SPECIFICATIONS MANUAL
100% Construction Documents
ALW Project No. 22470

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Kellogg Building Remodel

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SECTION 230100
GENERAL PROVISIONS FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Provisions of this Section apply to all Division 23 Specification Sections.

1.02 SUMMARY

A. Section includes basic requirements for heating, ventilation, and air-conditioning systems.

B. Related Work:

1. Division 02 – Existing Conditions

    a. Refer to Division 02 for demolition and for abatement of hazardous materials.
    b. Comply with the requirements of Division 02 for selective demolition.

2. Division 03 – Concrete

    a. Refer to Division 03 for rough grouting in and around work, patching concrete cut to accommodate work, and sumps for work.
    b. Comply with the requirements of Division 03 for curbs, foundations, inertia bases, and equipment pads for equipment.

3. Division 05 – Metals

    a. Refer to Division 05 for framed openings for equipment.
    b. Comply with the requirements of Division 05 for supports for work.

4. Division 06 – Wood, Plastics, and Composites

    a. Refer to Division 06 for framed openings for equipment.

5. Division 07 – Thermal and Moisture Protection

    a. Refer to Division 07 for installation of roof curbs and roof supports and for caulking and waterproofing of wall- and roof-mounted work.
    b. Comply with the requirements of Division 07 for penetration firestopping and furnishing roof curbs and roof supports for equipment and piping.

6. Division 08 – Openings

    a. Refer to Division 08 for installation of access doors and frames and for louvers and vents.
    b. Comply with the requirements of Division 08 for access doors and frames and for louvers and vents, unless otherwise included in the Contract Documents.

7. Division 09 – Finishes

    a. Refer to Division 09 for paint products and applications in finished spaces.
    b. Comply with the requirements of Division 09 for paint products and applications identified in the Contract Documents.

8. Division 10 – Specialties

    a. Refer to Division 10 for fire protection cabinets and fire extinguishers.

9. Division 11 – Equipment

    a. Refer to Division 11 for to be provided.
    b. Comply with the requirements of Division 11 for connections and related devices to make these systems operational.

10. Division 21 – Fire Suppression

    a. Refer to Division 21 for all suppression work.

11. Division 22 – Plumbing

    a. Refer to Division 22 for all plumbing work.
    b. Comply with requirements of Division 22 for related equipment and components and for connections to systems.

12. Division 25 – Instrumentation and Control

    a. Refer to Division 25 for instrumentation and control systems.
    b. Comply with the requirements of Division 25 for installation of and integration with instrumentation and control components.

13. Division 26 – Electrical

    a. Refer to Division 26 for all electrical work.

14. Division 27 – Communications

    a. Refer to Division 27 for all communications work.

15. Division 28 – Electronic Safety and Security

    a. Refer to Division 28 for all electronic safety and security work.
    b. Coordinate with Division 28 for integration with security systems.

16. Division 29 – Fire Safety and Emergency Communications

    a. Refer to Division 29 for all fire safety and emergency communications work.
    b. Coordinate with Division 29 for integration with fire safety and emergency communications systems.

17. Division 31 – Earthwork

    a. Refer to Division 31 for all site related work greater than five feet outside the building, unless noted otherwise in the Contract Documents.

b. Comply with the requirements of Division 31 for site clearing, earth moving, and dewatering within five feet outside the building and otherwise as indicated in the Contract Documents.

18. Division 33 – Utilities

a. Refer to Division 33 for all utility related work greater than five feet outside the building, unless noted otherwise in the Contract Documents.
b. Comply with the requirements of Division 33 for utility work within five feet outside the building and otherwise as indicated in the Contract Documents.

1.03 DEFINITIONS

A. Experienced: When used with an entity or individual, “experienced” unless otherwise further described 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.

B. Furnish: Supply and deliver to project site, ready for subsequent requirements.

C. Install: Operations at project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar requirements.

D. Provide: Furnish and install, complete and ready for intended use.

E. Cutting: Removal of in-place construction necessary to permit installation or performance of subsequent work.

F. Patching: Fitting and repair work required to restore construction to original conditions after installation of subsequent work.

G. Concealed Work: Work hidden from view, including inside chases, furred spaces, or above ceilings.

H. Exposed Work: Work open to view, including inside mechanical and equipment rooms.

1.04 QUALITY ASSURANCE

A. General:

1. It is the intent of the plans and specifications to obtain a complete, operable and satisfactory installation.
2. All materials shall be new, be properly labeled and/or identified and be in full compliance with the contract documents.
3. All work shall comply with applicable Codes and Standards.
4. Manufacturer's model names and numbers used in these specifications are subject to change per manufacturer's action. Contractor shall therefore verify them with manufacturer's representative before ordering any product or equipment

B. Furnish new and unused materials and equipment manufactured in the U.S.A. Where two or more units of the same type or class of equipment are required provide units of a single manufacturer.

1.05 CODES AND STANDARDS

A. Perform work in accordance with the following codes and any applicable statutes, ordinances, codes, and regulations of governmental authorities having jurisdiction.

1. ASHRAE

   a. Standard 15 Safety Standard for Refrigeration Systems - 2019
   b. Standard 55 Thermal Environmental Conditions for Human Occupancy – 2017
   c. Standard 62.1 Ventilation Standard for Acceptable Indoor air Quality - 2019
   d. Standard 90.1 Energy Standard for Buildings Except Low Rise Residential Buildings - 2019

2. ASME

   a. Boiler and Pressure Vessel Code - 2019

      1) Section I Rules for Construction of Power Boilers
      2) Section IV Rules for Construction of Heating Boilers
      3) Section VIII Rules for Construction of Pressure Vessels

   b. ASME A17.1 Safety Code for Elevators and Escalators - 2019
   c. ASME A17.3 Safety Code for Existing Elevators and Escalators - 2020

3. Occupational Safety and Health Regulations (OSHA).
4. National Fire Codes

   a. NFPA 1 Uniform Fire Code – 2021 (Florida Edition)
   b. NFPA 30 Flammable and Combustible Liquids Code - 2021
   c. NFPA 54 National Fuel Gas Code – 2021
   d. NFPA 70 National Electrical Code – 2020
   e. NFPA 72 National Fire Alarm and Signaling Code - 2019
   f. NFPA 90A Standard for the Installation of Air Conditioning and Ventilation Systems - 2021
   g. NFPA 90B Standard for the Installation of Warm Air Heating and Air Conditioning Systems - 2021
   h. NFPA 91 Standard for the Installation of Blower and Exhaust Systems - 2020
   i. NFPA 101 Life Safety Code – 2021 (Florida Edition)

5. Florida Building Code, 2023 Edition

   a. Building Code
   b. Existing Building Code
   c. Energy Conservation Code
   d. Mechanical Code
   e. Plumbing Code
   f. Fuel Gas Code
   g. Accessibility Code

6. Florida Statutes

   a. Chapter 471 Engineering

b. Chapter 533.80 Building Construction Standards; Florida Building Code - Enforcement

7. Florida Administrative Code
   a. Chapter 9B-7 Florida Building Commission Handicapped Accessibility Standards
   b. Chapter 61C-5 Florida Elevator Safety Code
   c. Chapter 61G15-34 Responsibility Rules of Professional Engineers Concerning the Design of Mechanical Systems
   d. Chapter 69A-3 Fire Prevention – General Provisions
   e. Chapter 69A-47 Uniform Fire Safety Standards for Elevators
   f. Chapter 69A-60 The Florida Fire Prevention Code

B. Resolve, in writing, any code violation discovered in contract documents with the Engineer prior to bidding. After award of the contract, make any correction or addition necessary for compliance with applicable codes at no additional cost to Owner.

C. The Contractor shall include in the Work, without extra cost to the Owner, any labor, materials, services, apparatus, and drawings required to comply with all applicable laws, ordinances, rules, and regulations.

D. Where there is conflict between the Contract Documents and the applicable Codes, the Codes shall govern, except where the requirements of the Contract Documents are more stringent.

1.06 REFERENCE SPECIFICATIONS AND STANDARDS

A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, or AWWA Specifications; Federal Standards; or other standard specifications must comply with latest editions, revisions, amendments, or supplements in effect on date bids are received. Specifications and standards are minimum requirements for all equipment, material and work. In instances where capacities, size or other feature of equipment, devices or materials exceed these minimums, meet listed or shown capacities.

B. Whenever a reference is made to a standard, installation and materials shall comply with the latest published edition of the standard at the time project is bid unless otherwise specified herein

1.07 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1.08 PERMITS FEES AND INSPECTIONS

A. Obtain and pay for all permits, fees, tap fees, connection charges, demand charges, systems charges, impact fees, and inspections.

B. Deliver all certificates of inspection issued by authorities having jurisdiction to the Engineer.

1.09 CONFLICTING REQUIREMENTS

A. Conflicting Standards and Other Requirements: If compliance with two or more standards or requirements are specified and the standards or requirements 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 direction before proceeding.

1. If discrepancies or conflicts occur between drawings, or between drawings and specifications, notify the Engineer in writing prior to bid date; however, the most stringent requirement shall govern.

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.

1.10 REQUEST FOR INFORMATION (RFI)

A. General: Immediately on discovery of the need for additional information, clarification, or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.

1. Engineer will return without response those RFIs submitted to Engineer by other entities controlled by Contractor.
2. Coordinate and submit RFIs in a prompt manner to avoid delays in Contractor's work or work of subcontractors.

B. Prepare RFIs as PDF electronic files and electronically transmit to Engineer through email or web-based project software site, in accordance with Division 01 Specification Sections. **All electronic files shall ONLY be transmitted to inbox@h2engineering.com and shall not be transmitted to any individual email addresses for H2Engineering personnel.** Submittals shall be in searchable PDF format and not a scanned copy.

C. Engineer’s Action: Engineer will review each RFI, determine action required, and respond. Allow seven days for Engineer’s response for each RFI. RFIs received by Engineer after 1:00 p.m. Eastern Time will be considered as received the following working day.

1. The following Contractor-generated RFIs will be returned without action:

a. Requests for approval of submittals.
b. Requests for approval of substitutions.
c. Requests for approval of Contractor's means and methods.
d. Requests for coordination information already indicated in the Contract Documents.
e. Requests for adjustments in the Contract Time or the Contract Sum.
f. Requests for interpretation of Engineer’s actions on submittals.
g. Incomplete RFIs or inaccurately prepared RFIs.

2. Engineer’s action may include a request for additional information, in which case Engineer’s time for response will date from time of receipt by Engineer of additional information.

1.11 SUBMITTALS

A. Submittals (including Product Data, Shop Drawings, and any other Action Submittal or Information Submittal) will only be reviewed if they are submitted in full accordance with the General and Supplementary Conditions, Division 01, and the following:

1. Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are approved by the Engineer.
3. Submittals shall only contain relevant product data. Remove or strikeout irrelevant product data.
4. Prepare submittals as PDF electronic files and electronically transmit to Engineer through email or web-based project software site, in accordance with Division 01 Specification Sections. **All electronic files shall ONLY be transmitted to inbox@h2engineering.com and shall not be transmitted to any individual email addresses for H2Engineering personnel.** Submittals shall be in searchable PDF format and not a scanned copy.
5. Options: Identify options requiring selection by Engineer.
6. Deviations: Clearly identify deviations from requirements in the Contract Documents, including minor variations and limitations.
7. Revisions: Include relevant additional information and revisions, other than those specifically requested by Engineer on previous submittals. Indicate by highlighting on each submittal or noting on attached submittal sheet.
8. Contractor's Review:

    a. Submittals shall have been reviewed and approved by the General Contractor / Construction Manager. Include approval stamp, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.
    b. Engineer will not review submittals received from Contractor that do not have Contractor's review and approval.

9. Electrical Modifications:

    a. The electrical design indicated on the plans supports the Basis of Design specifications for the HVAC systems at the time of design.
    b. If HVAC equipment is submitted with different electrical requirements, it is the responsibility of the Contractor to resolve all required electrical design changes, including, but not limited to: wire and conduit size, type or size of disconnect or overload protection, breaker coordination, point(s) of connection, etc. Any corrections required shall be provided at no additional cost.
    c. Submittal shall clearly show the electrical design revisions with a written statement that this change will be provided at no additional cost. Submittals made with no written reference to the electrical design revisions will be presumed to work with the electrical design.

B. Processing Time: Time of review shall commence on Engineer's receipt of submittal. No extension of the Contract Time will be authorized because of the failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Allow not less than 15 days for submittal review. Allow not less than 21 days for review of large or complex submittals. Submittals received by Engineer after 1:00 p.m. Eastern Time will be considered as received the following working day.
2. If Contractor transmits more than five submittals over two consecutive business days, review time shall increase by no less than 7 days for submittal review.

3. Allow additional time if coordination with subsequent submittals is required. Engineer will advise Contractor when a submittal being processed must be delayed for coordination.
4. Engineer reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received. Time of review shall commence on receipt of all other related submittals.

C. The Contractor shall not be relieved of responsibility for deviations from requirements of the contract documents by the Engineer's approval of shop drawings, product data, samples, or similar submittals unless the Contractor has specifically informed the Engineer in writing of such deviation at the time of submittal, and the Engineer has given written approval to the specific deviation. The Contractor shall not be relieved of responsibility for errors or omissions in shop drawings, product data, samples, or similar submittals by the Engineer's approval thereof.

1.12 SUSTAINABLE DESIGN REQUIREMENTS

A. Sustainable Certification Program: Comply with requirements for Project to obtain certification based on FGBC's "Commercial Building Standard" (hereafter, "Certification Program"). Compliance with requirements needed to obtain Certification Program prerequisites and credits may be used as one criterion to evaluate substitution requests and comparable product requests.

B. Related Requirements:

1. General and Supplementary Conditions
2. Division 01 for general sustainable design certification and reporting requirements.
3. Comply with requirements in various Division 21 Sections specifying sustainable products and methods.

C. Sustainable design submittals are in addition to other submittals.

1. Comply with "Submittals" article in this Section.
2. If submitted item is identical to that submitted to comply with other requirements, include an additional copy with other submittal as a record of compliance with indicated Certification Program requirements instead of separate sustainable design submittal. Mark additional copy "Sustainable design submittal."

D. Sustainable Design Documentation Submittals

1. Environmental management system documents.
2. Environmental product declarations.
3. Third-party certifications based on multiple attribute standards.
4. Product Data and laboratory test reports for adhesives and sealants indicating VOC content and compliance with requirements for low-emitting materials.
5. Product Data and laboratory test reports for paints indicating VOC content and compliance with requirements for low-emitting materials.

1.13 COORDINATION DRAWINGS

A. Coordination Drawings, General: Prepare coordination drawings according to requirements in individual Sections, and additionally where installation is not completely indicated on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one entity.

1. Content: Project-specific information, drawn accurately to a scale large enough to indicate and resolve conflicts. Do not base coordination drawings on standard printed data. Include the following information, as applicable:

    a. Use applicable Drawings as a basis for preparation of coordination drawings. Prepare sections, elevations, and details as needed to describe relationship of various systems and components.
    b. Coordinate the addition of trade-specific information to coordination drawings by multiple contractors in a sequence that best provides for coordination of the information and resolution of conflicts between installed components before submitting for review.
    c. Indicate functional and spatial relationships of components of architectural, structural, civil, fire protection, mechanical, electrical, and communication systems.
    d. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.
    e. Show location and size of access doors required for access to concealed dampers, valves, pull boxes, junction boxes, and other controls.
    f. Indicate required installation sequences.
    g. Indicate dimensions shown on Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternative sketches to Engineer indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.

B. Coordination Drawing Organization: Organize coordination drawings as follows:

1. Floor Plans: Show architectural and structural elements, and Work associated with Divisions 21 through 29, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved. Supplement plan drawings with section drawings where required to adequately represent the Work.

    a. Mechanical Systems (Divisions 21, 22, 23, 25):

        1) Sizes and bottom elevations of ductwork and piping runs, including insulation, heat tracing, bracing, flanges, and support systems. Indicate proposed changes to layout.
        2) Locations and sizes of major equipment and components.
        3) Fire-rated enclosures around ductwork.
        4) Structural members to which ductwork and piping will be attached or suspended from.

    b. Electrical and Communication Systems (Divisions 25, 26, 27, 28, 29):

        1) Runs of vertical and horizontal conduit 1-1/4 inches in diameter and larger.
        2) Light fixture, exit light, emergency battery pack, smoke detector, and other fire-alarm locations.
        3) Panel board, switch board, switchgear, transformer, busway, generator, and motor-control center locations.
        4) Location of pull boxes and junction boxes, dimensioned from column center lines.
        5) Structural members to which luminaire and equipment will be attached or suspended from.
        6) Lightning protection system components attaching to or penetrating through the roofing and moisture protection systems, coordinated with the roofing system manufacturer.

7) Cable tray layout, offsets, transitions, clearances, elevations, and relationships between components and adjacent structural, mechanical and electrical elements.

2. Reflected Ceiling Plans: Show locations of visible devices mounted to, suspended from, or penetrating through the ceiling, relative to the finished ceiling, including the following:

   a. Fire suppression sprinklers and nozzles.
   b. Air outlets and inlets.
   c. Luminaires (Lighting fixtures).
   d. Lighting control devices.
   e. Speakers.
   f. Ceiling-mounted projectors.
   g. Access control devices.
   h. Video surveillance devices.
   i. Fire alarm devices.
   j. Access panels.
   k. Perimeter moldings.
   l. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the ceiling.

3. Plenum Space: Indicate subframing for support of ceiling and wall systems, equipment for Divisions 21 through 29, and related Work. Locate components within plenums to accommodate layout of components indicated on Drawings for Divisions 21 through 29. Indicate areas of conflict between components of Divisions 21 through 29.
4. Equipment Rooms: Provide coordination drawings for equipment rooms showing plans and elevations of equipment for Divisions 21 through 29.
5. Penetrations: Indicate locations of penetrations and openings in structural components, smoke barriers, and fire-rated construction.
6. Review: Engineer will review coordination drawings to confirm that in general the Work is being coordinated, but not for the details of the coordination, which are Contractor's responsibility. If Engineer determines that coordination drawings are not being prepared in sufficient scope or detail, or are otherwise deficient, Engineer will so inform Contractor, who shall make suitable modifications and resubmit.

C. Coordination Digital Data Files: Prepare coordination digital data files according to the following requirements:

1. File Submittal Format: Submit or post coordination drawing files using PDF format.
2. BIM File Incorporation: Develop and incorporate coordination drawing files into BIM established for Project.

   a. Perform three-dimensional component conflict analysis as part of preparation of coordination drawings. Resolve component conflicts prior to submittal. Indicate where conflict resolution requires modification of design requirements by Engineer.

3. Engineer will furnish Contractor one set of digital data files of Drawings for use in preparing coordination digital data files.

   a. Engineer makes no representations as to the accuracy or completeness of digital data files as they relate to Drawings.
   b. Contractor shall execute a data licensing agreement in the form of Agreement form acceptable to Engineer.

1.14 SUBSTITUTIONS

A. By submitting a bid, the Bidder represents that its bid is based on materials and equipment described in the Procurement and Contracting Documents, including Addenda. Bidders are encouraged to request approval of qualifying substitute materials and equipment when the Specifications Sections list materials and equipment by product or manufacturer name.

