any of the following:
 - 1. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
- B. Hot-water heating piping, aboveground, **NPS 2-1/2 (DN 65)** and larger, shall be any of the following:
 - 1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
- C. Chilled-water piping, aboveground, **NPS 2 (DN 50)** and smaller, shall be any of the following:
 - 1. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
- D. Chilled-water piping, aboveground, **NPS 2-1/2 (DN 65)** and larger, shall be any of the following:
 - 1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
- E. Condensate-Drain Piping: Type **M (C)**, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- F. Air-Vent Piping:
 - 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
 - 2. Outlet: Type **K (A)**, annealed-temper copper tubing with soldered or flared joints.

3.2 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.
- B. Install calibrated-orifice, balancing valves at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
 - 1. Balancing valve may be omitted where flow control valve or pressure independent control valve is provided.
- D. Install calibrated-orifice, balancing valves in the return pipe for each coil where split coils are provided.

3.3 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping to permit valve servicing.
- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- K. Install drains, consisting of a tee fitting, **NPS 3/4 (DN 20)** ball valve, and short **NPS 3/4 (DN 20)** threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- L. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- M. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- N. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- O. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."
- P. Install unions in piping, **NPS 2 (DN 50)** and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- Q. Install flanges in piping, **NPS 2-1/2 (DN 65)** and larger, at final connections of equipment and elsewhere as indicated.
- R. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install **NPS 3/4 (DN 20)** nipple and ball valve in

blowdown connection of strainers **NPS 2 (DN 50)** and larger. Match size of strainer blowoff connection for strainers smaller than **NPS 2 (DN 50)**.

- S. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Section 230516 "Expansion Fittings and Loops for HVAC Piping."
- T. Identify piping as specified in Section 230553 "Identification for HVAC Piping and Equipment."
- U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than **20 feet (6 m)** long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping **20 feet (6 m)** or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping **20 feet (6 m)** or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
 - 1. **NPS 3/4 (DN 20)**: Maximum span, **7 feet (2.1 m)**; minimum rod size, **1/4 inch (6.4 mm)**.
 - 2. **NPS 1 (DN 25)**: Maximum span, **7 feet (2.1 m)**; minimum rod size, **1/4 inch (6.4 mm)**.
 - 3. **NPS 1-1/2 (DN 40)**: Maximum span, **9 feet (2.7 m)**; minimum rod size, **3/8 inch (10 mm)**.
 - 4. **NPS 2 (DN 50)**: Maximum span, **10 feet (3 m)**; minimum rod size, **3/8 inch (10 mm)**.
 - 5. **NPS 2-1/2 (DN 65)**: Maximum span, **11 feet (3.4 m)**; minimum rod size, **3/8 inch (10 mm)**.
 - 6. **NPS 3 (DN 80)**: Maximum span, **12 feet (3.7 m)**; minimum rod size, **3/8 inch (10 mm)**.
 - 7. **NPS 4 (DN 100)**: Maximum span, **14 feet (4.3 m)**; minimum rod size, **1/2 inch (13 mm)**.
 - 8. **NPS 6 (DN 150)**: Maximum span, **17 feet (5.2 m)**; minimum rod size, **1/2 inch (13 mm)**.
 - 9. **NPS 8 (DN 200)**: Maximum span, **19 feet (5.8 m)**; minimum rod size, **5/8 inch (16 mm)**.

- D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
 - 2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
 - 3. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
- E. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- E. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.6 HYDRONIC SPECIALTIES INSTALLATION

- A. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.

3.7 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.

- C. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Section 230519 "Meters and Gages for HVAC Piping."

3.8 CHEMICAL TREATMENT

- A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling.
- B. Existing Condenser Water Pipes:
 - 1. Perform an analysis of the existing abandoned condenser water pipes that will be used for new chilled water piping. Determine type and quantities of chemical treatment needed to remove existing scale, corrosion, and fouling.
 - 2. Provide all necessary provisions and equipment (including, but not limited to, temporary pumps, bypass piping, valves, and associated electrical) to perform chemical treatment according to Section 232500 "HVAC Water Treatment".
- C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.9 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
 - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 - 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 - 3. Isolate expansion tanks and determine that hydronic system is full of water.
 - 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any

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

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

This Page Left Intentionally Blank

SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following HVAC water-treatment systems:
 - 1. HVAC water-treatment chemicals.

1.3 DEFINITIONS

- A. TDS: Total dissolved solids.

1.4 PERFORMANCE REQUIREMENTS

- A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1.5 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:
 - 1. Chemical material safety data sheets.
- B. Other Informational Submittals:
 - 1. Confirmation Report: Verify existing condenser water pipes have been cleaned, and confirm this observation in a letter to Engineer.

1.6 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

PART 3 - Motor characteristics such as NEMA designation, temperature rating, service factor, enclosure type, and efficiency are specified in Division EXECUTION

3.1 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 2. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 3. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 4. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.