B. Substitution Requests shall include, at a minimum:

1. Statement indicating why specified material, equipment, or installation method cannot be provided, if applicable.
2. Coordination of information, including a list of changes and revisions needed to other parts of the Work and to construction performed by Owner and separate contractors that will be necessary to accommodate proposed substitution.
3. Detailed comparison of significant qualities of proposed substitutions with those of the Work specified. Include an annotated copy of applicable Specification Section. Significant qualities may include attributes, such as performance, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements indicated. Indicate deviations, if any, from the Work specified.
4. Product Data, including drawings and descriptions of products and fabrication and installation procedures.
5. Detailed comparison of Contractor's construction schedule using proposed substitutions with products specified for the Work, including effect on the overall Contract Time. If specified product or method of construction cannot be provided within the Contract Time, include letter from manufacturer, on manufacturer's letterhead, stating date of receipt of purchase order, lack of availability, or delays in delivery.
6. Cost information, including a proposal of change, if any, in the Contract Sum.
7. Contractor's certification that proposed substitution complies with requirements in the Contract Documents, except as indicated in substitution request, is compatible with related materials and is appropriate for applications indicated.
8. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.

C. Procurement Substitution Requests submitted prior to receipt of bids will be received and considered by Owner when the following conditions are satisfied, as determined by Engineer; otherwise, requests will be returned without action:

1. Requests for substitution of materials and equipment are received no later than 10 days prior to date of bid opening.
2. Extensive revisions to the Contract Documents are not required.
3. Proposed changes are in keeping with the general intent of the Contract Documents, including the level of quality of the Work represented by the requirements therein.
4. The request is fully documented and properly submitted.

D. Substitutions for Cause, as required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms will be received and considered by Engineer, only when the following conditions are satisfied; otherwise, requests will be returned without action, except to record noncompliance with these requirements:

1. Requested substitution is consistent with the Contract Documents and will produce indicated results.
2. Substitution request is fully documented and properly submitted.
3. Requested substitution has received necessary approvals of authorities having jurisdiction.
4. Requested substitution is compatible with other portions of the Work.
5. Requested substitution has been coordinated with other portions of the Work.

6. Requested substitution provides specified warranty.
7. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

E. Substitutions for Convenience, not required in order to meet other Project requirements but may offer advantage to Contractor or Owner, will be received and considered by Owner, as determined by Engineer, only when the following conditions are satisfied; otherwise, requests will be returned without action, except to record noncompliance with these requirements:

1. Requested substitution is received within 60 days after the Notice of Award.
2. Requested substitution offers Owner a substantial advantage in cost, time, energy conservation, or other considerations, after deducting additional responsibilities Owner must assume. Owner's additional responsibilities may include compensation to Engineer for redesign and evaluation services, increased cost of other construction by Owner, and similar considerations.
3. Requested substitution does not require extensive revisions to the Contract Documents.
4. Requested substitution is consistent with the Contract Documents and will produce indicated results.
5. Substitution request is fully documented and properly submitted.
6. Requested substitution has received necessary approvals of authorities having jurisdiction.
7. Requested substitution is compatible with other portions of the Work.
8. Requested substitution has been coordinated with other portions of the Work.
9. Requested substitution provides specified warranty.
10. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

F. If a requested substitution is approved but contains differences or omissions not specifically identified to the attention of the Engineer in the substitution request, the Owner reserves the right to require equal or similar features to be added to the substituted products or to have the substituted products replaced at the Contractor's expense.

1.15 PROJECT RECORD DOCUMENTS

A. Recording: Maintain one copy of the Contract Documents and Shop Drawings during the construction period for project record document purposes. Post changes and revisions to project record documents as they occur; do not wait until end of Project.

B. Preparation:

1. Contract Drawings and Shop Drawings:

a. Mark revisions to show where the actual installation varies from that shown originally.
b. Mark record sets completely and accurately, including important information that was either shown schematically or omitted from original Drawings.
c. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
d. Record underground and under-slab piping installed, dimensioning exact location and elevation of piping.

2. Mark Specifications to indicate the actual product installation where installation varies from that indicated in Specifications, addenda, and contract modifications.
3. Mark Product Data to indicate the actual product installation where installation varies substantially from that indicated in Product Data submittal.

C. Deliver: Prior to Final Completion, provide record documents to Owner as indicated below:

1. Record Drawings: Submit PDF electronic files of scanned record prints and one set of prints.
2. Record Specifications: Submit annotated PDF electronic files of Project's Specifications, including addenda and contract modifications.
3. Record Product Data: Submit annotated PDF electronic files and directories of each submittal.
4. Miscellaneous Record Submittals: Submit annotated PDF electronic files directories of each submittal.

1.16 OPERATION AND MAINTENANCE MANUALS

A. Prepare and submit a comprehensive manual of emergency, operation, and maintenance data and materials in full accordance with the General and Supplementary Conditions, Division 01, and the following:

1. Operations and Maintenance Manuals: Assemble a complete set of data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system, including:

   a. Information required for daily operation and management, operating standards, and routine and special operating procedures.
   b. Manufacturers' maintenance documentation, preventative maintenance procedures and frequency, repair procedures, wiring and systems diagrams, list of spare parts, and warranty information.

2. Submit manuals as PDF electronic files and electronically transmit to Engineer through email or web-based project software site, in accordance with Division 01 Specification Sections. Submittals shall be in searchable PDF format and not a scanned copy.

1.17 DEMONSTRATION AND TRAINING

A. Prepare and provide services of qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not a part of a system in accordance with the General and Supplementary Conditions, Division 01, individual Specification Sections, and the following:

1. Demonstration and training shall occur upon completion of the Work and at a time designated by the Owner's representative.
2. Provide a high-resolution, digital video recording of each training session to the Owner.

1.18 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft and vandalism. Comply with manufacturer's written instructions.

B. Inspect products on delivery to determine compliance with the Contract Documents and to determine that products are undamaged and properly protected.

1.19 WARRANTY

A. Warranty work and equipment within specified warranty period. During the warranty period, provide labor and materials to make good any faults or imperfections that may arise due to defects or omissions in materials or workmanship without expense to the Owner.

1. Warranty Period: One year from date of Substantial Completion.

B. Warranties specified in other Sections shall be in addition to, and run concurrent with, other warranties required by the Contract Documents. Manufacturer’s disclaimers and limitations on product warranties do not relieve Contractor of obligations under requirements of Contract Documents.

C. Owner reserves the right to make emergency repairs as required to keep equipment in operation without voiding Contractor’s Guarantee Bond nor relieving the Contractor of responsibilities during the warranty period.

PART 2 - PRODUCTS (NONE)

PART 3 - EXECUTION

3.01 CONTRACT DOCUMENTS

A. Examine all drawings and specifications carefully before submitting a bid. Architectural drawings take precedence over mechanical or electrical drawings with reference to building construction.

B. For purposes of clearness and legibility, drawings are essentially diagrammatic and, although size and location of equipment are drawn to scale wherever possible, Contractor shall make use of all data in all of the contract documents and shall verify this information at the building site.

C. The drawings indicate required size and points of termination of pipes, conduits, and ducts and suggest proper routes to conform to structure avoid obstructions and preserve clearances. However, it is not intended that drawings indicate all necessary offsets, and it shall be the responsibility of the Contractor to make the installation in such a manner as to conform to structure, avoid obstructions, preserve headroom and keep openings and passageways clear, without further instructions or cost to the Owner.

D. Furnish, install and/or connect with appropriate services all items shown on any drawing without additional compensation.

E. Any and all questions about a subcontractor's scope of work responsibility shall be addressed to and answered by the General Contractor / Construction Manager.

F. Questions About Construction Documents: Any and all questions shall be submitted through the proper channels IN WRITING and, in turn, shall be answered by the Engineer in writing. All telephone conversations shall be considered unofficial and, as such, shall not be considered official or binding responses to Contractor's questions.

G. Drawings, specifications, or other documents issued by the Engineer in electronic format and/or electronic media are provided for convenience only and are not intended for use as Contract Documents.

1. The electronic files are provided merely as a convenience to the Recipient.
2. The electronic files do not replace or supplement the paper copies of any drawings, specifications, or other documents included in the Contract Documents for use on the project.
3. The Engineer makes no representation, warranty, or guarantee that electronic files:

    a. Are suitable for any other usage or purpose.
    b. Have any particular durability.
    c. Will not damage or impair the Recipient's computer or software.
    d. Contain no errors or mechanical flaws or other discrepancies that may render them unsuitable for the purpose intended by the Recipient.

4. Due to the unsecured nature of the electronic files and the inability of Engineer or the Recipient to establish controls over their use, the Engineer assumes no responsibility for any consequences arising out of the use of the data. It is the sole responsibility of the Recipient to check the validity of all information contained therein. The Recipient shall at all times refer to the signed and sealed drawings, specification or other documents for the project during all phases of the project. The Recipient shall assume all risks and liabilities resulting from the use of the electronic files.

3.02 SUPERVISION OF WORK

A. Perform all work under the direct supervision of an experienced, qualified superintendent. The Engineer has the right to remove a superintendent who, in the Engineer's opinion, is not satisfactory.

3.03 EXAMINATION

A. Existing Conditions: The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning sitework, investigate and verify the existence and location of underground utilities, mechanical and electrical systems, and other construction affecting the Work.

B. Examination and Acceptance of Conditions: Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Examine roughing-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
2. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.
3. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.

C. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

3.04 PREPARATION

A. Existing Utility Information: Furnish information to Owner that is necessary to adjust, move, or relocate existing utility structures, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.

B. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

C. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.

D. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for clarification of the Contract Documents caused by differing field conditions outside the control of Contractor, submit a request for information to Engineer.

E. Interruption of Service: Before any existing equipment or system is shut down for disconnecting or tie-ins, coordinate with Engineer and Owner regarding acceptable dates and times for this Work to be performed. Work shall be performed at the time best suited for the Owner, which typically is either on weekends, holidays, and/or after normal working hours. Services shall be restored the same day unless prior arrangements are made. All overtime or premium costs associated with this Work shall be included in the Contractor's bid.

3.05 INSTALLATION

A. Install materials and equipment in a professional manner. The Engineer may direct replacement of items which, in the Engineer's opinion, do not present a professional appearance or do not allow adequate space for maintenance. Replace or reinstall items at the expense of the Contractor.

B. General: Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.

1. Make vertical work plumb and make horizontal work level.
2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
3. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.
4. Maintain minimum headroom clearance of 96 inches in occupied spaces and 90 inches in unoccupied spaces.

C. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.

D. Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.

E. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.

F. Sequence the Work and allow adequate clearances to accommodate movement of construction items on site and placement in permanent locations.

G. Obstructions

1. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.
2. Before any cutting or trenching operations are begun, verify with Owner's representative, utility companies, municipalities, and other interested parties that all available information has been provided. Verify locations given.
3. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.
4. Assume total responsibility for and repair any damage to existing utilities or construction, whether or not such existing facilities are shown.

H. Where "rated" walls, floor, roofs and ceilings are penetrated or cut to install equipment, materials, devices, etc. the Contractor shall provide and install all materials required to re-establish the rating of the wall, floor, roof, or ceiling to the satisfaction of the authority having jurisdiction.

I. Structural Elements: Do not cut structural elements without written approval from Engineer. Notify Engineer of locations and details of cutting and await directions from Engineer before proceeding. If approved by Engineer:

1. Shore, brace, and support structural elements during cutting and patching.
2. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection.

J. Space Requirements: Consider space limitations imposed by contiguous work in selection and location of equipment and material. Do not provide equipment or material which is not suitable in this respect.

K. Tools and Equipment: Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions without cost to the Owner.

L. Phasing: Provide all temporary valves, piping, ductwork, equipment, and devices as required. Maintain temporary services to areas as required. Remove all temporary material and equipment on completion of work unless Engineer concurs that such material and equipment would be beneficial to the Owner on a permanent basis.

3.06 OWNER-INSTALLED PRODUCTS

A. Coordination: Coordinate construction and operations of the Work with work performed by Owner's construction personnel.

3.07 PROTECTION OF EXISTING FINISHES, CARPET, AND FURNISHING

A. Protect existing finishes, carpet, casework, furnishing, and other building components against damage and soiling throughout construction activities. Take care during construction not to damage existing items. Contractor shall be responsible for replacing damaged material or restoring damaged materials to the Owner’s satisfaction.

B. When permitted by Engineer, items may be removed to a suitable, protected storage location during construction and cleaned and reinstalled in their original locations after construction operations are complete.

C. Furniture may be relocated during construction and reinstalled in their original locations after construction operations are complete.

D. Means and methods for protection are the responsibility of the Contractor. Utilize plywood, polyethylene sheeting, dust cloths, and other means as required.

3.08 UTILITY SERVICES AND MECHANICAL SYSTEMS

A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.

B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off utility services and mechanical/electrical systems serving areas to be selectively demolished.

1. Owner will arrange to shut off indicated services/systems when requested by Contractor.
2. Arrange to shut off utilities with utility companies.
3. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
4. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated on Drawings to be removed.

    a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
    b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material and leave in place.
    c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
    d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
    e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
    f. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
    g. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material and leave in place.

3.09 CUTTING AND PATCHING

A. Cutting and Patching, General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.

1. Cut in-place construction to provide for installation of other components or performance of other construction, and subsequently patch as required to restore surfaces to their original condition.

B. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during installation or cutting and patching operations, by methods and with materials so as not to void existing warranties.

C. Temporary Support: Provide temporary support of work to be cut.

D. Protection: Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.

E. Structural Elements: When cutting and patching structural elements, notify Engineer of locations and details of cutting and await directions from Engineer before proceeding. Shore, brace, and support structural elements during cutting and patching. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection.

F. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety.

G. Other Construction Elements: Do not cut and patch other construction elements or components in a manner that could change their load-carrying capacity, that results in reducing their capacity to perform as intended, or that result in increased maintenance or decreased operational life or safety.

H. Visual Elements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch exposed construction in a manner that would, in Engineer's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.

I. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.

1. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots neatly to minimum size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
2. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
3. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
4. Excavating and Backfilling: Comply with requirements in applicable Sections where required by cutting and patching operations.
5. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.
6. Proceed with patching after construction operations requiring cutting are complete.

J. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other work. Patch with durable seams that are as invisible as practicable. Provide materials and comply with installation requirements specified in other Sections, where applicable or with in-place materials.

1. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.

2. If identical materials are unavailable or cannot be used, use materials that, when installed, will provide a match acceptable to Engineer for the visual and functional performance of in-place materials.

K. Cleaning: Clean areas and spaces where cutting and patching are performed. Remove paint, mortar, oils, putty, and similar materials from adjacent finished surfaces.

3.10 PAINTING

A. Comply with requirements with General and Supplementary Conditions, Division 01, Division 09, and individual Specification Sections.

B. Touch-up factory finishes on equipment provided under Division 23. Obtain matched color coatings from the manufacturer and apply as directed. If corrosion if found during inspection on the surface of any equipment, clean, prime, and paint, as required.

C. Paint the following work where exposed to view:

1. Uninsulated Metal Piping (bare copper piping not required to be painted unless noted otherwise):
   a. Other: To be determined by Engineer

2. Uninsulated plastic piping
3. Tanks that do not have factory-applied final finishes.
4. Duct, equipment, and pipe insulation having a cotton or canvas insulation covering or other paintable jacket material, as outlined in individual Specification Sections.

D. Paint the following work where exposed in occupied spaces:

1. Duct, equipment, and pipe insulation having a cotton or canvas insulation covering or other paintable jacket material, as outlined in individual Specification Sections.
2. Other items as directed by Engineer.

E. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

3.11 REPAIR OF WORK

A. Complete repair and restoration operations before requesting inspection for determination of Substantial Completion.

B. Repair or remove and replace defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specified condition.

1. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that that already show evidence of repair or restoration.

a. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.

2. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.

3.12 FIELD QUALITY CONTROL

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

B. Furnish a letter from an authorized factory representative of the air conditioning unit manufacturer stating that the complete refrigeration installation including pipe sizing and routing and operating and safety controls has been checked and is operating properly.

C. Tests

1. Include all tests specified and/or required under laws, rules and regulations of all departments having jurisdiction. Tests shall also be performed as indicated herein and other sections of the specifications.
2. After all systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation. Make adjustments as required to ensure proper functioning of all systems.
3. All parts of the work and associated equipment shall be tested and adjusted to work properly and be left in perfect operating condition.
4. Correct defects disclosed by these tests without any additional cost to the Owner. Repeat tests on repaired or replaced work.
5. Maintain a log of all tests being conducted and have it available for review by the Engineer. Log to indicate date, type of tests, duration, and defects noted and when corrected.
6. Special tests on individual systems are specified under individual Specification Sections.

D. 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.

3.13 CLEANING

A. Progress Cleaning: Clean Project site and work areas daily, including common areas. Enforce requirements strictly. Dispose of materials lawfully.

1. Comply with requirements in NFPA 241 for removal of combustible waste materials and debris.
2. Do not hold waste materials more than seven days during normal weather or three days if the temperature is expected to rise above 80 deg F.
3. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately and dispose of legally, according to regulations.

B. Final Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.

1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a designated portion of Project:

    a. Remove tools, construction equipment, machinery, and surplus material from Project site.
    b. Remove labels that are not permanent.
    c. Wipe surfaces of equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.

END OF SECTION

SECTION 230513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

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

1.03 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.02 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.03 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Power factor: 0.80.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Re-greasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324Tand larger; rolled steel for motor frame sizes smaller than 324T

2.04 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers:

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.05 SINGLE-PHASE MOTORS

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

1. Permanent-split capacitor.

B. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

C. Motors 1/20 HP and Smaller: Shaded-pole type.

D. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

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SECTION 230516
EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Metal, compensator packless expansion joints.
   2. Flexible-hose packless expansion joints.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.04 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.02 PACKLESS EXPANSION JOINTS

A. Metal, Compensator Packless Expansion Joints:

   1. Basis-of-Design Product: Subject to compliance with requirements, provide Twin City Hose, Inc.; TCHS (steel pipe), TCHB (copper pipe) or comparable product by one of the following:

      a. Flex-Hose Co., Inc.
      b. Metraflex, Inc.; SST / MLP (steel), BBS (copper).

   2. Minimum Pressure Rating: 175 psig, unless otherwise indicated.
   3. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.

4. Joint Axial Movement: 2 inches of compression and 1/2 inch of extension.
5. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.

    a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint.
    b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Threaded.

6. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.

    a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
    b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Flanged.

B. Flexible-Hose Packless Expansion Joints:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Metraflex Company; Superflex or comparable product by one of the following:

    a. Mason Industries, Inc.; Mercer Rubber Co.
    b. Metraflex, Inc.

2. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.

3. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.