END OF SECTION 232500

SECTION 233423 - HVAC POWER VENTILATORS

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. Utility set fans.
 - 2. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on sea level.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also 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 thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Roof curbs.
 - 7. Fan speed controllers.
- B. Delegated-Design Submittal: For attaching and securing stairwell shaft and elevator hoistway pressurization fans to isolate vibration and resist wind forces to comply with performance requirements and design criteria, including analysis data and details signed and sealed by the qualified professional engineer responsible for their preparation. Refer to Section 230548 – Vibration Controls for HVAC.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

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. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
- C. UL Standards: Power ventilators shall comply with UL 705.

1.8 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.
- C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 UTILITY SET FANS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Carnes Company.
 - 2. Greenheck Fan Corporation.
 - 3. Loren Cook Company.
 - 4. PennBarry.
- B. Housing: Fabricated of aluminum with side sheets fastened with a deep lock seam or welded to scroll sheets.
 - 1. Housing Discharge Arrangement: Adjustable to eight standard positions.
- C. Fan Wheels: Single-width, single inlet; welded to aluminum inlet cone, with hub keyed to shaft.
 - 1. Blade Materials: Aluminum.
 - 2. Blade Type: Airfoil.

- D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
- E. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L₅₀ of 200,000 hours.
 - 1. Extend grease fitting to accessible location outside of unit.
- F. Belt Drives:
 - 1. Factory mounted, with final alignment and belt adjustment made after installation
 - 2. Service Factor Based on Fan Motor Size: 1.5.
 - 3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - 4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - 5. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
 - 6. Provide 1.5 times the number of belts required for operation with minimum of 2 belts.
- G. Accessories:
 - 1. Inlet and Outlet: Flanged.
 - 2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 - 3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge. (Basis of Design: Ruskin CBS8 Heavy Duty Counterbalanced Backdraft Damper with Internal Counter-weights or Approved Equal.)
 - 4. Access Door: Gasketed door in scroll with latch-type handles.
 - 5. Inlet Screens: Removable wire mesh.
 - 6. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing.
 - 7. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
 - 8. Integral Curb: Cap and Plenum Assembly: Plenum box shall include removable gasketed access door with adjustable quick release latches.
 - 9. Vibration Isolators:
 - a. Type: Isolation pads.
 - 10. Other features as indicated on drawings.
 - 11. Coating:
 - a. Baked powder coating, with UV inhibitors.
 - b. Color: As selected by Architect from manufacturer's full range.

2.2 IN-LINE CENTRIFUGAL FANS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Carnes Company.
 2. Greenheck Fan Corporation.
 3. Loren Cook Company.
 4. PennBarry.
- 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-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- E. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 2. Companion Flanges: For inlet and outlet duct connections.
- F. Characteristics:
1. Vibration Isolators:
 - a. Type: Spring hangers .
 - b. Static Deflection: 1 inch (25 mm) .
 2. Spark Arrestance Class: A .

2.3 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Enclosure Type: Totally enclosed, fan cooled.

2.4 SOURCE QUALITY CONTROL

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

Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.
- C. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch (25 mm) . Vibration-control devices are specified in Section 230548 "Vibration Controls for HVAC Piping and Equipment." Install units with clearances for service and maintenance.
- D. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - 5. Adjust belt tension.

6. Adjust damper linkages for proper damper operation.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

END OF SECTION 233423

SECTION 233900 - LOUVERS AND VENTS

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. Combination, extruded-aluminum louvers.
- B. Related Sections:
 - 1. Section 230900 "Instrumentation and Control for HVAC" for electric, electronic, and pneumatic control of adjustable louvers.
 - 2. Section 237313 "Modular Outdoor Central-Station Air Handling Units" for louver requirements of outdoor air handling units.

1.3 DEFINITIONS

- A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.
- B. Horizontal Louver: Louver with horizontal blades; i.e., the axes of the blades are horizontal.
- C. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.
- D. Storm-Resistant Louver: Louver that provides specified wind-driven rain performance, as determined by testing according to AMCA 500-L.

1.4 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
 - 1. Wind Loads: Determine loads based on pressures as indicated on Drawings.

- B. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
- B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.
 - 1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.
 - 2. Show mullion profiles and locations.
 - 3. Wiring Diagrams: For power, signal, and control wiring for motorized adjustable louvers.

1.6 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: Based on evaluation of comprehensive tests performed according to AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.

1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain louvers and vents from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.
- B. Welding: Qualify procedures and personnel according to the following:
 - 1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - 2. AWS D1.3, "Structural Welding Code - Sheet Steel."
 - 3. AWS D1.6, "Structural Welding Code - Stainless Steel."
- C. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.
- D. UL and NEMA Compliance: Provide motors and related components for motor-operated louvers that are listed and labeled by UL and comply with applicable NEMA standards.