PART 3 - EXECUTION

3.01 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.02 EXPANSION-JOINT SCHEDULE

A. Chiller Evaporator and Condenser Connections: Metal compensator packless expansion joints.

B. Water Cooled Condenser: Metal compensator packless expansion expansion joints.

C. Boiler Connections: Metal compensator packless expansion joints..

D. Hydronic Pump Suction and Discharge: Metal compensator packless expansion joint..

E. Air Handling Unit Hydronic Coil Connections: Metal compensator packless expansion joints..

F. Fan Coil Unit Hydronic Coil Connections: Flexible hose packless expansion joints.

G. Terminal Unit Hydronic Coil Connections: Flexible hose packless expansion joints.

H. Chiller Refrigerant Pressure Relief Valves: Metal compensator packless expansion joints.

END OF SECTION

SECTION 230517
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Sleeves.
2. Grout.
3. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration Firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.04 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.01 SLEEVES

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

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

2.02 GROUT

A. Description: Non-shrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.

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

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

D. Packaging: Premixed and factory packaged.

2.03 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, non-sag, plus 25 percent and minus 25 percent movement capability, non-traffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, use NT.

1. Sealant shall have a VOC content of 250 g/L or less.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and non-traffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

1. Sealant shall have a VOC content of 250 g/L or less.

C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

1. Sealant shall have a VOC content of 250 g/L or less.

PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION

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

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 12-inch (50-mm) annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using groutorsilicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

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

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

3.02 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

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

3.03 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls Above Grade:

   a. Piping Smaller Than NPS 6: Steel pipe sleeves.
   b. Piping NPS 6 and Larger: Steel pipe sleeves.

2. Concrete Slabs Above Grade:

   a. Piping Smaller Than NPS 6: Steel pipe sleeves.
   b. Piping NPS 6 and Larger: Steel pipe sleeves.

3. Interior Partitions:

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

END OF SECTION

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SECTION 230518
ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.03 DEFINITIONS

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

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 ESCUTCHEONS

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

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

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

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

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

2.02 FLOOR PLATES

A. .

B. One-Piece Floor Plates: Cast-iron flange.

PART 3 - EXECUTION

3.01 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.
      b. Insulated Piping: One-piece stamped steel with polished, chrome-plated finish.
      c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
      d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
      e. Bare Piping in Unfinished Service Spaces: One-piece cast brass with rough-brass finish.
      f. Bare Piping in Equipment Rooms: One-piece cast brass 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.

3.02 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 230519
METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
1. Liquid-in-glass thermometers.
2. Thermowells.
3. Dial-type pressure gages.
4. Gage attachments.
5. Test plugs.

B. Related Requirements:
1. Section 231123 "Facility Natural-Gas Piping" for gas meters.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.04 INFORMATIONAL SUBMITTALS

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

1.05 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.01 FILLED-SYSTEM THERMOMETERS

A. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Trerice H.O. Co.; V803 or comparable product by one of the following:

a. Ashcroft Inc.
b. Miljoco Corporation.
c. Weiss Instruments, Inc.

2. Standard: ASME B40.200.
3. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch nominal diameter with back flange and holes for panel mounting.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Non-reflective aluminum with permanently etched scale markings graduated in deg F.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: Stainless steel.
10. Connector Type(s): Union joint, back for panel mount 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-inch outside diameter reversible aluminum flange.
    b. Design for Thermowell Installation: Bare stem.

12. Accuracy: Plus or minus 1 percent of scale range.

2.02 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 nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Non-reflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass.
8. Stem: Brass and of length to suit installation.

    a. Design for Air-Duct Installation: With 6-inch3-inch (76-mm) outside diameter reversible aluminum flange and perforated aluminum guard.
    b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches, 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.

2.03 DUCT-THERMOMETER MOUNTING BRACKETS

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

2.04 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: CNR (copper nickel 90-10).
4. Material for Use with Steel Piping: CRES (stainless steel).
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

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

2.05 PRESSURE GAGES

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

1. Basis-of-Design Product: Subject to compliance with requirements, provide Trerice, 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 nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, 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: Non-reflective aluminum with permanently etched scale markings graduated in psi.
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.

B. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Trerice, H.O. Co.; 600CB w/ threaded diaphragm and capillary tubing kit 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; cast aluminum; 4-1/2-inch nominal diameter with back flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, 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: Non-reflective aluminum with permanently etched scale markings graduated in psi.
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.

2.06 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, 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, ASME B1.20.1 pipe threads.

2.07 TEST PLUGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Petersen Equipment Co., Inc.; Model 310-110-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 in 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, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: EPDM self-sealing rubber.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install thermowells with socket extending a minimum of 2 inches 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 remote-mounted pressure gages on panel.

I. Install valve and snubber in piping for each pressure gage for fluids (except steam).

J. Install test plugs in piping tees.

K. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

L. Install flowmeter elements in accessible positions in piping systems.

M. Install flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

N. Install Venturi flowmeter downstream of electromagnetic flowmeters, with at least minimum straight lengths of pipe, upstream and downstream from meter according to manufacturer’s written instructions. Straight lengths of pipe required downstream of electromagnetic flowmeter and upstream of Venturi flowmeter may be shared.

O. Install permanent indicators on walls or brackets in accessible and readable positions.

P. Install connection fittings in accessible locations for attachment to portable indicators.

Q. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

R. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Inlets and outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Inlet and outlet of each storage tank.
6. `Air handler supply air ducts with an airflow of 2000 cfm or greater.

S. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.
4. Inlet and outlet of each air handling unit hydronic coil.

T. Install test plugs in the following locations:

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

3.02 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow space for service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.03 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.

3.04 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be the following:
1. Remote-.
2. Industrial-style, liquid-in-glass type.

B. Thermometers at inlet and outlet of each hydronic boiler shall be the following:

1. where indicated.
2. Industrial-style, liquid-in-glass type.
3. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial or remote mounted thermometers.

C. Thermometers at inlets and outlets of each chiller shall be the following:
1. Remote-mounted, metal-case, vapor-actuated type where indicated.
2. Industrial-style, liquid-in-glass type.
3. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial or remote mounted thermometers.

D. 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.
2. Industrial-style, liquid-in-glass type.
3. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial or remote mounted thermometers.

E. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be the following:
1. Remote-mounted, metal-case, vapor-actuated type where indicated.
2. Industrial-style, liquid-in-glass type.
3. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial or remote mounted thermometers.

F. Thermometers at inlet and outlet of each thermal-storage tank shall be the following:
1. Industrial-style, liquid-in-glass type.
2. Test plug with EPDM self-sealing rubber inserts shall be provided in addition to industrial or remote mounted thermometers.

G. Thermometers at supply-, -air ducts shall be the following:
   1. Remote]-mounted, case, vapor-actuated type where indicatedIndustrial-style, liquid-in-glass type.

H. Thermometer stems shall be of length to match thermowell insertion length.

3.05 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.

B. Scale Range for Process Cooling-Water Piping: 0 to 150 deg F.

C. Scale Range for Heat Recovery-Water Piping: 0 to 150 deg F.

D. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F.

E. Scale Range for Air Ducts: 0 to 150 deg F.

3.06 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be the following:

   1. Solid-front, pressure-relief,-remote mounted where indicated on plans, direct mounted otherwise, metal case.

B. 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.

C. 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 self-sealing rubber inserts shall be provided in addition to direct or remote mounted gages.

3.07 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 160 psi.

B. Scale Range for Process Cooling-Water Piping: 0 to 160 psi.

C. Scale Range for Heat Recovery-Water Piping: 0 to 160 psi.

D. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi.

3.08 FLOWMETER SCHEDULE

A. Flowmeters for Chilled-Water Piping: Venturi type.

B. Flowmeters for Process Cooling-Water Piping: Venturi type.

C. Flowmeters for Heat Recovery-Water Piping: Venturi type.

D. Flowmeters for Heating, Hot-Water Piping: Venturi type.

END OF SECTION

SECTION 230523.11
GENERAL DUTY VALVES FOR HYDRONIC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Bronze ball valves.
2. Iron, single-flange butterfly valves.
3. Bronze swing check valves.
4. Iron swing check valves.
5. Iron, center-guided check valves.
6. Bronze angle valves.
7. Bronze globe valves.
8. Iron globe valves.

1.03 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene-diene terpolymer rubber.

C. SWP: Steam working pressure.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

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

B. Use the following precautions during storage:

1. Maintain valve end protection.

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

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

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B31.9 for building services piping valves.
3. ASME B16.1 for flanges on iron valves.
4. ASME B16.5 for flanges on steel valves.
5. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
6. ASME B31.9 for building service piping valves.

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

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

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

F. Valve Actuator Types:

1. Gear Actuator: For valves NPS 8 and larger.
2. Handlever: For valves NPS 6 and smaller.
3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.

G. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handles of non-thermal conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

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

2.02 BRONZE BALL VALVES

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

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

a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded [**or press**].
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

2.03 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:

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

a. Crane Co.; Crane Valve Group; Jenkins 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-67, Type I.
b. CWP Rating: 150 psig and 200 psig.
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.

2.04 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Nonmetallic Disc, Class 150:

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

a. Crane Co.; Crane Valve Group; Crane 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-80, Type 4.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: PTFE.

B. Bronze Swing Check Valves, Press Ends:

1. Description:

a. Standard: MSS SP-80 and MSS SP-139.
b. CWP Rating: Minimum 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 584, bronze.
e. Ends: Press.
f. Press Ends Connection Rating: Minimum 200 psig
g. Disc: Brass or bronze.

2.05 IRON SWING CHECK VALVES

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

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

a. Crane Co.; Crane Valve Group; Crane 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-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged or threaded. See valve schedule articles.
g. Trim: Bronze.
h. Gasket: Asbestos free.

2.06 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Iron Swing Check Valves with Lever- and Spring-Closure Control, Class 125:

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

a. Crane Co.; Crane Valve Group; Crane 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-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged or threaded. See valve schedule articles.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed exterior lever and weight.

2.07 IRON, CENTER-GUIDED, SPRING-LOADED CHECK VALVES

A. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 125:

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

a. Crispin Valve.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. Mueller Steam Specialty; a division of SPX Corporation.
e. NIBCO INC.
f. Spence Strainers International; a division of CIRCOR International.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron.
e. Style: Compact wafer.
f. Seat: Bronze.

B. Iron Globe, Center-Guided Check Valves with Metal Seat, Class 125:

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

a. Crispin Valve.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. Mueller Steam Specialty; a division of SPX Corporation.
e. NIBCO INC.
f. Spence Strainers International; a division of CIRCOR International.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: Bronze.

2.08 BRONZE ANGLE VALVES

A. Bronze Angle Valves, Class 150:

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

a. Crane Co.; Crane Valve Group; Stockham Division.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. NIBCO INC.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem and Disc: Bronze and PTFE.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron.

2.09 BRONZE GLOBE VALVES

A. Bronze Globe Valves, Class 150:

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

a. Hammond Valve.
b. Milwaukee Valve Company.
c. NIBCO INC.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: PTFE.
g. Packing: Asbestos free.

h. Handwheel: Malleable iron.

2.10 IRON GLOBE VALVES

A. Iron Globe Valves, Class 125:

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

a. Crane Co.; Crane Valve Group; Stockham Division.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

2.11 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain.

1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc or epoxy coating.
2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.01 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 damage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

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

3.02 VALVE INSTALLATION

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

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

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

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

E. Check Valves: Install check valves for proper direction of flow.

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

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

G. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.03 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.

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

B. If valve applications are not indicated, use the following:

1. Shutoff Service:

    a. NPS 2 and Smaller: Ball valves.
    b. NPS 2-1/2 and Larger: Butterfly valves.

2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Throttling Service: Globe or angle valves.
4. Pump-Discharge Check Valves:

    a. NPS 2 and Smaller: Bronze swing check valves with nonmetallic disc.
    b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal -seat check valves.

C. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where press-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged.

3. For Copper Tubing, NPS 5 and Larger: Flanged.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends except where press-end option is indicated in valve schedules below.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged.
6. For Steel Piping, NPS 5 and Larger: Flanged.

3.05 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze ball valves, two-piece with full port and stainless-steel trim. Provide with threaded [**or press connection**] joint ends.
2. Bronze swing check valves with nonmetallic disc, Class 150, with threaded [**or press connection**] joint ends.
3. Bronze angle or globe valves, Class 150, PTFE disc, with threaded ends.

B. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze disc, 200 CWP, and EPDM seat.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: Aluminum-bronze disc, 150 CWP, and EPDM seat.
3. Iron swing check valves with metal seats, Class 125, with flanged end connections.
4. Iron, compact-wafer or globe, center-guided check valves, metal seat, Class 125, with flanged end connections.
5. Iron globe valves, Class 125, with flanged ends.

3.06 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze ball valves, two-piece with full port and stainless-steel trim. Provide with threaded [**or press connection**] joint ends.
2. Bronze swing check valves with nonmetallic disc, Class 150, with threaded [**or press connection**] joint ends.
3. Bronze angle or globe valves, Class 150, PTFE disc, with threaded ends.

B. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze disc, 200 CWP, and EPDM seat.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: Aluminum-bronze disc, 150 CWP, and EPDM seat.
3. Iron swing check valves with metal seats, Class 125, with flanged end connections.
4. Iron, compact-wafer or globe, center-guided check valves, metal seat, Class 125, with flanged end connections.
5. Iron globe valves, Class 125, with flanged ends.

END OF SECTION

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SECTION 230523.21
GENERAL DUTY VALVES FOR STEAM AND CONDENSATE PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Stainless steel ball valves.
2. High-performance butterfly valves.
3. Bronze swing check valves.
4. Iron swing check valves.
5. Iron, center-guided check valves
6. Bronze angle valves.
7. Bronze globe valves.

1.03 DEFINITIONS

A. CWP: Cold working pressure.

B. OS&Y: Outside screw and yoke.

C. SWP: Steam working pressure.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

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

B. Use the following precautions during storage:

1. Maintain valve end protection.

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

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

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

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

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B31.9 for building services piping valves.
3. ASME B16.1 for flanges on iron valves.
4. ASME B16.5 for flanges on steel valves.
5. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
6. ASME B31.9 for building service piping valves.

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

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

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

F. Valve Actuator Types:

1. Gear Actuator: For valves NPS 8 and larger.
2. Handlever: For valves NPS 6 and smaller.
3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.

G. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handles of non-thermal conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

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

2.02 STAINLESS STEEL BALL VALVES

A. Stainless Steel Ball Valves with Full Port and Stainless-Steel Trim, Class 300:

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

a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-72.
b. CWP Rating: 600 psig (4140 kPa).
c. Body Design: Two Piece
d. Body Material: Stainless steel.
e. Ends: Threaded
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Reduced

2.03 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Single-Flange, High-Performance Butterfly Valves, Class 150:

1. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 285 psig at 100 deg F.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

B. Single-Flange, High-Performance Butterfly Valves, Class 300:

1. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 720 psig at 100 deg F.
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, cast iron, or ductile iron.
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

2.04 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Nonmetallic Disc, Class 150:

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

    a. Crane Co.; Crane Valve Group; Crane 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-80, Type 4.
    b. CWP Rating: 300 psig.
    c. Body Design: Horizontal flow.
    d. Body Material: ASTM B 62, bronze.
    e. Ends: Threaded.
    f. Disc: PTFE.

2.05 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats, Class 250:

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

    a. Crane Co.; Crane Valve Group; Stockham Division.
    b. Hammond Valve.
    c. Milwaukee Valve Company.
    d. NIBCO INC.
    e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Standard: MSS SP-71, Type I.
    b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
    c. NPS 14 to NPS 24, CWP Rating: 300 psig.
    d. Body Design: Clear or full waterway.
    e. Body Material: ASTM A 126, gray iron with bolted bonnet.
    f. Ends: Flanged.
    g. Trim: Bronze.
    h. Gasket: Asbestos free.

2.06 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Iron Swing Check Valves with Lever- and Spring-Closure Control, Class 125:

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

    a. Crane Co.; Crane Valve Group; Crane Valves.
    b. Milwaukee Valve Company.
    c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged or threaded. See valve schedule articles.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed exterior lever and weight.

2.07 IRON, CENTER-GUIDED, SPRING-LOADED CHECK VALVES

A. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 125:

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

a. Crispin Valve.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. Mueller Steam Specialty; a division of SPX Corporation.
e. Spence Strainers International; a division of CIRCOR International.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron.
e. Style: Compact wafer.
f. Seat: Bronze.

B. Iron Globe, Center-Guided Check Valves with Metal Seat, Class 125:

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

a. Crispin Valve.
b. Hammond Valve.
c. Milwaukee Valve Company.
d. Mueller Steam Specialty; a division of SPX Corporation.
e. Spence Strainers International; a division of CIRCOR International.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A 126, gray iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: Bronze.

2.08 BRONZE ANGLE VALVES

A. Bronze Angle Valves, Class 150:

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

   a. Crane Co.; Crane Valve Group; Stockham Division.
   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. NIBCO INC.

2. Description:

   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem and Disc: Bronze and PTFE.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

2.09 BRONZE GLOBE VALVES

A. Bronze Globe Valves, Class 150:

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

   a. Hammond Valve.
   b. Milwaukee Valve Company.
   c. NIBCO INC.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

PART 3 - EXECUTION

3.01 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 damage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

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

3.02 VALVE INSTALLATION

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

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

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

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

E. Check Valves: Install check valves for proper direction of flow.

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

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

G. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.03 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.

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

B. If valve applications are not indicated, use the following:

1. Shutoff Service:

   a. NPS 2 and Smaller: Ball valves.
   b. NPS 2-1/2 and Larger: High-performance butterfly valves.

2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Throttling Service: Globe or angle valves.

4. Pump-Discharge Check Valves:

    a. NPS 2 and Smaller: Bronze swing check valves with nonmetallic disc.
    b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal -seat check valves.

C. Select valves with the following end connections:
1. For Steel Piping, NPS 2 and Smaller: Threaded ends.
2. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged.
3. For Steel Piping, NPS 5 and Larger: Flanged.

3.05 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS)

A. Pipe NPS 2 and Smaller:

1. Stainless steel ball valves, two piece with stainless-steel trim, and reduced port.
2. Bronze swing check valves with nonmetallic disc, Class 150.
3. Bronze angle or globe valves, Class 150, PTFE disc.

B. Pipe NPS 2-1/2 and Larger:

1. High-performance butterfly valves, single flange, Class 150.
2. Iron swing check valves with metal seats, Class 125.
3. Iron gate valves, OS&Y, Class 125.

3.06 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG

A. Pipe NPS 2 and Smaller:

1. Stainless steel ball valves, two piece with stainless-steel trim, and reduced port.
2. Bronze swing check valves with nonmetallic disc, Class 150
3. Bronze angle or globe valves, Class 150, PTFE disc.

B. Pipe NPS 2-1/2 and Larger:

1. High-performance butterfly valves, single flange, Class 300.
2. Iron swing check valves with metal seats, Class 250.
3. Iron gate valves, OS&Y, Class 250.

3.07 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Stainless steel ball valves, two piece with stainless-steel trim, and reduced port.
2. Bronze swing check valves with nonmetallic disc, Class 150
3. Bronze angle or globe valves, Class 150, PTFE disc.

B. Pipe NPS 2-1/2 and Larger:

1. High-performance butterfly valves, single flange, Class 150.
2. Iron swing check valves with metal seats, Class 125.
3. Iron gate valves, OS&Y, Class 125.

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SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Fastener systems.
5. Equipment supports.

1.03 DEFINITIONS

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

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.02 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

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

B. Stainless-Steel Pipe Hangers and Supports:

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

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

2.03 TRAPEZE PIPE HANGERS

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

2.04 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

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

   a. Cooper B-Line, Inc.
   b. Flex-Strut Inc.
   c. Unistrut Corporation; Tyco International, Ltd.

2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted carbon-steel channel with inturned lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of electroplated zinc indoors and stainless stell outdoors..
8. Metallic Coating: Electroplated zinc indoors and Hot-dip galvanized outdoors.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel channel with inturned lips.
4. Channel Width: Select for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of electroplated zinc indoors and stainless steel outdoors..
7. Metallic Coating: Hot-dip galvanized.

2.05 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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

2.06 EQUIPMENT SUPPORTS

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

2.07 MATERIALS

A. Aluminum: ASTM B 221.

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

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

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

E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

F. Grout: ASTM C 1107 / C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 APPLICATION

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

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.02 HANGER AND SUPPORT INSTALLATION

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

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36 / A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1 / D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.

D. Fastener System Installation:

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

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

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

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

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

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

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

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

L. Insulated Piping:

1. Install MSS SP-58, Type 40, protective shields on piping. Shields shall span an arc of 180 degrees. Secure shield to pipe on both ends with stainless steel bands.

2. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
b. NPS 4: 12 inches long and 0.06 inch thick.
c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

3.03 EQUIPMENT SUPPORTS

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

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

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

3.04 METAL FABRICATIONS

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

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

C. Field Welding: Comply with AWS D1.1 / D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.05 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.06 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

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

3.07 HANGER AND SUPPORT SCHEDULE

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

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

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

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

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

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

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

I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
3. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
4. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
5. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.

K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

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

M. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

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

END OF SECTION

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SECTION 230548.13
VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Open-spring isolators.
4. Housed-spring isolators.
5. Restrained-spring isolators.
6. Elastomeric hangers.
7. Spring hangers.
8. Vibration isolation equipment bases.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.

B. Shop Drawings:

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

C. Delegated-Design Submittal: For each vibration isolation device.

1. Include design calculations for designing vibration isolation bases.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation and for designing vibration isolation bases.
   a.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For professional engineer.

PART 2 - PRODUCTS

2.01 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason Super W or comparable product by one of the following:

   a. Kinetics Noise Control, Inc.
   b. Vibration Mountings & Controls, Inc.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Waffle pattern.

2.02 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason ND or comparable product by one of the following:

   a. Kinetics Noise Control, Inc.
   b. Vibration Mountings & Controls, Inc.

2. Mounting Plates:

   a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
   b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.03 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators: .

1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason SLFH or comparable product by one of the following:

   a. Kinetics Noise Control, Inc.
   b. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.04 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason C or comparable product by one of the following:

    a. Kinetics Noise Control, Inc.
    b. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top housing with attachment and leveling bolt.

2.05 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason SLR or a comparable product by one of the following:

    a. Kinetics Noise Control, Inc.

    b. Vibration Mountings & Controls, Inc.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

    a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top plate with threaded mounting holes.
    c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.06 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: .

1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Mason HD or comparable product by one of the following:

    a. Kinetics Noise Control, Inc.
    b. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.07 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; HS-B or comparable product by one of the following:

    a. Kinetics Noise Control, Inc.
    b. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.08 VIBRATION ISOLATION EQUIPMENT BASES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Mason Industries, Inc.; Type K (Fans) or BMK/KSL-6 (Pumps) or comparable product by one of the following:

1. Kinetics Noise Control.
2. Vibration Mountings & Controls, Inc.

B. Concrete Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

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

3.02 VIBRATION CONTROL DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

3.03 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03.

END OF SECTION

SECTION 230553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

C. Valve numbering scheme.

D. Valve Schedules: For each piping system to include in maintenance manuals.

E.

1.04 CLOSEOUT SUBMITTALS

A. Maintenance Data: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch 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.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, tabulate equipment label information. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch 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.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters 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.

2.03 PIPE LABELS

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

B. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.04 STENCILS

A. Stencils for Ducts:

1. Lettering Size: Minimum letter height of 1-1/4 inches for viewing distances up to 15 feet and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Fiberboard or metal.
3. Stencil Paint: Exterior, gloss, acrylic enamel. Paint may be in pressurized spray-can form.

2.05 VALVE TAGS

A.

B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain

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

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

2.06 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.01 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.

3.02 GENERAL INSTALLATION REQUIREMENTS

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

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

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

3.03 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.04 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions. Install marker tape with arrows around the entire circumference of the pipe at the beginning and end of the pipe-label content.

C. Pipe Label Color Schedule:

1. Chilled-Water Piping: White letters on a safety-green background.
2. Heating Water Piping: White letters on a safety-green background.
3. Refrigerant Piping: Black letters on a safety-orange background.
4. Fuel Gas Piping: Black letters on a safety-yellow background.

3.05 DUCT LABEL INSTALLATION

A. Stenciled Duct Label: Stenciled labels showing service and flow direction.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.06 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: 1-1/2 inches

2. Valve-Tag Colors:

a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
b. Flammable Fluids: Black letters on a safety-yellow background.
c. Combustible Fluids: White letters on a safety-brown background.
d. Potable and Other Water: White letters on a safety-green background.
e. Compressed Air: White letters on a safety-blue background.
f. Defined by User: White letters on a safety-purple background, black letters on a safety-white background, white letters on a safety-gray background, and white letters on a safety-black background

3.07 WARNING-TAG INSTALLATION

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

END OF SECTION

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SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

    a. Constant-volume air systems.
    b. Variable-air-volume systems.
    c. Multizone systems.

2. Balancing Hydronic Piping Systems:

    a. Constant-flow hydronic systems.
    b. Variable-flow hydronic systems.
    c. Primary-secondary hydronic systems.

3. Balancing steam systems.
4. Testing, Adjusting, and Balancing Equipment:

    a. Heat exchangers.
    b. Motors.
    c. Condensing units.
    d. Heat-transfer coils.
    e. .
5. Duct leakage tests.
6. Control system verification.

B. Related Sections:

1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements.

1.03 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

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

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

G. TDH: Total dynamic head.

H. Special Inspector: An entity engaged to inspect smoke control systems.

1.04 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.05 ACTION SUBMITTALS

A. Sustainable Design Submittals:

1. Air-Balance Report: Documentation indicating that Work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

B. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

C. Report Format Submittals: Within 60 days of Contractor’s Notice to Proceed, submit the following as specified in “Preparation” Article.

1. TAB strategies and step-by-step procedures.
2. System readiness checklists.

1.06 INFORMATIONAL SUBMITTALS

A. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

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

C. Certified TAB reports.

D. Sample report forms.

E. 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.

1.07 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC or NEBB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB. A TAB Field Supervisor shall be on the project site at all times during TAB work and shall have a minimum three years' of TAB experience with air, water, sound, and vibration testing.

   a. NEBB: Certified Professional (TAB-CP) or Certified Technician (TAB-CT).
   b. AABC: Certified Test and Balance Engineer (TBE) or Certified Technician.

2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB as a TAB technician.

   a. NEBB: Certified Technician (TAB-CT).
   b. AABC: Certified Technician.

3.

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

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

E. Warranty: Comply with the program requirements of either:

1. AABC National Performance Guaranty.
2. NEBB Conformance Certification.

1.08 TAB CONTRACTOR'S RESPONSIBILITIES

A. Attend testing, adjusting, and balancing review and coordination meeting.

B. Participate in verification of the TAB report by the CxA or Engineer for verification and diagnostic purposes.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 TAB SPECIALISTS

A. Subject to compliance with requirements, engage one of the following:

1. FTS Test and Balance

   a. Location: Tallahassee, Florida
   b. Contact: Heath Allbaugh, CP
   c. Phone Number: (850) 727-5391

2. HVAC Testing Services, Inc.

   a. Location: Thomasville, Georgia
   b. Contact: Greg Lang, CP / Pete Lang
   c. Phone Number: (229) 227-0255

3. Indoor Air Professionals, Inc.

   a. Location: Fort Myers, Florida
   b. Contact: Joseph Molloy, III, CP
   c. Phone Number: (239) 707-9732

See Allstate Construction's bid package

3.02 EXAMINATION

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

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

I. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

J. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

K. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine operating safety interlocks and controls on HVAC equipment.

O. 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.

3.03 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Project specific forms with specific identification for all equipment and systems. Project specific forms shall include design data for all equipment and systems to be tested and descriptions of any other necessary supporting data required in the final report that will be included (i.e. fan/pump curves, layout drawings, balancing valve charts, etc).

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning per the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.04 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance", ASHRAE 111, or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" , and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

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

3.05 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.06 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

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

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
6. Determine and make appropriate modifications for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.

2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.07 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
    f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
    g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Set terminals for maximum airflow. If system design includes diversity (where the total flow rate of all outlets is more than the indicated flow of the fans), adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.

        1) Determine diversity factor.
        2) Simulate system diversity by setting a required number of air terminals to minimum airflows, as approved by the design engineer.
        3) Set air terminals that were at minimum airflow to maximum airflow. Set a sufficient number of air terminals that were previously at maximum airflow to minimum airflow to maintain diversity, and balance terminals that were just set to maximum.

    c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
    f. Obtain approval from Engineer before adjustment of fan speed higher or lower than indicated speed. Determine and make appropriate modifications for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
    g. 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.

6. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
    b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor. Coordinate maximum and minimum static pressure setpoints with Controls Contractor for static pressure setpoint reset. Record damper positions for associated terminal units at maximum and minimum static pressure setpoints.

9. Simulate maximum filter loading. The intent is for the variable frequency drive to operate between 55-60 Hz at maximum filter loading. Remeasure the static pressure at the most critical terminal unit and adjust the static pressure controller to ensure that adequate static pressure is maintained at the most critical unit. Report the minimum static pressure value and speed of variable frequency drives.
10. Verify final system conditions as follows:

    a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
    b. Re-measure and confirm that total airflow is within design.
    c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
    d. Mark final settings.
    e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
    f. Verify tracking between supply and return fans.

3.08 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.09 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

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

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity (when the total flow rate of all valves is equal to the indicated flow of the pumps):

1. Adjust pumps to deliver total design gpm.

    a. Measure total water flow.

        1) Position valves for full flow through coils.

2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

a) If impeller sizes must be adjusted to achieve pump performance, obtain approval from Engineer and comply with requirements of Division 23 Section “Hydronic Pumps”.

5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differential-pressure set point. Re-measure the differential pressure at the most critical valve and adjust the system differential pressure set point to the most energy-efficient set point to maintain the optimum system differential pressure. Record set point and give to Controls Contractor. Coordinate maximum and minimum differential pressure setpoints with Controls Contractor for differential pressure setpoint reset. Record valve positions for associated units at maximum and minimum differential pressure setpoints.
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
    c. Mark final settings.
    d. Mark pump manufacturer’s head-capacity curve.

10. Verify that memory stops have been set.

D. For systems with diversity (when the total flow rate of all valves is more than the indicated flow of the pumps):

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
3. Adjust pumps to deliver total design gpm.

    a. Measure total water flow.

        1) Position valves for full flow through coils.
        2) Measure flow by main flow meter, if installed.
        3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

    b. Measure pump TDH as follows:

        1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
        2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
        3) Convert pressure to head and correct for differences in gage heights.
        4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

            a) If impeller sizes must be adjusted to achieve pump performance, obtain approval from Engineer and comply with requirements of Division 23 Section “Hydronic Pumps”.

        5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

   a. Measure flow in main and branch pipes.
   b. Adjust main and branch balance valves for design flow.
   c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

   a. Measure flow at terminals.
   b. Adjust each terminal to design flow.
   c. Re-measure each terminal after it is adjusted.
   d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
   e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

   a. Measure differential pressure, and verify that it is within manufacturer's specified range.
   b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point. Re-measure the differential pressure at the most critical valve and adjust the system differential pressure set point to the most energy-efficient set point to maintain the optimum system differential pressure. Record set point and give to Controls Contractor. Coordinate maximum and minimum differential pressure setpoints with Controls Contractor for differential pressure setpoint reset. Record valve positions for associated units at maximum and minimum differential pressure setpoints.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
    c. Mark final settings.
    d. Mark pump manufacturer’s head-capacity curve.

13. Verify that memory stops have been set.

3.10 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.11 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record fan and motor operating data.

3.12 PROCEDURES FOR HEAT EXCHANGERS

A. Steam To Water Heat Exchanger:
1. Measure and record entering and leaving water temperature.
2. Water flow rate
3. Water pressure drop
4. Measure and record entering-steam pressure.

3.13 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.
8. Coils with pressure independent control valves: Measure coil airflow rate, entering and leaving air temperatures and calculate energy transfer. Measure coil entering and leaving water temperatures and use energy balance calculation to determine actual flow rate and record.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.

2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

3.14 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.15 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.16 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.17 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for 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.

3.18 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.
4. Include warranty certificate meeting the requirements of one of the following programs:

    a. AABC – National Performance Guaranty
    b. NEBB – Conformance Certification

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves, marked with operating conditions.
2. Fan curves, marked with operating conditions.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

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

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.

15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

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

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

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

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.

2. Motor Data:

    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Filter static-pressure differential in inches wg.
    f. Preheat-coil static-pressure differential in inches wg.

g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.
l. Return-air damper position.
m. Vortex damper position.

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

1. Fan Data:

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

2. Motor Data:

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

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

G. 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.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.

k. Barometric pressure in psig.

H. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft..

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

I. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

J. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.

f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump rpm.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

K. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.19 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of commissioning authority

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

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

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

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, design professional may contact AABC Headquarters regarding the AABC National Performance Guaranty or NEBB Headquarters regarding the NEBB Conformance Certification.

F. Prepare test and inspection reports.

3.20 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

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SECTION 230713.11
INSULATION FOR INDOOR GENERAL HVAC DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply, return, and outdoor air.
2. Indoor, exposed supply, return, and outdoor air.
3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
4. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Related Sections:
1. Section 233113 "Metal Ducts" for duct liners.

1.03 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:

1. Detail application for each type of insulation and hanger.
2. Detail insulation application for each type of insulation.

1.04 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 E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

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

1.05 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.

1.06 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

1.07 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

2.01 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," and "Indoor Duct and Plenum 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 C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

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

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

   a. CertainTeed Corp.; SoftTouch Duct Wrap.
   b. Johns Manville; Microlite.
   c. Knauf Insulation; Friendly Feel Duct Wrap.

d. Owens Corning; SOFTR All-Service Duct Wrap.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

a. CertainTeed Corp.; Commercial Board.
b. Johns Manville; 800 Series Spin-Glas.
c. Knauf Insulation; Insulation Board.
d. Owens Corning; Fiberglas 700 Series.

H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.02 ADHESIVES

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

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

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
d. Mon-Eco Industries, Inc.; 22-25.

2. Fiberglass 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

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

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
    b. Eagle Bridges - Marathon Industries; 225.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.Mon-Eco Industries, Inc.; 22-25.

2. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.03 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

1. VOC Content: 50 g/L or less.
2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

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

    a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
    b. Vimasco Corporation; 749.
2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

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

    a. Childers Brand; H. B. Fuller Construction Products; CP-10.

    b. Eagle Bridges - Marathon Industries; 550.

    c. Foster Brand; H. B. Fuller Construction Products; 46-50.

    d. Mon-Eco Industries, Inc; 55-50.
2. Vimasco Corporation; WC-1/WC-5.Water-Vapor Permeance: ASTM E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.

4. Color: White.

2.04 SEALANTS

A. FSK FlashingSealants:

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.Eagle Bridges - Marathon Industries; 405.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
   c. 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.
5. Color: Aluminum.
6. Sealant shall have a VOC content of 420 g/L or less.

7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.05 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. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.06 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Childers Brand; H. B. Fuller Construction Products; Chil-Glas Number 5.

2.07 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

2.08 SECUREMENTS

A. Bands:

1. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

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

      1) AGM Industries, Inc.

      2) Gemco.

      3) Midwest Fasteners, Inc.
   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding; Speed Clips.
   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

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

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

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

3.02 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.03 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

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

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

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

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

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

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

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

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

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

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

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

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

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

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

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.05 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with insulation pins.
   1.
   2. Install metal, adhesively attached, perforated-base insulation hangers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

      a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
      b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
      c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
      d. Do not overcompress insulation during installation.
      e. Impale insulation over pins and attach speed washers.
      f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

   3. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

      a. Repair punctures, tears, and penetrations with mastic to maintain vapor-barrier seal.
      b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

   4. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
   5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
   6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
   2. Install metal, adhesively attached, perforated-base insulation hangers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

      a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

3. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

4. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
5. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.06 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:
1. Install lap or joint strips with same material as jacket.
2. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

3.07 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply, return, and outdoor air.
2. Indoor, exposed supply, return, and outdoor air.

3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
4. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:
1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.08 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply, return, and outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

B. Concealed, round and flat-oval, exhaust-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

C. Concealed, rectangular, supply, return, and outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

D. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:
1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

E. Concealed, supply, return, and outdoor-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

F. Concealed, exhaust-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. [**6-lb/cu. ft.**] nominal density.

G. Exposed, round and flat-oval, supply, return, and outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Pipe and Tank: 2 inches thick.

H. Exposed, round and flat-oval, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:
1. Mineral-Fiber Pipe and Tank: 2 inches thick.

I. Exposed, rectangular, supply, return, and outdoor-air duct insulation shall be the following:
1. Mineral-Fiber Board: 2 inches thick and nominal density.

J. Exposed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:
1. Mineral-Fiber Board: 2 inches thick and nominal density.

K. Exposed, supply, return, and outdoor-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

L. Exposed, exhaust-air plenum insulation shall be the following:
1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

END OF SECTION

SECTION 230716.11
INSULATION FOR CHILLED WATER EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following HVAC equipment that is not factory insulated:
   1. Chilled-water pumps.
   2. Expansion/compression tanks.
   3. Air separators.

1.03 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).

1.04 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 E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

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

1.05 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.

1.06 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. SCHEDULING

D. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

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

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. Comply with requirements in "Breeching Insulation Schedule" and "Equipment 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 C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

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

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. Pittsburgh Corning Corporation; Foamglass.

2. Block Insulation: ASTM C552, Type I.
3. Special-Shaped Insulation: ASTM C552, Type III.
4. Board Insulation: ASTM C552, Type IV.
5. Factory fabricate shapes according to ASTM C450 and ASTM C585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials and Type II for sheet 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-Sheet and K-FLEX LS.

2.02 ADHESIVES

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

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

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; 81-84.

2. Adhesives shall have a VOC content of 50 g/L or less.
3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

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. Adhesives shall have a VOC content of 50 g/L or less.
3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

D. 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. 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 Public Health's "Standard Method for the Testing and Evaluation of

Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.03 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

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).
2. VOC Content: 50 g/L or less.
3. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Vapor-Retarder Mastic: Water based; suitable for indoor and 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. 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: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
5. Color: White.