1.8 PROJECT CONDITIONS

- A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Aluminum Extrusions: **ASTM B 221 (ASTM B 221M)**, Alloy 6063-T5, T-52, or T6.
- B. Aluminum Sheet: **ASTM B 209 (ASTM B 209M)**, Alloy 3003 or 5005 with temper as required for forming, or as otherwise recommended by metal producer for required finish.
- C. Aluminum Castings: ASTM B 26/B 26M, Alloy 319.
- D. Fasteners: Use types and sizes to suit unit installation conditions.
 - 1. Use Phillips flat-head screws for exposed fasteners unless otherwise indicated.
 - 2. For fastening aluminum, use aluminum or 300 series stainless-steel fasteners.
 - 3. For fastening galvanized steel, use hot-dip-galvanized steel or 300 series stainless-steel fasteners.
 - 4. For color-finished louvers, use fasteners with heads that match color of louvers.
- E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2 FABRICATION, GENERAL

- A. Assemble louvers in factory to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
- B. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.
 - 1. Continuous Vertical Assemblies: Fabricate units without interrupting blade-spacing pattern unless horizontal mullions are indicated .
- C. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.
- D. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
 - 1. Frame Type: Exterior flange unless otherwise indicated.
- E. Include supports, anchorages, and accessories required for complete assembly.
- F. Provide vertical mullions of type and at spacings indicated, but not more than recommended by manufacturer, or **72 inches (1830 mm)** o.c., whichever is less.
 - 1. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling

limitations, provide interlocking split mullions designed to permit expansion and contraction.

- G. Provide extended sills for recessed louvers.
- H. Join frame members to each other and to fixed louver blades with fillet welds, threaded fasteners, or both, as standard with louver manufacturer unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.3 ADJUSTABLE, EXTRUDED-ALUMINUM LOUVERS

- A. Louver Construction and Operation: Provide combination louvers with extruded-aluminum frames and blades not less than **0.080-inch (2.03-mm)** nominal thickness, and with operating mechanisms to suit louver sizes. Frame shall contain both front stationary blades and rear adjustable blades. Front blades shall be drainable. Rear adjustable blades shall pivot on plated steel hex axles with stainless steel sleeve bearings.
 - 1. Motor operation with 2-position, spring-return application (with power on, motor opens louver; with power off, spring closes louver); 110-V, 60-Hz motor and limit switch ; equipped with terminals for controlling devices.
- B. Combination Louver and Damper :
 - 1. **Basis-of-Design Product:** Subject to compliance with requirements, provide Ruskin Company; ELC6375DAX or comparable product by one of the following:
 - a. Carnes Company, Inc.
 - b. Cesco Products; a division of Mestek, Inc.
 - c. Greenheck Fan Corporation.
 - 2. Louver Depth: **6 inches (150 mm)**.
 - 3. Blade Type: Drainable.
 - 4. Accessories: Equip louvers as follows:
 - a. Vinyl blade-edge gaskets for each louver blade.
 - b. Aluminum jamb seals.
 - 5. Louver Performance Ratings:
 - a. Free Area: Not less than **7.5 sq. ft. (0.70 sq. m)** for **48-inch- (1220-mm-)** wide by **48-inch- (1220-mm-)** high louver.
 - b. Point of Beginning Water Penetration: Not less than **1100 fpm (5.6 m/s)**.
 - c. Air Performance: Not more than **0.15-inch wg (25-Pa)** static pressure drop at **1100-fpm (5.6-m/s)** free-area intake velocity.
 - d. Air Leakage: Not more than **3.5 cfm/sq. ft. (17.8 L/s per sq. m)** of louver gross area at a differential static pressure of **0.15-inch wg (37 Pa)** with adjustable louver blades closed.
 - 6. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.4 LOUVER SCREENS

- A. General: Provide screen at each exterior louver.
 - 1. Screen Location for Adjustable Louvers: Interior face unless otherwise indicated.
 - 2. Screening Type: Bird screening.
- B. Secure screen frames to louver frames with stainless-steel machine screws , spaced a maximum of **6 inches (150 mm)** from each corner and at **12 inches (300 mm)** o.c.
- C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
 - 1. Metal: Same kind and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.
 - 2. Finish: Same finish as louver frames to which louver screens are attached.
 - 3. Type: Non-rewirable, U-shaped frames.
- D. Louver Screening for Aluminum Louvers:
 - 1. Bird Screening: Aluminum, **1/2-inch- (13-mm-)** square mesh, **0.063-inch (1.60-mm)** wire.

2.5 BLANK-OFF PANELS

- A. Insulated, Blank-Off Panels: Laminated panels consisting of insulating core surfaced on back and front with metal sheets and attached to back of louver.
 - 1. Thickness: **2 inches (50 mm)**.
 - 2. Metal Facing Sheets: Aluminum sheet, not less than **0.032-inch (0.81-mm)** nominal thickness.
 - 3. Insulating Core: Extruded-polystyrene foam .
 - 4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard extruded-aluminum-channel frames, not less than **0.080-inch (2.03-mm)** nominal thickness , with corners mitered and with same finish as panels.
 - 5. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
 - 6. Panel Finish: Same type of finish applied to louvers, but black color.
 - 7. Attach blank-off panels with sheet metal screws.

2.6 FINISHES, GENERAL

- A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

2.7 ALUMINUM FINISHES

- A. Finish louvers after assembly.
- B. High-Performance Organic Finish: 3 -coat fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in both color coat and clear

topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

- A. Locate and place louvers and vents level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Form closely fitted joints with exposed connections accurately located and secured.
- D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
- F. Protect unpainted galvanized and nonferrous-metal surfaces that will be in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.
- G. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required.

3.4 ADJUSTING AND CLEANING

- A. Test operation of combination louvers and adjust as needed to produce fully functioning units that comply with requirements.

- B. Clean exposed surfaces of louvers and vents that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.
- C. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
- D. Restore louvers and vents damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
 - 1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 233900

This Page Left Intentionally Blank

SECTION 237313 - MODULAR OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Variable-air-volume, single-zone air-handling units.

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Casing panels shall be self-supporting and capable of withstanding the greater of 8-inches water gauge or 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of $L/200$ where "L" is the unsupported span length within completed casings.
- B. Acoustical Performance: Sound power levels (dB) for the unit shall not exceed specified levels. The manufacturer shall provide necessary sound treatment to meet these levels if required.
- C. Leakage: The casing leakage rate shall not exceed 0.5 cfm per square foot of cabinet area at 6-inches of negative static pressure or 5-inches of positive static pressure (0.0025 m/s per square meter of cabinet area at 1.24 kPA static pressure).
- D. Condensation: During first year guarantee period, if condensation forms on any section of air handler when unit is operating at design conditions, contractor shall replace or repair unit to correct the situation. Repairs shall not impair unit or component accessibility and future repair ability and inherent access for maintenance. All repairs shall be subject to Engineer's approval.

1.4 ACTION SUBMITTALS

- A. Product Data: For each air-handling unit indicated.
 - 1. Unit dimensions and weight.
 - 2. Cabinet material, metal thickness, finishes, insulation, and accessories.
 - 3. Fans:
 - a. Certified fan-performance curves with system operating conditions indicated.
 - b. Certified fan-sound power ratings for discharge, radiated and return positions by octave band.
 - c. Fan construction and accessories.

- d. Motor ratings, electrical characteristics, and motor accessories.
- 4. Certified coil-performance ratings with system operating conditions indicated. Psychometric chart for each cooling coil with design and final operating points.
- 5. Calculations for required baserail heights to satisfy condensate trapping requirements of cooling coil.
- 6. Installation instructions.
- 7. Dampers, including housings, linkages, and operators.
- 8. Filters with performance characteristics.
- 9. Louvers with performance characteristics.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Mechanical layout and relationships between components and adjacent structural and mechanical elements.
 - 2. Support location, type, and weight.
 - 3. Field measurements.
 - 4. Required clearances.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: One set(s) for each air-handling unit.
 - 2. Gaskets: One set(s) for each access door.
 - 3. Fan Belts: One set(s) for each air-handling unit fan.

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. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

- C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
- D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- E. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. Comply with NFPA 70.

1.9 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.
- C. The Contractor and the air handling unit manufacturer shall be responsible for insuring that the unit will not exceed the allocated space shown on the drawings, including required clearances for service and future overhaul or removal of unit components. All structural, piping, wiring and ductwork alterations of units which are dimensionally different than those specified shall be the responsibility of the contractor at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
 1. [Carrier Corporation; a member of the United Technologies Corporation Family.](#)
 2. [McQuay International](#)
 3. [Trane; American Standard Inc.](#)
 4. Haakon.
 5. Temptrol.
 6. Temtrol.

2.2 UNIT CASINGS

- A. General Fabrication Requirements for Casings:
 1. General: Unit shall be designed and built specifically for outdoor installation. Unit shall be designed and constructed such that removal of any panel shall not affect the structural integrity of the unit. Plug panels may be used to enhance structural stability provided access space is not reduced.
 2. Forming: Fabricate with channel posts and panels. Form walls, roofs, and floors with at

least two breaks at each joint. Panels and access doors shall be constructed as 2-inch (50 mm) nominal thick; thermal broke double wall assembly.

3. Casing Joints: Mechanical fasteners.
4. Sealing: All panels and ship sections shall be sealed with permanently applied bulb-type gaskets. Shipped loose gasketing is not allowed. Module to module assembly shall be accomplished with an overlapping, full perimeter, insulated, internal splice joint sealed with bulb type gasketing on both mating modules.
5. Factory Finish for Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.
6. Casing Coating: Epoxy .
7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
8. Blank Offs: Provide where required to insure no air bypass between sections, through perforated panels or around coils or filters.
9. Roof shall be pitched for drainage and shall overlap the side panel on all four sides. The roof shall be gasketed and secured to the wall panels with zinc coated steel screws. Roof panel section joints shall be gasketed and bolted together.
10. Provide sealed sleeves, metal or plastic escutcheons or grommets for penetrations through casing for power and temperature control wiring and pneumatic tubing. Coordinate number and location with electrical and temperature control subcontractors. Coordinate lights, switches, duplex outlets and disconnect switch location and mounting. All field penetrations shall be performed neatly by drilling or saw cutting. No cutting by torches will be allowed. Neatly seal all openings.
11. Lifting brackets shall be provided by the manufacturer to permit lifting of unit sections without slings.