C. Vapor-Retarder 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: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Color: White.

2.04 SEALANTS

A. Joint Sealants for Cellular Glass Products:

1. 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.
5. Color: White or gray.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

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.
5. Color: Aluminum.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

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.
5. Color: White.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of

Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.05 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.

2.06 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, 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 B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 2.5-mil-thick polysurlyn.
d. Moisture Barrier for Outdoor Applications: 2.5-mil-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.

C. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with stucco-embossed aluminum-foil facing.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Polyguard Products, Inc.

2.07 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.08 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

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

      1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.

   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding; Speed Clips.

   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

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

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

2.09 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A167 or ASTM A240/A240M, Type 304.

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

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

3.02 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.

3.03 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 equipment.

C. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment 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. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

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

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

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

3.04 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Cellular Glass Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and bands or with anchor pins, speed washers, and bands.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    e. Impale insulation over anchor pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut

with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.05 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

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

3.06 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below .

1. Semi-gloss Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color per schedule below.

a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Color per schedule below.

C. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

1. Chilled Water & Brine: Dark Green.

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

3.07 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.
1.

C. Chilled-water pump insulation shall be the following:

1. Flexible Elastomeric: 1-1/2 inches thick.

D. Chilled-water expansion/compression tank insulation shall be the following:

1. Flexible Elastomeric: 1-1/2 inch thick.

E. Chilled-water air-separator insulation shall be the following:

1. Flexible Elastomeric: 2 inches thick.

3.08 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:

1. None.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Aluminum, Corrugated: 0.024 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Aluminum, with 1-1/4-Inch-Deep Corrugations: 0.032 inch thick.

END OF SECTION

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SECTION 230716.13
INSULATION FOR HEATING HOT WATER EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following HVAC equipment that is not factory insulated:
   1. Heat exchangers.
   2. Expansion/compression tanks.
   3. Air separators.

1.03 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).

1.04 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 E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

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

1.05 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.

1.06 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. SCHEDULING

D. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

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

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. Comply with requirements in ""Equipment 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 C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

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

a.

F.

a.

G. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

   a. Fibrex Insulations Inc.; FBX.Industrial Insulation Group (IIG); MinWool-1200 Industrial Board.
   b. Rock Wool; Delta Board.
   c. Roxul Inc.; RHT and RockBoard.
   d. Thermafiber, Inc.; Thermafiber Industrial Felt.

2.02 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

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.

2.03 ADHESIVES

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

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

1. Products: Subject to compliance with requirements, 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. Fiberglass 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. 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. 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.04 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

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).
2. VOC Content: 50 g/L or less.
3. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. 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 E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Color: White.

2.05 SEALANTS

A. 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.
5. Color: Aluminum.
6. Sealant shall have a VOC content of 420 g/L or less.

7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. 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.
5. Color: White.
6. Sealant shall have a VOC content of 420 g/L or less.

7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.06 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.

2.07 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, 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 B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

    a. Sheet and roll stock ready for shop or field sizing.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 2.5-mil-thick polysurlyn.
    d. Moisture Barrier for Outdoor Applications: 2.5-mil-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.

C. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a

rubberized bituminous resin on a cross laminated polyethylene film covered with stucco-embossed aluminum-foil facing.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. Polyguard Products, Inc.

2.08 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.09 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

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

        1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
        2) GEMCO; Perforated Base.
        3) Midwest Fasteners, Inc.; Spindle.

    b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
    d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

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

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

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

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

3.02 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.

3.03 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

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

J. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

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

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

M. 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.

3.04 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.

4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Do not overcompress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.05 FIELD-APPLIED JACKET INSTALLATION

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

3.06 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below .

1. Semi-gloss Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color per schedule below.

    a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.

B. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

1. Heating Hot Water and Heat Recovery: Yellow.

C. Do not field paint aluminum or stainless-steel jackets.

3.07 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Heat-exchanger (water-to-water for heating service) insulation shall be the following:
1. Mineral-Fiber Pipe and Tank: 2 inches thick.

D. Heating-hot-water expansion/compression tank insulation shall be the following:
1. Mineral-Fiber Pipe and Tank: 2 inch thick.

E. Heating-hot-water air-separator insulation shall be the following:
1. Mineral-Fiber Pipe and Tank: 2 inches thick.

3.08 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:

1. None.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
1. Aluminum, Corrugated: 0.024 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
1. Aluminum, with 1-1/4-Inch-Deep Corrugations: 0.032 inch thick.

END OF SECTION

SECTION 230716.14
INSULATION FOR STEAM EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following HVAC equipment that is not factory insulated:
   1. Steam condensate pumps.
   2. Steam flash tanks, flash separators, moisture separators, and blow-off tanks.

1.03 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).

1.04 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 E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

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

1.05 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.

1.06 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. SCHEDULING

D. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

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

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

A. Comply with requirements in "Equipment 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 C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

   a. Fibrex Insulations Inc.; FBX.Industrial Insulation Group (IIG); MinWool-1200 Industrial Board.
   b. Rock Wool; Delta Board.
   c. Roxul Inc.; RHT and RockBoard.
   d. Thermafiber, Inc.; Thermafiber Industrial Felt.

2.02 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

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.

2.03 ADHESIVES

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

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

1. Products: Subject to compliance with requirements, 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. Fiberglass 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. 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. 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.04 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

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).
2. VOC Content: 50 g/L or less.
3. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the

Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. 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 E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Color: White.

2.05 SEALANTS

A. 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.
5. Color: Aluminum.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. 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.
5. Color: White.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.06 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.

2.07 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, 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 B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

   a. Sheet and roll stock ready for shop or field sizing.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: 2.5-mil-thick polysurlyn.
   d. Moisture Barrier for Outdoor Applications: 2.5-mil-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.

2.08 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.

4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.09 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

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

      1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.

   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding; Speed Clips.

   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

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

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

2.10 CORNER ANGLES

A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A167 or ASTM A240/A240M, Type 304.

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

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

3.02 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.

3.03 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

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

J. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

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

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

M. 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.

3.04 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.

b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
d. Do not overcompress insulation during installation.
e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
f. Impale insulation over anchor pins and attach speed washers.
g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.05 FIELD-APPLIED JACKET INSTALLATION

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

3.06 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below .

1. Semi-gloss Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color per schedule below.

a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Color per schedule below.

C. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

1. Steam & Steam Condensate: Yellow.

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

3.07 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Steam condensate pump and boiler feedwater pump insulation shall be one of the following:

1. Mineral-Fiber Pipe and Tank: 2 inches thick.

D. Steam condensate tank and receiver insulation shall be the following:

1. Mineral-Fiber Pipe and Tank: 2 inches thick.

E. Steam flash-tank, flash-separator, moisture-separator, and blow-off-tank insulation shall be the following:

1. Mineral-Fiber Pipe and Tank: 2 inches thick.

3.08 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:

1. None.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Aluminum, Corrugated: 0.024 inch thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Aluminum, with 1-1/4-Inch-Deep Corrugations: 0.032 inch thick.

END OF SECTION

SECTION 230719.11
INSULATION FOR CONDENSATE DRAIN PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping, indoors.

1.03 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at pipe expansion joints for each type of insulation.
3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
4. Detail removable insulation at piping specialties.
5. Detail application of field-applied jackets.
6. Detail application at linkages of control devices.

1.04 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 E84, 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: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.05 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.

1.06 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.

1.07 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

2.01 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

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

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, 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.

2.02 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. 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.

2.03 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

1. VOC Content: 50 g/L or less.
2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Vapor-Retarder 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: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
5. Color: White.

2.04 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. 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.

2.05 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, 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 B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

    a. Sheet and roll stock ready for shop or field sizing.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 2.5-mil-thick polysurlyn.
    d. Moisture Barrier for Outdoor Applications: .
    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.

2.06 SECUREMENTS

A. Bands:
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. ITW Insulation Systems; Gerrard Strapping and Seals.
    b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.

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

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

J. Below Ambient Systems.

1. Provide continuous vapor barrier; seal joints, longitudinal seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic and joint sealant.
2. Where mastic is indicated provide vapor-barrier mastic as required for indoor or outdoor application.
3. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties

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

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

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

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

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

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

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

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

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

3.05 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 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.

C. 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.

3.06 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of mastic.
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 overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

C. Do not install metal jacket over field-applied glass-cloth jacket unless indicated in schedule.

3.07 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Color per schedule below.

B. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

1. White.

C. Do not field paint aluminum jackets.

3.08 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.

3.09 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 3/4 inch thick.

   b.

3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Piping, Concealed:

1. None.

C. Piping, Exposed:
1. Aluminum, Corrugated: 0.016 inch thick.

D. Fittings, valves, strainers, flanges, unions, and other specialties, Concealed:

1. None.

E. Fittings, valves, strainers, flanges, unions, and other specialties, Exposed:

1. Glass cloth jacket.

END OF SECTION

SECTION 230719.12
INSULATION FOR CHILLED WATER PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Chilled-water piping, indoors and outdoors.
   2. Process cooling-water piping, indoors.

1.03 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. s.
   6. Detail application of field-applied jackets.
   7. Detail application at linkages of control devices.

1.04 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 E84, 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: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.05 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.

1.06 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.07 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

2.01 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

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

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

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

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Pittsburgh Corning Corporation; Foamglas.
2. Block Insulation: ASTM C552, Type I.
3. Special-Shaped Insulation: ASTM C552, Type III.
4. Board Insulation: ASTM C552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C450 and ASTM C585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, 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.

2.02 ADHESIVES

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

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

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Foster Brand; H. B. Fuller Construction Products; 81-84.

2. Adhesives shall have a VOC content of 50 g/L or less.

3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

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.

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

1. Products: Subject to compliance with requirements, 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. 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. 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.03 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

1. VOC Content: 50 g/L or less.
2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Vapor-Retarder 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: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
5. Color: White.

C. Vapor-Retarder 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. 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: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Color: White.

2.04 SEALANTS

A. Cellular-Glass Joint Sealants:

1. 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. 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.
5. Color: White or gray.
6. Sealant shall have a VOC content of 420 g/L or less.

7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. ASJ Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Childers Brand; H. B. Fuller Construction Products; 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.
5. Color: White.
6. Sealant shall have a VOC content of 420 g/L or less.

7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.05 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

2.06 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. 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:

2.07 Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas Number 10.FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, 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 B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 2.5-mil-thick polysurlyn.
d. Moisture Barrier for Outdoor Applications: .
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.

C. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

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

a. Pittsburgh Corning Corporation; Pittwrap.
b. Polyguard Products, Inc.; Insulrap No Torch 125.

2.08 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

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. ABI, Ideal Tape Division; 428 AWF ASJ.

b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.09 SECUREMENTS

A. Bands:
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. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.

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

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

J. Below Ambient Systems.

1. Provide continuous vapor barrier; seal joints, longitudinal seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic and joint sealant.
2. Where mastic is indicated provide vapor-barrier mastic as required for indoor or outdoor application.
3. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties

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

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

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

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

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install

insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

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

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

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

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

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

3.05 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Provide factory applied ASJ-SSL jacket.
2. Create a water stop between insulation and pipe by brushing vapor barrier mastic around circumference of pipe every 3 feet.

B. Insulation Installation on Pipe Flanges, Fittings, Elbows, Valves and Pipe Specialties:

1. Provide insulation without factory applied jacket.
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. Provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Install preformed pipe insulation to outer diameter of pipe flange. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with insulating cement.
7. Secure mitered sections or segmented insulation with wire or bands.
8. Cover pipe fittings, valves, strainers, flanges, unions, and other specialties and any segmented insulated surfaces with a layer of finishing cement and install field-applied glass-cloth jacket.
9. Apply vapor-barrier mastic at exposed ends of insulation at pipe flanges, unions, and fittings.
10. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

3.06 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 Instrument Connections:

1. Install insulation on instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes.
2. Shape insulation at these connections by tapering it to and around the connection.
3. 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.

3.07 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of mastic.
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 overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

C. Do not install metal jacket over field-applied glass-cloth jacket unless indicated in schedule.

3.08 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.

1. Semi-glass Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color per schedule below.

a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.

2. Paint exposed piping without field applied metal jacket.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Color per schedule below.

C. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

1. Chilled Water: Dark Green.
2. Process Cooling: Light Green.

D. Do not field paint aluminum jackets.

3.09 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.

3.10 INDOOR PIPING INSULATION SCHEDULE

A. Chilled Water, above 40 Deg F:

1. Insulation in conditioned spaces without metal shall be the following:

a. Cellular Glass: 2 inches thick.

2. Insulation in conditioned spaces with metal jacket shall be the following:

a. Cellular Glass: 2-1/2 inches thick.

3. Insulation in unconditioned spaces such as ventilated attics and non-conditioned equipment rooms shall be the following:

a. Cellular Glass: 2-1/2 inches thick.

4. Instrument Connections:

a. Flexible Elastomeric: 1 inch thick.

B. Process Cooling Water, above 40 Deg F:

1. Insulation in conditioned spaces without metal shall be the following:

a. Cellular Glass: 2 inches thick.

2. Insulation in conditioned spaces with metal jacket shall be the following:

a. Cellular Glass: 2-1/2 inches thick.

3. Insulation in unconditioned spaces such as ventilated attics and non-conditioned equipment rooms shall be the following:

a. Cellular Glass: 2-1/2 inches thick.

4. Instrument Connections:

a. Flexible Elastomeric: 1 inch thick.

3.11 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water:

1. All Pipe Sizes: Insulation shall be the following:

a. Cellular Glass: 2-1/2 inches (63 mm) thick.

2. Instrument Connections:

a. Flexible Elastomeric: 1 inch thick.

3.12 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Loose-fill insulation, for belowground piping, is specified in Section 232113.13 "Underground Hydronic Piping".

3.13 WITHIN MANHOLE AND TUNNEL, PIPING INSULATION SCHEDULE

A. Chilled Water, All Sizes: Cellular glass, 2 inches 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. Piping, Concealed:

1. None.

C. Piping, Exposed:
1. Aluminum, Corrugated: 0.016 inch thick.

D. Fittings, valves, strainers, flanges, unions, and other specialties, Concealed:

1. None.

E. Fittings, valves, strainers, flanges, unions, and other specialties, Exposed:

1. Glass cloth jacket.

3.15 OUTDOOR, ABOVE GROUND, 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 thick.

D. Piping, Exposed:
1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.

E. Fittings, valves, strainers, flanges, unions, and other specialties, Exposed:

1. Glass cloth jacket. Install metal jacket over finished glass-cloth jacket.

3.16 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

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

3.17 WITHIN MANHOLE AND TUNNEL, FIELD-INSTALLED INSULATION JACKET

A. Chilled Water, All Sizes: Within utility manholes install field applied glass-cloth jacket over insulation material. Install aluminum, corrugated 0.024 inch thick metal jacket over finished glass cloth jacket.

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SECTION 230719.14
INSULATION FOR HEATING HOT WATER PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Heating hot-water piping, indoors and outdoors.
   2. Heat recovery water piping, indoors.

1.03 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.
   8. Fabrication drawings for reusable thermal insulation covers.

1.04 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 E84, 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: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.05 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.

1.06 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.07 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

2.01 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

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

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

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

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. Pittsburgh Corning Corporation; Foamglas.
2. Block Insulation: ASTM C552, Type I.
3. Special-Shaped Insulation: ASTM C552, Type III.
4. Board Insulation: ASTM C552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C450 and ASTM C585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, 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.

H. 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 Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.02 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

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.

2.03 ADHESIVES

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

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

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Foster Brand; H. B. Fuller Construction Products; 81-84.

2. Adhesives shall have a VOC content of 50 g/L or less.

3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of

Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

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.

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. - 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. Fiberglass 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

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

1. Products: Subject to compliance with requirements, 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. 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. 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.04 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

1. VOC Content: 50 g/L or less.
2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. 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. 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 E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Color: White.

2.05 SEALANTS

A. Cellular-Glass Joint Sealants:

1. 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. 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.
5. Color: White or gray.
6. Sealant shall have a VOC content of 420 g/L or less.

7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Childers Brand; H. B. Fuller Construction Products; 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.
5. Color: White.
6. Sealant shall have a VOC content of 420 g/L or less.

7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.06 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

2.07 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. 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

2.08 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

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

   a. Johns Manville; Zeston.
   b. P.I.C. Plastics, Inc.; FG Series.
   c. Proto Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

    a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Metal Jacket:

1. 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 B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

    a. Sheet and roll stock ready for shop or field sizing.
    b. Finish and thickness are indicated in field-applied jacket schedules.
    c. Moisture Barrier for Indoor Applications: 2.5-mil-thick polysurlyn.
    d. Moisture Barrier for Outdoor Applications: .
    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.

D. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

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

    a. Pittsburgh Corning Corporation; Pittwrap.
    b. Polyguard Products, Inc.; Insulrap No Torch 125.

2.09 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

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. ABI, Ideal Tape Division; 428 AWF ASJ.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
    c. Compac Corporation; 104 and 105.
    d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:
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. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.

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

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

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

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

N. 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.

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

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

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

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

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

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

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

3.05 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Provide factory applied ASJ-SSL jacket.
2. Create a water stop between insulation and pipe by brushing vapor barrier mastic around circumference of pipe every 3 feet.

B. Insulation Installation on Pipe Flanges, Fittings, Elbows, Valves and Pipe Specialties:

1. Provide insulation without factory applied jacket.
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. Provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Install preformed pipe insulation to outer diameter of pipe flange. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with insulating cement.
7. Secure mitered sections or segmented insulation with wire or bands.
8. Cover pipe fittings, valves, strainers, flanges, unions, and other specialties and any segmented insulated surfaces with a layer of finishing cement and install field-applied glass-cloth jacket.
9. Apply vapor-barrier mastic at exposed ends of insulation at pipe flanges, unions, and fittings.
10. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

3.06 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 Instrument Connections:

1. Install insulation on instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes.
2. Shape insulation at these connections by tapering it to and around the connection.
3. 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.

3.07 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Provide factory applied ASJ-SSL jacket.

B. Insulation Installation on Pipe Flanges, Fittings, Elbows, Valves and Pipe Specialties:

1. Insulate pipe elbows and tee fittings using preformed fitting insulation. Each piece shall be butted tightly against adjoining piece.
2. Insulate flanges and unions using a section of oversized preformed pipe insulation. Install preformed pipe insulation to outer diameter of pipe flange. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with insulating cement.
3. Insulate strainers, valves, and other pipe specialties using preformed fitting insulation. When preformed sections are not available, install mitered sections of pipe insulation. Secure mitered sections with wire or bands.
4. Arrange valve insulation to permit access to packing and to allow valve operation without disturbing insulation.
5. In concealed locations install fitted PVC cover over preformed fitting insulation. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
6. Cover pipe fittings, valves, strainers, flanges, unions, and other specialties in exposed locations and any segmented insulated surfaces with a layer of finishing cement and install field-applied glass-cloth jacket.
7. Apply breather mastic at exposed ends of insulation at pipe flanges, unions, and fittings.
8. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulation Installation on Instrument Connections:

1. Install insulation on instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes.
2. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with mastic.
3. 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.