B. Casing Insulation and Adhesive:

1. Materials: ASTM C 1071, injected foam insulation with a composite minimum R-value of R-13.
2. Location and Application: Encased between outside and inside casing.

C. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
2. Access Doors:
 - a. Hinges: A minimum of two ball-bearing hinges or minimum 6 inch (150 mm) stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - b. Gasket: Permanently applied neoprene bulb-type gaskets, applied around entire perimeters of panel frames. Shipped loose gasketing is not allowed.
 - c. Fabricate windows in fan section doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
 - d. Size: At least 18 inches (450 mm) wide by full height of unit casing up to a maximum height of 60 inches (1500 mm) .

3. Locations and Applications:
 - a. Fan Section: Doors .
 - b. Access Section: Doors.
 - c. Doors.Damper Section: Doors.
 - d. Filter Section: Doors large enough to allow periodic removal and installation of filters.
4. Service Light: 100-W vaporproof fixture with switched junction box located outside adjacent to door.
 - a. Locations: Each section accessed with door .

D. Condensate Drain Pans:

1. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
 - a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1 .
 - b. Depth: A minimum of **2 inches (50 mm)** deep.
2. Formed sections .
3. Double-wall, 304 stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
4. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
 - a. Minimum Connection Size: **NPS 2 (DN 50)** .
5. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

- E. Air-Handling-Unit Mounting Frame: **8-inch (200 mm)** high full perimeter formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs. Welded or bolted cross members shall be provided as required for lateral stability.

2.3 FAN, DRIVE, AND MOTOR SECTION

- A. Fan and Drive Assemblies: Statically and dynamically balanced on all three planes and at all bearing points and designed for continuous operation at maximum-rated fan speed and motor horsepower.
1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
 - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
 - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's

speed range.

- B. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.
- C. Fan Array: The fan array shall consist of multiple fan and motor "cubes", spaced in the air way tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein. The velocity profile shall not exceed the specified cooling coil and/or filter bank face velocity when measured at a point 12" from the intake side of the fan array intake plenum wall, and at a distance of 48" from the discharge side of the fan intake plenum wall.
 - 1. Each fan/motor assembly shall be removable through a 30" wide (free area) access door located on the inlet side of the fan wall array.
 - 2. Each fan motor shall be individually field wired to a point of common coupling on a single VFD configured with dual motor output terminals rated for the total connected HP for all fan motors contained in the array.
 - 3. Fans: Provide direct driven, arrangement 4 plenum fans constructed per AMCA requirements for the duty specified, (Class II). All fans shall be selected to deliver the specified airflow quantity at the specified operating total static pressure and specified fan/motor speed. The fan array shall be selected to operate at a system total static pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed. Each fan/motor "cube" shall include an 11 gauge, A60 Galvanized steel intake wall, 14 gauge spun steel inlet funnel, and an 11 gauge G90 Galvanized steel motor support plate and structure. The fan intake wall, inlet funnel, and motor support structure shall be powder coated for superior corrosion resistance. All motors shall be standard pedestal mounted type, ODP, T-frame motors selected at the specified operating voltage, RPM, and efficiency as specified or as scheduled elsewhere. All motors shall include isolated bearings or shaft grounding. Each fan/motor cartridge shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 2.5 residual unbalance.
- D. Fan Shaft Bearings:
 - 1. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit.
- E. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.
 - 1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - 2. Motor Pulleys: Adjustable pitch for use with 7-1/2-hp motors and smaller; fixed pitch for use with motors larger than 7-1/2 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - 3. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
- F. Internal Vibration Isolation: Fans shall be factory mounted with rubber-in-shear vibration isolation mounting devices having a minimum static deflection of 1 inch (25 mm).
- G. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and

efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Open drip-proof.
2. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.4 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with ARI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit and shall be removable through side and/or top panels of unit without need to remove and disassemble the entire section from the unit.
4. Enclose coil headers and return bends completely within unit casing.
5. Coil connections shall be factory sealed with grommets on interior and exterior and gasket sleeve between outer wall and liner to minimize air leakage and condensation inside panel assembly. If not factory packaged; contractor shall supply all coil connection grommets and sleeves.
6. Vent and drain fittings shall be furnished on coil connections exterior to the air handler.

2.5 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:

1. Comply with NFPA 90A.
2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Provide filter holding frames arranged for flat or angular orientation, with access doors on one side of unit. Filters shall be removable from one side or lifted out from access plenum.
4. Provide filter types indicated. Comply with requirements in Section 234100 "Particulate Air Filtration" .