3.08 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of mastic.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.
4. Finish to achieve smooth, uniform finish.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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

D. Do not install metal jacket over field-applied glass-cloth jacket unless indicated in schedule.

3.09 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.

1. Semi-glass Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color per schedule below.

a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.

2. Paint exposed piping without field applied metal jacket.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Color per schedule below.

C. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

1. Heating Hot Water and Heat Recovery: Yellow.

D. Do not field paint aluminum jackets.

3.10 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.

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Heating-Hot-Water Supply and Return:

1. NPS 12 and Smaller: Insulation shall be the following:
   a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

2. Instrument Connections:

a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick

B. Heat Recovery Supply and Return:

1. NPS 12 and Smaller: Insulation shall be the following:

    a. Mineral-Fiber, Preformed Pipe, Type I: 2 inches thick.

2. Instrument Connections:

    a. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick

3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Heating-Hot-Water Supply and Return:

1. All Pipe Sizes: Insulation shall be the following:

    a. Cellular Glass: 2 inches (50 mm) thick.

2. Instrument Connections:

    a. Flexible Elastomeric: 1 inch thick.

3.13 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Loose-fill insulation, for belowground pre-insulated piping, is specified in Section 232113.13 "Underground Hydronic Piping".

3.14 WITHIN MANHOLE AND TUNNEL, PIPING INSULATION SCHEDULE

A. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F and Below: Cellular glass, 2 inches (50 mm) thick.

3.15 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Piping, Concealed:

1. None.

C. Piping, Exposed:
1. Aluminum, Corrugated: 0.016 inch thick.

D. Fittings, valves, strainers, flanges, unions, and other specialties, Concealed:

1. PVC jacket.

E. Fittings, valves, strainers, flanges, unions, and other specialties, Exposed:

1. Glass cloth jacket.

3.16 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. Heating Hot Water, All Sizes: For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

3.17 WITHIN MANHOLE AND TUNNEL, FIELD-INSTALLED INSULATION JACKET

A. Heating Hot Water, All Sizes: Within utility manholes install field applied glass-cloth jacket over insulation material. Install aluminum, corrugated 0.024 inch thick metal jacket over finished glass cloth jacket.

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SECTION 230719.15
INSULATION FOR STEAM PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Steam and steam condensate piping, indoors and outdoors.
2. Hot overflow piping, indoors and outdoors.
3. Hot drain piping, indoors and outdoors.

1.03 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.
8. Fabrication drawings for reusable thermal insulation covers.

1.04 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 E84, 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: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

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

1.05 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.

1.06 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.07 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

2.01 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

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

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

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

F. Calcium Silicate:

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

    a. Industrial Insulation Group, LLC (IIG-LLC).

2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.
3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.
4. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Pittsburgh Corning Corporation; Foamglas.

2. Block Insulation: ASTM C552, Type I.
3. Special-Shaped Insulation: ASTM C552, Type III.
4. Board Insulation: ASTM C552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C450 and ASTM C585.

H. Mineral-Fiber, Preformed Pipe Insulation:
1. Products: Subject to compliance with requirements, provide one of the following:

    a. Johns Manville; Micro-Lok HP.
    b. Owens Corning; SSL II with ASJ Max Fiberglas Pipe Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. UL listed and labeled for installation over PVC and other polymer pipes within a plenum.

2.02 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

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.

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

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Foster Brand; H. B. Fuller Construction Products; 81-27.

2. Adhesives shall have a VOC content of 50 g/L or less.
3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

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

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Foster Brand; H. B. Fuller Construction Products; 81-84.

2. Adhesives shall have a VOC content of 50 g/L or less.
3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

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. - 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. Fiberglass 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

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

1. Products: Subject to compliance with requirements, 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. 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. 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 Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.04 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

1. VOC Content: 50 g/L or less.
2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. 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. 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 E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Color: White.

2.05 SEALANTS

A. Cellular-Glass Joint Sealants:

1. 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. 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.
5. Color: White or gray.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Childers Brand; H. B. Fuller Construction Products; 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.
5. Color: White.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.06 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

2.07 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. 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.

2.08 FIELD-APPLIED CLOTHS

A. Woven Cotton Fabric: 100% cotton, plain weave, and pre-sized a minimum of 8 oz./sq. yd..

2.09 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

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

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Metal Jacket:

1. 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 B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 2.5-mil-thick polysurlyn.
d. Moisture Barrier for Outdoor Applications: .
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.

D. Underground Direct-Buried Jacket: 125-mil-thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

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

a. Pittsburgh Corning Corporation; Pittwrap.
b. Polyguard Products, Inc.; Insulrap No Torch 125.

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

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. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

a. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

2.11 SECUREMENTS

A. Bands:
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. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.

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

2.12 REMOVABLE / REUSABLE THERMAL INSULATION SYSTEM

A. Insulation Covers:

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. Superior Energies, Inc.
   b. ThermaXX, LLC
   c. Fit Tight Covers
   d. Advance Thermal Corp.

2. Description: Removable insulation cover constructed with double sewn lock stitch and fastened with hook and loop straps and 1-inch slide buckles.
3. Insulation: Minimum 6 lb density glass mat, type E needled fiber. Thickness required for maximum exterior temperature of 120 deg F.
4. Jacket and Liner: PTFE or silicone fiberglass composite, 17oz/sq. yd. minimum.
5. Thread: PTFE coated with service temperature of 800 deg F.
6. Service Temperature Range: 150 to 450 deg F.
7. Drain: Stainless steel grommet at low point.

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

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

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

N. 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.

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

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

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

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

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

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements Division 07 for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

G. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07.

3.05 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.
4. Install field-applied canvas jacket.

B. Insulation Installation on Pipe Flanges, Fittings, Elbows, Valves and Pipe Specialties:

1. 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.
2. 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.
3. 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.
4. 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. Provide a design that maintains vapor barrier.
5. Insulate flanges and unions using a section of oversized preformed pipe insulation. Install preformed pipe insulation to outer diameter of pipe flange. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with insulating cement.
6. Secure mitered sections or segmented insulation with wire or bands.
7. Cover pipe fittings, valves, strainers, flanges, unions, and other specialties and any segmented insulated surfaces with a layer of finishing cement and install field-applied glass-cloth jacket.
8. Apply breather mastic at exposed ends of insulation at pipe flanges, unions, and fittings.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulation Installation on Instrument Connections:

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

3.06 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Provide factory applied ASJ-SSL jacket.
2. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.

B. Insulation Installation on Pipe Flanges, Fittings, Elbows, Valves and Pipe Specialties:

1. Provide insulation without factory applied jacket.
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. Provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Install preformed pipe insulation to outer diameter of pipe flange. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with insulating cement.
7. Secure mitered sections or segmented insulation with wire or bands.
8. Cover pipe fittings, valves, strainers, flanges, unions, and other specialties and any segmented insulated surfaces with a layer of finishing cement and install field-applied glass-cloth jacket.
9. Apply vapor-barrier mastic at exposed ends of insulation at pipe flanges, unions, and fittings.
10. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

3.07 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Provide factory applied ASJ-SSL jacket.

B. Insulation Installation on Pipe Flanges, Fittings, Elbows, Valves and Pipe Specialties:

1. Insulate pipe elbows and tee fittings using preformed fitting insulation. Each piece shall be butted tightly against adjoining piece.
2. Insulate flanges and unions using a section of oversized preformed pipe insulation. Install preformed pipe insulation to outer diameter of pipe flange. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with insulating cement.

3. Insulate strainers, valves, and other pipe specialties using preformed fitting insulation. When preformed sections are not available, install mitered sections of pipe insulation. Secure mitered sections with wire or bands.
4. Arrange valve insulation to permit access to packing and to allow valve operation without disturbing insulation.
5. In concealed locations install fitted PVC cover over preformed fitting insulation. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
6. Cover pipe fittings, valves, strainers, flanges, unions, and other specialties in exposed locations and any segmented insulated surfaces with a layer of finishing cement and install field-applied glass-cloth jacket.
7. Apply breather mastic at exposed ends of insulation at pipe flanges, unions, and fittings.
8. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulation Installation on Instrument Connections:

1. Install insulation on instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes.
2. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with mastic.
3. 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.

3.08 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of mastic.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.
4. Finish to achieve smooth, uniform finish.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

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

D. Do not install metal jacket over field-applied glass-cloth jacket unless indicated in schedule.

3.09 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.

1. Semi-glass Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color per schedule below.

    a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.

2. Paint exposed piping without field applied metal jacket.

B. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

1. Steam & Steam Condensate: Yellow.
2. All other services: White.

C. Do not field paint aluminum jackets.

3.10 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.

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Steam and Steam Condensate:

1. NPS 3/4 and Smaller: Insulation shall be one of the following:

    a. Calcium Silicate: 3-1/2 inches thick.
    b. Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches Insert dimension thick.

2. NPS 1 and Larger: Insulation shall be one of the following:

    a. Calcium Silicate: 3-1/2 inches thick.
    b. Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches thick.

B. Flash Steam Piping, from blowdown separator, deaerator tank, hot condensate drain cooler, safety relief valve, and drip pan elbow: Insulation shall be one of the following:

1. Calcium Silicate: 3-1/2 inches thick.
2. Cellular Glass: 4 inches thick.
3. Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches thick.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Piping, Concealed:

1. None.

C. Piping, Exposed:

1. Aluminum, Corrugated: 0.016 inch thick.

D. Fittings, valves, strainers, flanges, unions, and other specialties, Concealed:

1. Mineral fiber insulation: PVC jacket.
2. Insulation other than mineral fiber: None.

E. Fittings, valves, strainers, flanges, unions, and other specialties, Exposed:

1. Glass cloth jacket.

END OF SECTION

SECTION 230719.16
INSULATION FOR REFRIGERANT PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Refrigerant suction and hot-gas piping, indoors and outdoors.

1.03 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   3. Detail application of field-applied jackets.

1.04 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 E84, 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: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.05 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.

1.06 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.

1.07 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

2.01 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

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

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, 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.

2.02 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. 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.

2.03 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

1. VOC Content: 50 g/L or less.
2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Vapor-Retarder 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: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
5. Color: White.

C. Vapor-Retarder 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. 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: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Color: White.

2.04 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, 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 B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Sheet and roll stock ready for shop or field sizing.
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 2.5-mil-thick polysurlyn.
d. Moisture Barrier for Outdoor Applications: .
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.

2.05 SECUREMENTS

A. Bands:
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. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch thick, 1/2 inch wide with wing seal.

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

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

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

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

J. Below Ambient Systems.

1. Provide continuous vapor barrier; seal joints, longitudinal seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic and joint sealant.
2. Where mastic is indicated provide vapor-barrier mastic as required for indoor or outdoor application.
3. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties

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

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

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

3.04 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

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

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

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

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

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

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

3.05 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.

3.06 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of mastic.
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 overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.07 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below .

1. Semi-glass Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color per schedule below.

a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.

2. Paint exposed piping without field applied metal jacket.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Color per schedule below.

C. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

1. White.

D. Do not field paint aluminum jackets.

3.08 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.

3.09 INDOOR PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 1 inch thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be the following:

   a. Flexible Elastomeric: 1 inch thick.

3.10 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be the following:

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

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Piping, Concealed:

1. None.

C. Piping, Exposed:
1. Aluminum, Corrugated: 0.016 inch thick.

3.12 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 thick.

D. Piping, Exposed:
   1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.

END OF SECTION

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SECTION 232113.11
CONDENSATE DRAIN PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Piping joining materials.
3. Dielectric fittings.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe and tube.
2. Fittings.
3. Joining materials.
4. Transition fittings.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation are to be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
1. Condensate-Drain Piping: 150 deg F.

2.02 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: ASTM B88, Type L.

B. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4.

C. Wrought-Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than NPS 4.

D. Copper-Tube, Pressure-Seal-Joint Fittings - Copper or Bronze:

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

a. Mueller Streamline Co.; a company of Mueller Industries.

b. Victaulic Company.

c. Viega LLC.
2. Source Limitations: Obtain copper-tube pressure-seal-joint fittings from single manufacturer.
3. Housing: Copper or bronze.
4. O-Rings and Pipe Stops: EPDM.
5. Tools: Manufacturer's special tools.
6. Minimum 200 psig working pressure rating at 250 deg F.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

A. Condensate-Drain Piping Installed Aboveground to Be Any of the Following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40, PVC plastic pipe and fittings and solvent-welded joints.

3.02 INSTALLATION OF PIPING

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

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

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

M. 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.

N. Install valves according to the following:
1. Section 230523.12 "Ball Valves for HVAC Piping."

O. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

P. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

Q. 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."

R. 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."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.03 JOINT CONSTRUCTION

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

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

C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

3.04 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

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

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

D. Support horizontal piping within 12 inches of each fitting and coupling.

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

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

3.05 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

3.06 FIELD QUALITY CONTROL

A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:

1. Leave joints uninsulated and exposed for examination during test.
2. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

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. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure is not to exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9.
3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
4. Prepare written report of testing.

END OF SECTION

SECTION 232113.12
ABOVEGROUND METAL HYDRONIC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Piping joining materials.
4. Transition fittings.
5. Dielectric fittings.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe and tube.
2. Fittings.
3. Joining materials.
4. Transition fittings.

1.03 QUALITY ASSURANCE

A. Furnish new and unused piping materials manufactured in the United States of America. Piping shall be marked with country of origin from the manufacturer.

B. Pipe Welding: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9 for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation are to be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. Hot-Water Heating Piping: 150 psig at 200 deg F.
2. Chilled-Water Piping: 150 psig at200 deg F.
3. Dual-Temperature Heating- and Cooling-Water Piping:150 psig at200 deg F.
4. Condenser-Water Piping: 150 psig at150 deg F.
5. Glycol Cooling-Water Piping: 150 psig at 150 deg F.
6. Makeup-Water Piping: 150 psig at 150 deg F.

7. Air-Vent Piping: 200 deg F.
8. Pressure-Relief-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.02 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: ASTM B88, Type L.

B. Annealed-Temper Copper Tube: ASTM B88, Type K.

C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4.

D. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Do not use solder joints on pipe sizes greater than NPS 4.

E. Wrought-Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than NPS 4.

F. Copper-Tube, Pressure-Seal-Joint Fittings - Copper or Bronze:

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

   a. Mueller Streamline Co.; a company of Mueller Industries.

   b. Victaulic Company.

   c. Viega LLC.

2. Source Limitations: Obtain copper-tube pressure-seal-joint fittings from single manufacturer.
3. Housing: Copper or bronze.
4. O-Rings and Pipe Stops: EPDM.
5. Tools: Manufacturer's special tools.
6. Minimum 200 psig working pressure rating at 250 deg F.

2.03 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M black steel with plain ends; welded and seamless, Grade B, and schedule number as indicated in Part 3,"Piping Applications" Article.

B. 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 "Piping Applications" Article.

E. Wrought-Steel Fittings: ASTM A234/A234M; wall thickness to match adjoining pipe.

F. 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. Grooved Mechanical-Joint Fittings and Couplings:

1. Source Limitations: Obtain grooved mechanical-joint fittings and couplings from single manufacturer.
2. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

H. Steel Piping, Pressure-Seal-Joint Fittings:

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

   a. Mueller Streamline Co.; a company of Mueller Industries.

   b. Victaulic Company.

   c. Viega LLC.

2. Obtain steel piping pressure-seal-joint fittings from single manufacturer.
3. Material: Carbon steel with corrosion-resistant coating.
4. O-Rings and Pipe Stop: EPDM.
5. Tools: Manufacturer's special tool.
6. Minimum 200 psig working-pressure rating at 230 deg F.

I. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.

2.04 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

C. Solder Filler Metals: ASTM B32, lead-free alloys.

D. Flux: ASTM B813, water flushable.

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

2.05 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. Source Limitations: Obtain dielectric unions from single manufacturer.
2. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig minimum at 180 deg F.
c. End Connections: Solder-joint copper alloy and threaded ferrous. Solder joints are not to be used on pipe sizes greater than NPS 4.

C. Dielectric-Flange Insulating Kits:

1. Source Limitations: Obtain dielectric-flange insulating kits from single manufacturer.
2. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

A. Hot-Water Heating Piping, Aboveground, NPS 2 and Smaller, to Be Any of the Following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.
2. Schedule 40, Grade B, steel pipe; Class 150, malleable-iron fittings; and threaded or pressure-seal joints.

B. Hot-Water Heating Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:

1. Schedule 40, Grade B, steel pipe; Class 150, malleable-iron fittings; welded joints, cast-iron flanges, flange-fittings, and flanged joints.

C. Chilled-Water Piping, Aboveground, NPS 2 (DN 50) and Smaller, to be Any of the Following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.

2. Schedule 40, Grade B steel pipe; Class 150, malleable-iron fittings; and threaded or pressure-seal joints.

D. Chilled-Water Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:

1. Schedule 40, Grade B, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

E. Makeup-Water Piping Installed Aboveground to Be Any of the Following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.

F. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems, according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered joints.

G. Pressure-Relief-Valve-Inlet and -Outlet Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems, according to piping manufacturer's written instructions.
2. Outlet: Type L, drawn-temper copper tubing with soldered joints.

3.02 INSTALLATION OF PIPING

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

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

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

M. 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 230523.11 "General Duty Valves for Hydronic Piping."

P. Install air vents and pressure-relief valves in accordance with Section 232116 "Hydronic Piping Specialties."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

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

T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install 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."

W. 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."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.03 JOINT CONSTRUCTION

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

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

C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

D. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators in accordance with "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.

G. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

H. Pressure-Seal Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.

3.04 INSTALLATION OF DIELECTRIC FITTINGS

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

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 and Larger: Use dielectric flange kits.

3.05 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

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

C. Support horizontal piping within 12 inches of each fitting and coupling.

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

3.06 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections are to be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Where 3-way control valve is specified, install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gauges for HVAC Piping."

3.07 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

3.08 SYSTEM STARTUP

A. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.
8. Verify installation of system pressure relief valve(s) and that they are set at as indicated on the plan documents but in no case greater than 100 psig.

3.09 FIELD QUALITY CONTROL

A. Perform the following low pressure leak test on hydronic piping as follows:

1. Isolate sections of piping to be tested.
2. Leave joints uninsulated and exposed for examination during test.
3. Subject piping system to a maximum pneumatic test pressure of 15 psig.
4. After pneumatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage by using a lead finder solution.
5. If a leak is detected or test pressure drops to 0 psig, eliminate leaks by tightening, repairing, or replacing components, and repeat pneumatic test until there are no leaks.

B. Prepare hydronic piping in accordance with ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
3. Isolate equipment from piping. If a valve is used to isolate equipment, its closure is to be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
4. Install pressure-relief valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

C. Perform the following tests on hydronic piping:

1. Use ambient-temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.

4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure is not to exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9.
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

END OF SECTION

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SECTION 232116
HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Hydronic coil packages.
3. Air vents.
4. Expansion tanks and fittings.
5. Air/dirt separators and purgers.
6. Strainers.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.03 CLOSEOUT SUBMITTALS

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

1.04 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.05 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators in accordance with ASME BPVC, Section IX.

B. Pressure-relief and safety-relief valves and pressure vessels bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC, Section VIII, Division 1.