B. Filter Gage:

1. ~~3-1/2-inch~~ (90-mm) diameter, diaphragm-actuated dial in metal case.
2. Vent valves.
3. Black figures on white background.
4. Front recalibration adjustment.
5. 2 percent of full-scale accuracy.
6. Range: ~~0- to 2.0-inch wg~~ (0 to 500 Pa) .
7. Accessories: Static-pressure tips with integral compression fittings, ~~1/4-inch~~ (6-mm)

aluminum tubing, and 2- or 3-way vent valves.

2.6 ADDITIONAL SECTIONS

- A. Access Sections: Provide to allow access between coils and as otherwise required or indicated. Access section shall be a minimum of **20 inches (508 mm)** deep.
- B. Custom Section(s): Provided by the air handler manufacturer as an integral section of the unit for field installation of special components.
- C. Inlet and/or Discharge Plenum: Provide with single or multiple openings as indicated.
- D. Operable Storm Louver: Provide operable storm louver according to Section 233900 – “Louvers and Vents”.

2.7 DAMPERS

- A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at **2000-fpm (10-m/s)** face velocity through damper and **4-inch wg (1000-Pa)** pressure differential.
- B. Damper Operators: Comply with requirements in Section 230900 "Instrumentation and Control for HVAC."
- C. Combination Filter and Mixing Section:
 - 1. Cabinet support members shall hold **4-inch- (100-mm-)** thick, pleated, flat, permanent or throwaway filters.

2.8 CAPACITIES AND CHARACTERISTICS

- A. Casing:
 - 1. Outside Casing: G90 galvanized steel, minimum **0.064 inch (1.6 mm)** thick.
 - 2. Inside Casing: G90 galvanized steel, solid, minimum **0.064 inch (1.6 mm)** thick.
 - 3. Floor Plate: G90 galvanized steel, minimum **0.064 inch (1.6 mm)** thick.
 - 4. Insulation Thickness: **2 inches (50 mm)** .
 - 5. Static-Pressure Classifications for Unit Sections before Fans: **6-inch wg (1500 Pa)** .
 - 6. Static-Pressure Classifications for Unit Sections after Fans: **6-inch wg (1500 Pa)** .
- B. Supply Fan:
 - 1. Class II : AMCA 99-2408.
 - 2. Drive: Direct.
 - 3. Type: Plenum.
 - 4. Fan Housing and Wheel Coating: Epoxy ; .
- C. Preheat Coil:

1. Maximum Air-Side, Static-Pressure Drop: 0.25 inches wg (62 Pa).
2. Coil Type: Self-draining .
3. Coil Type: Steam distributed .
4. Piping Connections: Threaded , same end of coil.
5. Tube Material: Copper .
6. Tube Diameter: 0.625 inches (16 mm).
7. Tube Thickness: 0.025 inches (0.64 mm).
8. Fin Type: Plate .
9. Fin Material: Aluminum .
10. Maximum Fin Spacing: [<12 fins per inch (2.1 fins per mm).
11. Fin Thickness: 0.0075 inches (0.19 mm).
12. Fin and Tube Joint: Mechanical bond .
13. Headers: Seamless copper tube with brazed joints, prime coated.
14. Frames: Channel frame, 0.0625-inch (- 1.58-mm-) thick stainless steel.
15. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C) .
16. Water: Maximum Water Pressure Drop: 5.0 feet of head (14.9 kPa).

D. Cooling Coil:

1. Maximum Face Velocity: 500 fpm (152 m/s).
2. Maximum Air-Side, Static-Pressure Drop: 1.0 inches wg (249 Pa).
3. Coil Type: Self-draining .
4. Piping Connections: Threaded , same end of coil.
5. Tube Material: Copper .
6. Tube Diameter: 0.625 inches (16 mm).
7. Tube Thickness: 0.025 inches (0.64 mm).
8. Fin Type: Plate .
9. Fin Material: Aluminum .
10. Maximum Fin Spacing: 12 fins per inch (2.1 fins per mm).
11. Fin Thickness: 0.0075 inches (0.19 mm).
12. Fin and Tube Joint: Mechanical bond .
13. Headers: Seamless copper tube with brazed joints, prime coated.
14. Frames: Channel frame, 0.0625-inch (- 1.58-mm-) thick stainless steel.
15. Maximum Number of Rows: 10.
16. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C) .
17. Water: Maximum Water Pressure Drop: 10.0 feet of head (29.8 kPa).

2.9 ACCESSORIES

- A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

2.10 SOURCE QUALITY CONTROL

- A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

- B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density,

rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

- C. Water Coils: Factory tested to 300 psig (2070 kPa) according to ARI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to site.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish

3.3 INSTALLATION

- A. Unit Support: Install unit level on structural rails . Coordinate wall penetrations and flashing with wall construction. Secure unit to structural support with anchor bolts.
- B. Install wind and seismic restraints according to manufacturer's written instructions
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
- E. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.4 CONNECTIONS

- A. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to air-handling unit to allow service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using , **ASTM B 88, Type M (ASTM B 88M, Type C)** copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

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. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks.
 - 2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.