PART 2 - PRODUCTS

2.01 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Taco Comfort Solutions; Accu-Flo or a comparable product by one of the following:

    a. Bell & Gossett; a Xylem brand.

    b. Griswold Controls, LLC.

2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Bell & Gossett; CB or a comparable product by one of the following:

    a. Taco Comfort Solutions; Accu-flo
    b. Watts; CSM-81-F.
    c. Wheatley; PSV

2. Body: Cast-iron or steel body, ball, butterfly, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass- and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged.
8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F.

2.02 HYDRONIC COIL PACKAGES

A. Combination Strainer / Isolation Ball Valve:

1. Body: Forged or cast brass.
2. Connections: Threaded with union inlet.
3. Combination Assemblies: Include bronze ball valve, union and strainer.
4. 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.

5. Valve: Bronze ball valve with stainless-steel trim.
6. Size: NPS 2 and smaller.
7. Minimum CWP Rating: 275 psig.
8. Maximum Operating Temperature: 250 deg F.

B. Combination Union / Isolation Ball Valve:

1. Body: Forged or cast brass.
2. Connections: Threaded with union inlet.
3. Combination Assemblies: Include bronze ball valve and union.
4. Union: Provide union with four 1/4-inch 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.
5. Valve: Bronze ball valve with stainless-steel trim.
6. Size: NPS 2 and smaller.
7. Minimum CWP Rating: 275 psig.
8. Maximum Operating Temperature: 250 deg F.

C. Isolation Union:

1. Body: Forged or cast brass.
2. Connections: Threaded.
3. Union: Provide union with four 1/4-inch body tappings with brass end connections. Union seal shall be EPDM O-rings. Provide a pressure/temperature test plug.
4. Size: NPS 2 and smaller.
5. Minimum CWP Rating: 275 psig.
6. Maximum Operating Temperature: 250 deg F.

D. Stainless Steel, Flexible Connectors:

1. Body: Flame retardant, flexible, stainless steel braided hose with EPDM core.
2. End Connections: Threaded to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

2.03 AIR VENTS

A. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

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.

5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

2.04 EXPANSION TANKS AND FITTINGS

A. Bladder-Type ASME Expansion Tanks:

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

   a. Amtrol, Inc.

   b. Bell & Gossett; a Xylem brand.

   c. Taco Comfort Solutions.

2. Tank: Welded steel, rated for 125 psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity. Field-replaceable bladder.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.05 AIR/DIRT SEPARATORS AND PURGERS

A. Coalescing-Type Air and Dirt Separators:

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

   a. Bell & Gossett; a Xylem brand.

   b. Spirotherm, Inc.

   c. Taco Comfort Solutions.

2. Tank: Fabricated steel tank; ASME constructed and stamped for 125 psig working pressure and 270 deg F maximum operating temperature.
3. Coalescing Medium: Stainless steel.
4. Air Vent: Threaded to top of separator.
5. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for NPS 2-1/2 and larger.
6. Blowdown Connection: Threaded to bottom of separator with ball valve.
7. Flushing Connection: Threaded to side of separator with ball valve.
8. Size: Match system flow capacity.

2.06 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.

2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless steel, 20-mesh strainer, or perforated stainless steel basket.
4. CWP Rating: 125 psig.

PART 3 - EXECUTION

3.01 EXAMINATION

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

B. Examine threads on all devices for form and cleanliness.

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

D. Do not attempt to repair defective piping specialties; replace with new devices. Remove defective piping specialties from site.

3.02 INSTALLATION OF VALVES

A. Install calibrated-orifice balancing valve at each branch connection to return main.

B. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.

C. Install pressure-relief and safety-relief valves at hot-water generators and elsewhere as required by ASME BPVC. Pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME BPVC, Section VIII, Division 1, for installation requirements.

3.03 HYDRONIC SPECIALTIES INSTALLATION

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

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.

1. Provide air outlet drain line full size of air outlet to floor drain or to other point indicated on Drawings.

C. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

D. Install air purgers in pump suction.

E. Install air/dirt separators in pump suction. Install blowdown piping with gate or full-port ball valve full size of separator outlet; extend full size to nearest floor drain.

F. Install bladder-type expansion tanks on the floor.

G. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

3.04 MAKEUP-WATER SYSTEM INSTALLATION

A. Comply with requirements in Division 22 for backflow preventers, water meters, and water regulators associated with makeup-water system.

B. Install reduced-pressure-principle backflow preventers in each makeup-water supply to mechanical equipment and systems. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

C. Install water meter in each makeup-water supply to mechanical equipment and systems.

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

3.05 BALANCING VALVE SCHEDULE

1. Coil Connections, NPS 2 and smaller, shall be one or more of the following (as indicated on the Drawings):
   a. Bronze, Calibrated-Orifice, Balancing Valves

2. Coil Connections, NPS 2-1/2 and larger, shall be one or more of the following (as indicated on the Drawings):
   a. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves

3. Pump Connections, NPS 2 and smaller, shall be the following:
   a. Bronze, Calibrated-Orifice, Balancing Valves

4. Pump Connections, NPS 2-1/2 and larger, shall be the following:
   a. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves

3.06 HYDRONIC COIL PACKAGE SCHEDULE

A. Coil Connections, NPS 2 and Smaller, where indicated on the Drawings:

1. Combination Strainer / Isolation Ball Valve: Supply side of coil.
2. Isolation Union: Return side of coil, on inlet side of control valve.
3. Combination Union / Isolation Ball Valve: Return side of coil, on leaving side of control valve.
4. Stainless Steel, Flexible Connectors: Supply and return sides of coil.

END OF SECTION

SECTION 232123
HYDRONIC PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Close-coupled, end-suction centrifugal pumps.

1.03 DEFINITIONS

A. EPDM: Ethylene propylene diene monomer.

B. EPR: Ethylene propylene rubber.

C. HI: Hydraulic Institute.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of pump.

   1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
   2. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

   1. Show pump layout and connections.
   2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
   3. Include diagrams for power, signal, and control wiring.

1.05 CLOSEOUT SUBMITTALS

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

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

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

1. Armstrong Pumps, Inc.
2. ITT Corporation.
3. TACO Comfort Solutions, Inc.

B. Source Limitations: Obtain pumps from single source from single manufacturer.

C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

D. Pump Construction:

1. Casing: Radially split, cast iron, with drain plug at bottom and air vent at top of volute, threaded gauge tappings at inlet and outlet, and flanged connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft Sleeve: Type 304 stainless steel.
4. Pump Stub Shaft: Type 304 stainless steel.
5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and EPDM bellows and gasket. Include water slinger on shaft between motor and seal.

E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

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

2.03 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
3. Bronze 16-mesh wire startup and bronze or Type 304 stainless steel permanent strainers with 3/16-inch.
4. Bronze or Type 304 stainless steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

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

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

3.02 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Equipment Mounting:

1. Install base-mounted pumps on cast-in-place concrete equipment bases or inertia bases with restrained spring isolators, as indicated on the plans. Comply with requirements for equipment bases and foundations specified in Division 03.
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and spring hangers of size required to support weight of in-line pumps.

1. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.03 ALIGNMENT

A. Engage a factory-authorized service representative to perform laser alignment service.

B. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.04 PIPING CONNECTIONS

A. Where installing piping adjacent to pump allow space for service and maintenance.

B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

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

D. Install check, shutoff, and calibrated balancing valves on discharge side of pumps.

E. Install Y-type strainer or suction diffuser, as indicated on the Plans, and shutoff valve on suction side of pumps.

1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.

F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

G. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

3.05 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Division 26.

B. Ground equipment in accordance with Division 26.

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Division 26.
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.06 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Division 26.

3.07 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping. Use startup strainer for initial startup.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Hydronic pumps will be considered defective if they do not pass tests and inspections.

3.09 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION

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SECTION 232213.11
ABOVEGROUND STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Steel pipe and fittings.
2. Joining materials.

B. Related Requirements:

1. Section 232213.13 "Underground Steam and Condensate Heating Piping" for conduit steam and condensate piping installed underground outside the building and steel piping within manholes.
2. Section 232216 "Steam and Condensate Heating Piping Specialties" for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Steel pipe and fittings.
2. Joining materials.

1.04 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. Furnish new and unused piping materials manufactured in the United States of America. Piping shall be marked with country of origin from the manufacturer.

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

C. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. HP Steam Piping: 300 psig.
2. LP Steam Piping: 125 psig.
3. Condensate Piping: 300 psig at 250 deg F.
4. Makeup-Water Piping: 80 psig at 150 deg F.
5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.02 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A106/A106M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

C. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.

D. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.

E. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.

F. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

G. Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.03 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

    a. Full-Face Type: For flat-face flanges.
    b. Narrow-Face Type: For raised-face flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel of type to match pipe unless otherwise indicated.

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

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

PART 3 - EXECUTION

3.01 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 300 malleable-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 300 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.02 HP STEAM PIPING APPLICATIONS

A. HP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 300 malleable-iron fittings; and threaded joints; Schedule 80 pipe nipples.

B. HP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 300 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. Condensate piping above grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 300 malleable-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 300 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.03 ANCILLARY PIPING APPLICATIONS

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.04 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

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

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

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

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

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

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

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

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to Section 230523.21 "General Duty Valves for Steam and Condensate Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet.
2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.05 INSTALLATION OF STEAM AND CONDENSATE PIPING SPECIALTIES

A. Comply with requirements in Section 232216 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.06 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers, supports, and anchor devices.

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

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

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

E. Support vertical runs of steel steam supply piping and steel steam condensate piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.07 PIPE JOINT CONSTRUCTION

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

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

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.08 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.09 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.9, "Building Services Piping," and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Perform the following tests and inspections:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 150 psig. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

C. Prepare test and inspection reports.

END OF SECTION

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SECTION 232216
STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes the following piping specialties for steam and condensate piping:

1. Strainers.
2. Stop-check valves.
3. Safety valves.
4. Pressure-reducing valves.
5. Steam traps.
6. Thermostatic air vents and vacuum breakers.
7. Moisture separators.
8. Steam meters

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Strainer.
2. Valve.
3. Steam trap.
4. Air vent and vacuum breaker.
5. Connector.
6. Separators.
7. Acoustic Silencers.
8. Meter.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. HP Steam Piping: 300 psig.
2. LP Steam Piping: 125 psig.
3. Condensate Piping: 300 psig at.
4. Makeup-Water Piping: 80 psig at 150 deg F.
5. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
6. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.02 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer or perforated stainless-steel basket.
4. Tapped blow-off plug.
5. CWP Rating: 250-psig working steam pressure.

2.03 STOP-CHECK VALVES

A. Stop-Check Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Crane Co.; Figure 30E or comparable product by one of the following:

    a. Crane; Crane Energy Flow Solutions.
    b. Jenkins Valves.
    c. Stockham Valves.

2. Body and Bonnet: Malleable iron.
3. End Connections: Flanged.
4. Disc: Cylindrical with removable liner and machined seat.
5. Stem: Brass alloy.
6. Operator: Outside screw and yoke with cast-iron handwheel.
7. Packing: PTFE-impregnated packing with two-piece packing gland assembly.
8. Pressure Class: 250.

2.04 STEAM SAFETY VALVES

A. Bronze Steam Safety Valves: ASME labeled.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Kunkle Valve; 6030 or comparable product by one of the following:

    a. Armstrong International, Inc.
    b. Kunkle Valve.
    c. Spirax Sarco, Inc.
    d. Watts Regulator Co.

2. Disc Material: Stainless steel with stainless steel nozzle and O-ring seats.
3. End Connections: Threaded inlet and outlet.
4. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
5. Pressure Class: 300.
6. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet, with threads complying with ASME B1.20.1.
7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

B. Cast-Iron Steam Safety Valves: ASME labeled.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Kunkle Valve; 6252 or comparable product by one of the following:

    a. Armstrong International, Inc.
    b. Kunkle Valve.
    c. Spirax Sarco, Inc.
    d. Watts Regulator Co.

2. Disc Material: Stainless steel with stainless steel nozzle.
3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
7. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
8. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.05 ELECTRIC ACTUATED PRESSURE REDUCING VALVES

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

1. Armstrong International, Inc.
2. Hoffman Specialty.
3. Spirax Sarco, Inc.

B. ASME labeled.

C. Description: Two-port, single seat globe valve with cage retained seats.

D. Body: Ductle iron.

E. End Connections: Threaded connections for valves NPS 2 and smaller and flanged connections for valves NPS 2-1/2 and larger.

F. Trim: Hardened stainless steel, low noise option.

G. Bonnet Type: Extended.

H. Gaskets: Non-asbestos materials.

2.06 STEAM TRAPS

A. Thermodynamic Steam Traps:

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

    a. Armstrong International, Inc.
    b. Hoffman Specialty.
    c. Spirax Sarco, Inc.

2. Body: Stainless steel with screw-in cap.
3. End Connections: Threaded.
4. Disc and Seat: Stainless steel.
5. Maximum Operating Pressure: 600 psig.

B. Float and Thermostatic Steam Traps:

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

    a. Armstrong International, Inc.
    b. Hoffman Specialty.
    c. Spirax Sarco, Inc.

2. Body and Bolted Cap: ASTM A 126 cast iron.
3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Head and Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.
8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless-steel cage, valve, and seat.
10. Maximum Operating Pressure: 125 psig.

2.07 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

1. Body: Cast iron, bronze, or stainless steel.
2. End Connections: Threaded.
3. Float, Valve, and Seat: Stainless steel.

4. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
5. Pressure Rating: 300 psig.
6. Maximum Temperature Rating: 350 deg F.

B. Vacuum Breakers:

1. Body: Cast iron, bronze, or stainless steel.
2. End Connections: Threaded.
3. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
4. O-Ring Seal: Ethylene propylene rubber.
5. Pressure Rating: 300 psig.
6. Maximum Temperature Rating: 350 deg F.

2.08 MOISTURE SEPERATOR

A. Basis-of-Design Product: Subject to compliance with requirements, provide Spirax Sarco, S3.

B. Description: High efficiency internal baffle type having a pressure drop that does not exceed an equivalent length of pipe.

1. Body: Ductile or cast iron.
2. End Connections: Screwed for NPS 2 and smaller, flanged for NPS 2-1/2and larger.
3. Drain: Threaded bottom drain shall be provided for the installation of a trap to discharge any accumulated liquid.

PART 3 - EXECUTION

3.01 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.02 PIPING INSTALLATION

A. Install piping to permit valve servicing.

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

C. Install valves according to the following:

1. Section 230523.21 "Globe Valves for Steam and Condensate Piping."
2. Section 230523.22 "Ball Valves for Steam and Condensate Piping."
3. Section 230523.23 "Butterfly Valves for Steam and Condensate Piping."
4. Section 230523.24 "Check Valves for Steam and Condensate Piping."

5. Section 230523.25 "Gate Valves for Steam and Condensate Piping."

D. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.

E. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

F. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full-port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blow-off connection for strainers smaller than NPS 2.

3.03 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.04 PRESSURE-REDUCING VALVE INSTALLATION

A. Install pressure-reducing valves in accessible location for maintenance and inspection.

B. Install high performance butterfly valves on both sides of pressure-reducing valves.

C. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections, respectively.

D. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to Section 230519 "Meters and Gages for HVAC Piping."

E. Install strainers upstream for pressure-reducing valve.

F. Install safety valve downstream from pressure-reducing valve station.

3.05 SAFETY VALVE INSTALLATION

A. Install safety valves according to ASME B31.9, "Building Services Piping."

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

3.06 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION

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SECTION 232223
STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes steam condensate pumps.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated. Indicate pump's operating point on curves. Include receiver capacity and material.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.04 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.01 SINGLE-STAGE, CENTRIFUGAL PUMPS WITH FLOOR-MOUNTED RECEIVER

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

1. Skidmore

2. Armstrong Fluid Handling; Div. of Armstrong International, Inc.
3. ITT Corporation; Domestic Pump Division.
4. Shipco Pumps.

5. Spirax-Sarco Inc.

B. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pumps, controls, and accessories suitable for operation with steam condensate.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Configuration: Duplex floor-mounted pump with receiver and float switches; rated to pump 200 deg F steam condensate.

D. Receiver:

1. Floor mounted.
2. Close-grained cast iron.
3. Externally adjustable float switches.
4. Flanges for pump mounting.
5. Water-level gage and dial thermometer.
6. Pressure gage at pump discharge.
7. Bronze fitting isolation valve between pump and receiver.
8. Lifting eyebolts.
9. Inlet vent and an overflow.
10. Cast-iron inlet strainer with vertical self-cleaning bronze screen and large dirt pocket.

E. Pumps:

1. Centrifugal, close coupled, vertical design.
2. Permanently aligned.
3. Bronze fitted.
4. Replaceable bronze case ring.
5. Mechanical seals rated at 250 deg F.
6. Mounted on receiver flange.

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: Open, drip-proof.

G. Control Panel:

1. Factory wired between pumps and float switches, for single external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 250, Type 1 enclosure with hinged door and grounding lug, mounted on pump.
4. Motor controller for each pump.
5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Manual lead-lag control to override electrical pump alternator and manually select the lead pump.
7. Momentary-contact "TEST" push button on cover for each pump.
8. Numbered terminal strip.
9. Disconnect switch.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

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

3.02 INSTALLATION

A. Install pumps according to HI 1.1-1.2, HI 1.3, and HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

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

D. Install thermometers and pressure gages.

E. Equipment Mounting: Install pumps on cast-in-place concrete equipment base(s) using elastomeric pads. Comply with requirements for equipment bases specified in Division 03. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC Piping and Equipment."

1. Minimum Deflection: 1/4 inch.
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Install on 4-inch-high concrete base and extend base not less than 6 inches in all directions beyond the maximum dimensions of pumps unless otherwise indicated or unless required for seismic-anchor support..

3.03 CONNECTIONS

A. Comply with requirements for piping specified in Section 232213.11 "Aboveground Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

B. Where installing piping adjacent to machine, allow space for service and maintenance.

C. Install a globe and check valve and pressure gage before inlet of each pump and a gate and check valve at pump outlet.

D. Pipe drain to nearest floor drain for overflow and drain piping connections.

E. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.

F. Ground equipment according to Division 26.

G. Connect wiring according to Division 26.

3.04 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Clean strainers.
3. Set steam condensate pump controls.
4. Set pump controls for automatic start, stop, and alarm operation.
5. Perform the following preventive maintenance operations and checks before starting:

    a. Set float switches to operate at proper levels.
    b. Set throttling valves on pump discharge for specified flow.
    c. Check motors for proper rotation.
    d. Test pump controls and demonstrate compliance with requirements.
    e. Replace damaged or malfunctioning pump controls and equipment.
    f. Verify that pump controls are correct for required application.

6. Start steam condensate pumps according to manufacturer's written startup instructions.

3.05 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain steam condensate pumps.

END OF SECTION

SECTION 232300
REFRIGERANT PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

1.03 ACTION SUBMITTALS

A. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
3. Show interface and spatial relationships between piping and equipment.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.05 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.06 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

2.02 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 88, Type K or L.