3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that outdoor- air dampers open and close, and maintain minimum outdoor-air setting.
7. Comb coil fins for parallel orientation.
8. Install new, clean filters.
9. Verify that manual and automatic volume control in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. .
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.8 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237313

SECTION 260953 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 1. System smoke detectors.
 2. Heat detectors.
 3. Notification appliances.
 4. Addressable interface device.
 5. Smoke Control System.
 6. Firefighters' two-way telephone communication service.

1.3 SYSTEM DESCRIPTION

- A. The existing Fire Alarm System is a Simplex, Noncoded, UL-certified, addressable system, with multiplexed signal transmission. A BACpac Ethernet module shall be added to the fire alarm panel to communicate with the BAS.
- B. Project Description: Add smoke pressurization in the 2 stairwells, in the 2 elevator shafts, and in the elevator machine room. Add firefighters' two-way telephone communications in the stairwells and elevator lobbies, and the control of 4 automatic door openers and provisions for 1 future automatic door opener.

1.4 PERFORMANCE REQUIREMENTS

- A. Fire alarm system design shall be approved by authorities having jurisdiction.
- B. Fire alarm system, as designed and installed, shall comply with NFPA 72.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. General Submittal Requirements:
 1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 260170 "Operation and Maintenance Data," include the following:
 - 1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
 - 2. Manufacturer's required maintenance related to system warranty requirements.
 - 3. Abbreviated operating instructions for mounting at fire-alarm control unit.
- B. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
 - 3. Device address list.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Source Limitations for Fire-Alarm Components: Obtain fire-alarm components from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. NFPA Certification: Obtain certification according to NFPA 72. PROJECT CONDITIONS
- E. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
 - 1. Notify Architect and Owner no fewer than fourteen days in advance of proposed interruption of fire-alarm service.
 - 2. Do not proceed with interruption of fire-alarm service without Architect's and Owner's written permission.

1.8 SEQUENCING AND SCHEDULING

- A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted.

1.9 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - 1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide products that are compatible with the existing fire alarm controller:
 - 1. SimplexGrinnell Model 4100U.

2.2 SYSTEM SMOKE DETECTORS

- A. General Requirements for System Smoke Detectors:
 - 1. Comply with UL 268; operating at 24-V dc, nominal.
 - 2. Detectors shall be two-wire type.
 - 3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 - 4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 - 5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 6. Integral Visual-Indicating Light: LED type indicating detector has operated.
 - 7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
- B. Photoelectric Smoke Detectors:
 - 1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 - 2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

- a. Primary status.
- b. Device type.
- c. Present average value.
- d. Present sensitivity selected.
- e. Sensor range (normal, dirty, etc.).

2.3 HEAT DETECTORS

- A. General Requirements for Heat Detectors: Comply with UL 521.
- B. Heat Detector, Combination Type: Actuated by either a fixed temperature of **135 deg F (57 deg C)** or a rate of rise that exceeds **15 deg F (8 deg C)** per minute unless otherwise required by NFPA 72.
 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
- C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of **190 deg F (88 deg C)**.
 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.4 ADDRESSABLE INTERFACE DEVICE

- A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall or to circuit-breaker shunt trip for power shutdown.

2.5 SMOKE CONTROL SYSTEM

- A. Smoke Control System: Provide a smoke control system which is UL 864 listed for smoke control system service. The system shall meet the requirements of the Florida Building Code, Section 909, Smoke Control Systems.

The purpose of this section is to establish minimum requirements for the design, installation, and testing of smoke control systems that are intended to provide a tenable environment for the evacuation or relocation of occupants. The system shall provide automatic operation of smoke zone pressurization fans, dampers, and doors for pressure relief.

Provide and install addressable modules to monitor status/operation of each smoke control fan, damper, and door. The fire alarm contractor shall terminate the modules to status indicators. Provide smoke control system adjacent to the existing FACP in a NEMA 1 painted enclosure with hinged, lockable front door/cover.

- B. Compatibility: The smoke control system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network. Compatibility shall be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers or protocol converters.
- C. Architecture: System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.
- D. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers, and operator devices.
- E. The annunciator shall graphically depict the building arrangement and smoke control system zones. Fans, major ducts, dampers, controlled doors, and airflow direction shall be indicated.

2.6 SMOKE CONTROL SYSTEM ANNUNCIATOR PANEL - LED STYLE

- A. Smoke Control System Panel: Provide LED-indicating lights located on the smoke control panel to indicate the status for all smoke control equipment.

Fans, dampers, and doors shall be indicated by the following color of LED for the indicated status:

NORMAL STATUS = GREEN LED
 OFF or CLOSED STATUS = RED LED
 FAULT STATUS = YELLOW LED

When the Smoke Control System is in the AUTO position, the actual status of each device shall continue to be indicated by the LED lamps listed above.

The Annunciator Panel shall have a label with the LED indicator lights to clearly indicate which fan is operating.

2.7 AUTOMATIC/MANUAL OPERATION

- A. Provide HOA (Hand-Off-Automatic) switches labeled "ON-AUTO-OFF" on the annunciator to permit fire-fighters' manual control of each individual smoke control fan, damper, and door.
- B. Smoke control system shall be automatically activated per NFPA 101.7.2.3.10.
- C. In the "AUTO" switch positions, fans, and exhaust fans operate automatically as controlled by the Smoke Control Panel. Automatic operation can be overridden with the HOA switches. HOA switches allow manual control override of any device.

- D. Provide a toggle or push-button switch to test the LED's mounted on the unit.

2.8 SCOPE OF TESTING

- A. The Smoke Control System testing shall meet the requirements of Specification Section 019113, paragraphs 1.4 and 1.10, and Specification Section 230130, paragraph 1.7.
- B. In addition to the initial testing, the smoke control system as a whole shall be automatically tested once a week per Florida Building Code, Section 909 requirements.

2.9 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION SERVICE

- A. Existing Simplex dedicated, two-way, supervised, telephone voice communication linking fire-alarm control unit and remote firefighters' telephone stations. Provide the following:
 - 1. Remote Telephone Jack Stations: Single-gang, stainless-steel-plate mounted plug, engraved "Fire Emergency Phone."

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72 for installation of fire-alarm equipment.
- B. Install wall-mounted equipment, with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
- C. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
 - 1. Connect new equipment to existing control panel in existing building.
 - 2. Expand, modify, and supplement existing control equipment as necessary to extend existing control and monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

3.2 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section "Door Hardware." Connect hardware and devices to fire-alarm system.
 - 1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and

systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to stairwell and elevator shaft pressurization systems.
2. Smoke dampers.
3. Automatic door openers.
4. Controlled doors for pressure relief.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

3.4 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by Engineer and authorities having jurisdiction .
- 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. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
 2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72, and Florida Building Code Section 909.
 3. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
- D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- E. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.5 DEMONSTRATION

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

END OF SECTION 260953

SECTION 264313 - TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

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 field-mounted TVSS for low-voltage (120 to 600 V) power distribution and control equipment.

1.3 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. SVR: Suppressed voltage rating.
- C. TVSS: Transient voltage surge suppressor(s), both singular and plural; also, transient voltage surge suppression.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.
- B. Product Certificates: For TVSS devices, from manufacturer.
- C. Warranties: Sample of special warranties.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For TVSS devices to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.
- B. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.

- C. Comply with NEMA LS 1.
- D. Comply with the latest edition of UL 1449.
- E. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

- A. Service Conditions: Rate TVSS devices for continuous operation under the following conditions unless otherwise indicated:
 - 1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
 - 2. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
 - 3. Humidity: 0 to 85 percent, noncondensing.

1.8 COORDINATION

- A. Coordinate location of field-mounted TVSS devices to allow adequate clearances for maintenance.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARD SUPPRESSORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Advanced Protection Technologies Inc. (APT).
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Liebert Corporation; a division of Emerson Network Power.
 - 4. Siemens Energy & Automation, Inc.
 - 5. Square D; a brand of Schneider Electric.
 - 6. Surge Suppression Incorporated.
- B. Surge Protection Devices:
 - 1. Comply with UL 1449.
 - 2. Short-circuit current rating complying with UL 1449, and matching or exceeding the

- panelboard short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
 - 3. Fuses, rated at 200-kA interrupting capacity.
 - 4. Fabrication using bolted compression lugs for internal wiring.
 - 5. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 6. LED indicator lights for power and protection status.
- C. Peak Single-Impulse Surge Current Rating: 150 kA per phase.
- D. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2:
- 1. Line to Neutral: 70,000 A.
 - 2. Line to Ground: 70,000 A.
 - 3. Neutral to Ground: 50,000 A.
- E. Protection modes and UL 1449 SVR for grounded wye circuits with 208Y/120 V, 3-phase, 4-wire circuits shall be as follows:
- 1. Line to Neutral: 400 V for 208Y/120 V.
 - 2. Line to Ground: 400 V for 208Y/120 V.
 - 3. Neutral to Ground: 400 V for 208Y/120 V.

2.2 ENCLOSURES

- A. Indoor Enclosures: NEMA 250 Type 1.
- B. Outdoor Enclosures: NEMA 250 Type 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install TVSS devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

3.2 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.
 - 1. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- 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:
- D. TVSS device will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Do not energize or connect service entrance equipment to their sources until TVSS devices are installed and connected.
- B. Do not perform insulation resistance tests of the distribution wiring equipment with the TVSS installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

END OF SECTION 264313