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

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

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

2.03 VALVES AND SPECIALTIES

A. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

B. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

C. Thermostatic Expansion Valves: Comply with AHRI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig.

D. Moisture/Liquid Indicators:
1. Body: Forged brass.

2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in parts per million (ppm).
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

E. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

2.04 REFRIGERANTS

A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type L, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type L, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

3.02 VALVE AND SPECIALTY APPLICATIONS

A. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

B. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

C. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.

3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

D. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

E. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

F. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

G. Install receivers sized to accommodate pump-down charge.

H. Install flexible connectors at compressors.

3.03 PIPING INSTALLATION

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

B. Install refrigerant piping according to ASHRAE 15.

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

D. 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.

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

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

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

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Install refrigerant piping in protective conduit where installed belowground.

L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

M. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.

2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Liquid lines may be installed level.

N. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

O. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

P. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

Q. 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."

R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.04 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: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

3.05 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

B. Install the following pipe attachments:
1. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

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

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

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

3.06 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.

2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.07 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.08 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

D. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 232513
WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes the following water treatment for closed-loop hydronic systems:

1. Chemicals.

1.03 DEFINITIONS

A. RO: Reverse osmosis.

B. TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.

C. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.04 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
1. Chemical-treatment test equipment.
2. Chemical material safety data sheets.

1.05 INFORMATIONAL SUBMITTALS

A. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.

B. Field quality-control reports.

C. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.

D. Water Analysis: Illustrate water quality available at Project site.

1.06 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

2.01 PERFORMANCE REQUIREMENTS

A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including hot-water heating below 250 deg F, chilled water, heat recovery water, and process cooling water shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.
2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
3. Boron: Maintain a value within 100 to 200 ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
6. TSS: Maintain a maximum value of 10 ppm.
7. Ammonia: Maintain a maximum value of 20 ppm.
8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
9. Scale Control: Provide softened water for initial fill and makeup. Where softened water is not used, provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.
10. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
11. Microbiological Limits:

    a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
    d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
    e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

2.02 CHEMICALS

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

PART 3 - EXECUTION

3.01 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.02 INSTALLATION

A. Install water-testing equipment on wall near water-chemical-application equipment.

3.03 PIPING CONNECTIONS

A. Piping installation requirement are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in:
   1. Section 230523.12 "Ball Valves for HVAC Piping".
   2. Section 230523.13 "Butterfly Valves for HVAC Piping".

E. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

   1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
   3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
   4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
   5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
   7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and

allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.

8. Repair leaks and defects with new materials, and retest piping until no leaks exist.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. At six-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis, advising Owner of changes necessary to adhere to "Performance Requirements" Article.

F. Comply with ASTM D3370 and with the following standards:

1. Silica: ASTM D859.
2. Acidity and Alkalinity: ASTM D1067.
3. Iron: ASTM D1068.
4. Water Hardness: ASTM D1126.

3.05 MAINTENANCE SERVICE

A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:

1. Initial water analysis and HVAC water-treatment recommendations.
2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
3. Periodic field service and consultation.
4. Customer report charts and log sheets.
5. Laboratory technical analysis.
6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.06 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION

SECTION 232923
VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.02 DEFINITIONS

A. CPT: Control power transformer.

B. DDC: Direct digital control.

C. LED: Light-emitting diode.

D. NC: Normally closed.

E. NO: Normally open.

F. OCPD: Overcurrent protective device.

G. PID: Control action, proportional plus integral plus derivative.

H. VFC: Variable-frequency motor controller.

1.03 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

1. Include dimensions and finishes for VFCs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

1. Include mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each VFC from manufacturer.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.05 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Division 01, include the following:

a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
b. Manufacturer's written instructions for setting field-adjustable overload relays.
c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store in space that is enclosed, air conditioned, and free of construction born debris and dust.

B. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and connect factory-installed space heaters to temporary electrical service.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.08 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 VARIABLE-FREQUENCY MOTOR CONTROLLERS

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

1. ABB, Inc; ACH580 Series.
2. Danfoss, Inc; VLT HVAC Drive FS 102 Series.
3. Yaskawa Electric America, Inc; HV600 Series.

2.02 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

B. Application: Variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Pulse-Width-Modulated Inverter: 6-pulse, unless noted otherwise on Drawings.

G. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 5 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
8. Humidity Rating: Less than 95 percent (noncondensing).

9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 0.1 percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

H. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

I. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

J. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 6,000 seconds.
4. Deceleration: 0.1 to 6,000 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

K. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
2. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
3. NC alarm contact that operates only when circuit breaker has tripped.

2.03 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).

8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

   a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
   b. A minimum of six multifunction programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:

   a. 0- to 10-V dc.
   b. 4- to 20-mA dc.
   c. Potentiometer using up/down digital inputs.

3. Output Signal Interface: A minimum of two programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:

   a. Output frequency (Hz).
   b. Output current (load).
   c. DC-link voltage (V dc).
   d. Motor torque (percent).
   e. Motor speed (rpm).
   f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of three programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

   a. Motor running.
   b. Set point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: One.

G. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.

1. Hardwired Points:

   a. Monitoring: On-off status.
   b. Control: On-off operation and speed operation.

2. Communication Interface: Comply with ASHRAE 135 and Modbus. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.04 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning (Harmonic Mitigation): As indicated on Drawings.

2.05 BYPASS DRIVE PACKAGE

A. Bypass Drive Package shall be provided where indicated on Drawings.

B. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

C. Bypass Mode:

1. Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback.

D. Bypass Controller:

1. Three-Contactor-Style Bypass: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

    a. Bypass Contactor: Load-break, NEMA-rated contactor.
    b. Input and Output Isolating Contactors: Non-load-break, NEMA-rated contactors.
    c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

E. Bypass Contactor Configuration: Full-voltage (across-the-line) type.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 100 VA.

6. Overload Relays: NEMA ICS 2.

    a. Solid-State Overload Relays:

        1) Switch or dial selectable for motor-running overload protection.
        2) Sensors in each phase.
        3) Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
        4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
        5) Analog communication module.

    b. NC isolated overload alarm contact.
    c. External overload, reset push button.

2.06 REDUNDANT DRIVE PACKAGE

A. Redundant Drive Package shall be provided where indicated on Drawings.

B. Description: Two VFD drives (Drive A, Drive B) shall be supplied in a NEMA rated enclosure, fully pre-wired and ready for installation as a single UL listed device.

C. Redundant Drive Operation:

1. Safely transfers motor between Drive A and Drive B, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running).
2. Field-selectable automatic or manual, allows local and remote transfer between Drive A and Drive B and retransfer, either via manual operator interface or automatic-control system feedback.

D. Redundant Drive Package features:

1. DRIVE A / AUTO / DRIVE B selector switch.
2. HAND / OFF / AUTO selector switch.
3. FAULT TRANSFER selector switch.
4. Status Lights: Door-mounted LED indicators displaying the following conditions:

    a. External Fault.
    b. Drive A Fault.
    c. Drive B Fault.
    d. Drive A Run.
    e. Drive B Run.

5. Semiconductor fuses for each VFC.
6. Output contactor for each VFC.
7. Single power input/output wiring points
8. Single control wiring points
9. Two door mounted drive control keypads.
10. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

11. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

2.07 OPTIONAL FEATURES

A. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it and generates fault indications when overload protection activates.

1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.

B. Damper control circuit with end-of-travel feedback capability.

C. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.

D. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.

E. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station, this password-protected input:

1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
3. Causes display of override mode on the VFC display.
4. Reset VFC to normal operation on removal of override signal automatically.

F. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a notebook computer.

2.08 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 3R.
3. Other Wet or Damp Indoor Locations: Type 4.
4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.09 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: Covered.
2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.

B. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

C. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

D. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

E. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

F. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Cooling Fan and Exhaust System: For NEMA 250, Type 1; UL 508 component recognized: Supply fan, with stainless steel intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

H. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

2.10 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

3.02 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Division 26.

B. Floor-Mounting Controllers: Install VFCs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in Division 03.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFC.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26.

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.03 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices. Comply with requirements in Division 25 and Division 26.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.04 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 25 and Division 26.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.05 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
5. Test each motor for proper phase rotation.

6. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
7. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. VFCs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.06 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Document all internal configurations and settings upon completion of startup and include with startup report.

3.07 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges per coordination studies as specified in Division 26.

F. Set field-adjustable pressure switches.

3.08 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.09 DEMONSTRATION

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

END OF SECTION

SECTION 233113.11
METAL DUCTS FOR GENERAL HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes duct services for supply, return, outdoor air, and general exhaust (ASHRAE 62.1, Class 1 and 2):

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round and flat-oval ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Duct liner.
7. Sealants and gaskets.
8. Hangers and supports.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

B. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans or BIM model, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.

6. Items penetrating finished ceiling including the following:

    a. Luminaires (Lighting fixtures).
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.
    g. Fire alarm devices.
    h. Lighting control devices.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.02 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

    1. Construct ducts of galvanized sheet steel unless otherwise indicated.
    2. For ducts exposed to weather, comply with requirements per "Ductwork Exposed to Weather" Article.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.03 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, comply with requirements per "Ductwork Exposed to Weather" Article.
3. Basis-of-Design Product: Subject to compliance with requirements, provide SEMCO, LLC; SEMCO Single-Wall Round Duct & Fittings or a comparable product by one of the following:

    a. Crown Products Company, Inc.

    b. McGill AirFlow LLC.

    c. Sheet Metal Connectors, Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.04 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

D. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

E. Tie Rods: Galvanized steel, 1/4-inch-minimum diameter for lengths 36 inches or less; 3/8-inch-minimum diameter for lengths longer than 36 inches.

2.05 DUCT LINER

A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

a. Adhesive shall have a VOC content of 80 g/L or less.
b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.

C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpmor greater.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

    a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.06 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Sealant shall have a VOC content of 420 g/L or less.
9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
10. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.07 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

PART 3 - EXECUTION

3.01 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.02 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.03 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:
1. Ductwork shall be galvanized steel.

a. If duct outer surface is uninsulated, protect outer surface with suitable paint.

2. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 230713 "Duct Insulation."

3.04 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to Seal Class A in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

3.05 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.06 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.07 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Ducts with a Pressure Class of 3-Inch wg: Test representative duct sections, selected by Engineer from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.09 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive 2-inch wg.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive 3-inch wg.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive 2-inch wg.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 2-inch wg.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.

3. Ducts Connected to Equipment Not Listed above:

a. Pressure Class: Positive or negative 2-inch wg.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 2-inch wg.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 3-inch wg.

3. Ducts Connected to Equipment Not Listed above:

a. Pressure Class: Positive or negative 2-inch wg.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 2-inch wg.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2-inch wg.

3. Ducts Connected to Equipment Not Listed Above:

    a. Pressure Class: Positive or negative 2-inch wg.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.

2. Stainless-Steel Ducts:

    a. Exposed to Airstream: Match duct material.
    b. Not Exposed to Airstream: Match duct material.

G. Liner:
1. Supply-Air Ducts: Flexible elastomeric, 1 inch(es thick.
2. Return-Air Ducts: Flexible elastomeric, 1 inch(es thick.
3. Exhaust-Air Ducts: Flexible elastomeric ,1 inch(es thick.
4. Supply Fan Plenums: Flexible elastomeric,1 inch(es thick.
5. Return- and Exhaust-Fan Plenums: Flexible elastomeric,2 inches thick.
6. Transfer Ducts: Flexible elastomeric,1 inch(es thick.

H. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
    b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
    c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

        1) Mitered elbows are not permitted in Noise Critical Spaces.

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

    a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

    b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
    c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

I. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

    a. Rectangular Main to Rectangular Branch: 45-degree entry.
    b. Rectangular Main to Round Branch: 45-degree entry.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

    a. Velocity 1000 fpm or Lower: Conical tap.
    b. Velocity 1000 to 1500 fpm: Conical tap.
    c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION

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SECTION 233300
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Combination fire and smoke dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
9. Flexible connectors.
10. Duct accessory hardware.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.02 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company; CBD4 or a comparable product by one of the following:

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.

B. Description: Gravity balanced with adjustable counterweights.

C. Performance:

1. Maximum Air Velocity: 2000 fpm (10 m/s).
2. Maximum System Pressure: 3 inches wg (0.8 kPa).
3. AMCA Certification: Test and rate in accordance with AMCA 511.

D. Construction:

1. Frame:

   a. Hat shaped.
   b. 0.093-inch- (2.4-mm-) thick extruded aluminum, with welded or mechanically attached corners.

2. Blades:

   a. Multiple single-piece blades.
   b. End pivoted, maximum 6-inch (150-mm) width, 0.050-inch- (1.2-mm-) thick aluminum sheet with sealed edges.

3. Blade Action: Parallel.

E. Blade Seals: Extruded vinyl, mechanically locked.

F. Blade Axles:

1. Material: Nonmetallic.
2. Diameter: 0.50 inch (13 mm) .

G. Tie Bars and Brackets: Aluminum.

H. Return Spring: Adjustable tension.

I. Bearings: Steel ball.

J. Accessories:

1. Adjustment device to permit setting for varying differential static pressure between 0.01-inch wg (0.003 kPa) and 0.05-inch wg (0.013 kPa).
2. Counterweights and spring-assist kits for vertical airflow installations.
3. 90-degree stops.

2.03 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company; MD35 (rectangular) and MDRS25 (round) or a comparable product by one of the following:

   a. Greenheck Fan Corporation.
   b. Nailor Industries Inc.

2. Performance:

   a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. (203 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.

3. Construction:

   a. Linkage out of airstream.
   b. Suitable for horizontal or vertical airflow applications.

4. Frames:

   a. Hat-shaped, 16-gauge- (1.6-mm-) thick, galvanized sheet steel.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

   a. Multiple or single blade.
   b. Opposed-blade design (rectangular).
   c. Stiffen damper blades for stability.
   d. Galvanized steel; 16 gauge (1.6 mm) thick.

6. Blade Axles: Galvanized steel.
7. Bearings:

   a. Molded synthetic.
   b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.

8. Tie Bars and Brackets: Galvanized steel.
9. Locking device to hold damper blades in a fixed position without vibration.

2.04 CONTROL DAMPERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company; CD60 or a comparable product by one of the following:

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.

B. General Requirements:

1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.

C. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA 511.
2. Leakage:

    a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.

3. Pressure Drop: 0.05 inch wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm (15 m/s).
5. Temperature: Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C).
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

D. Construction:

1. Linkage out of airstream.
2. Suitable for horizontal or vertical airflow applications.
3. Frames:

    a. Hat, U, or angle shaped.
    b. 16-gauge- (1.6-mm-) thick, galvanized sheet steel.
    c. Mitered and welded corners.
    d. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

    a. Multiple blade with maximum blade width of 6 inches (150 mm).
    b. Opposed-blade design.
    c. Galvanized steel.
    d. 14-gauge- (1.9-mm-) thick air foil dual skin.

5. Blade Edging Seals:

    a. Replaceable Closed-cell neoprene.
    b. Inflatable seal blade edging, or replaceable rubber seals.

6. Blade Jamb Seal: Flexible stainless steel, compression type.

7. Blade Axles: 1/2-inch (13-mm) diameter; galvanized steel.
8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
9. Bearings:

    a. Oil-impregnated stainless steel sleeve.
    b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

E. Damper Operators: Comply with requirements in Section 250923.12 "Control Damper Accessories."

2.05 FIRE DAMPERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company; DIBD or a comparable product by one of the following:

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.

B. Type: Dynamic; rated and labeled in accordance with UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2000 fpm (1 m/s) velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed galvanized sheet steel, interlocking. Material gauge is to be in accordance with UL listing.

I. Horizontal Dampers: Include blade lock and stainless steel closure spring.

J. Heat-Responsive Device:

1. Replaceable, 165 deg F (74 deg C) rated, fusible links.

2.06 COMBINATION FIRE AND SMOKE DAMPERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company; FSD60 or a comparable product by one of the following:

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.

B. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
3. Unless otherwise indicated, use parallel-blade configuration.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2000 fpm (10 m/s) velocity.

D. Fire Rating: 1-1/2 hours.

E. Performance:

1. AMCA Certification: Test and rate in accordance with AMCE Publication 511.
2. Leakage:

    a. Class I: Leakage shall not exceed 4 cfm/sq. ft. (20 L/s/ per sq. m) against 1-inch wg (250-Pa) differential static pressure.

3. Pressure Drop: 0.05 in. wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm (15 m/s).
5. Temperature: Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C).
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

F. Construction:

1. Suitable or horizontal or vertical airflow applications.
2. Linkage out of airstream.
3. Frame:

    a. Hat shaped.
    b. Galvanized sheet steel, with welded corners and mounting flange.
    c. Gauge is to be in accordance with UL listing.

4. Blades:

    a. Roll-formed, opposed-blade, horizontal, airfoil, galvanized sheet steel.
    b. Maximum width and gauge in accordance with UL listing.

5. Blade Edging Seals:

    a. Silicone rubber.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch- (13-mm-) diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of airstream.
8. Bearings:

    a. Oil-impregnated stainless steel sleeve.

G. Mounting Sleeve:

1. Factory installed, galvanized sheet steel.
2. Length to suit wall or floor application.
3. Gauge in accordance with UL listing.

H. Heat-Responsive Device:

1. Electric resettable link and switch package, factory installed, rated.

I. Master control panel for use in dynamic smoke-management systems.

J. Damper Operators: Comply with requirements in Section 250923.12 "Control Damper Accessories."

K. Accessories:

1. Auxiliary switches for position indication.
2. Test and reset switches, damper mounted.
3. Smoke Detector: Furnished by Division 29.

2.07 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gauge and Shape: Match connecting ductwork.

2.08 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

C. Vane Construction:

1. Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.

2.09 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."

1. Door:

    a. Double wall, rectangular.
    b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
    c. 24-gauge- (0.70-mm-) thick galvanized steel or 24-gauge- (0.70-mm-) thick stainless steel door panel.
    d. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
    e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

    a. 24-gauge- (0.70-mm-) thick galvanized steel or 0.032-inch- (0.81-mm-) thick aluminum frame.

3. Number of Hinges and Locks:

    a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
    b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
    c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
    d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.

2.10 FLEXIBLE CONNECTORS

A. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Materials: Flame-retardant or noncombustible fabrics.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and [**360 lbf/inch (63 N/mm)**] in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

2.11 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

2.12 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G90 (Z275).
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2D finish for concealed ducts and No. 2B finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B221 (ASTM B221M), Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

PART 3 - EXECUTION

3.01 COORDINATION OF WORK WITH OTHER TRADES

A. Smoke Dampers and Combination Fire and Smoke Dampers:

1. Damper furnished and installed by Division 23.
2. Damper actuator furnished and installed by Division 23.
3. Electrical power for damper actuator furnished and installed by Division 26.
4. Smoke detector furnished by Division 29.
5. Smoke detector installed in ductwork by Division 23.
6. Control and/or signal wiring for smoke detector and damper actuator furnished and installed by Division 29.

B. Control Dampers:

1. Damper furnished and installed by Division 23.
2. Damper actuator furnished and installed by Division 25.

3.02 INSTALLATION

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

H. Install fire and smoke dampers in accordance with UL listing.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links.
7. At each change in direction and at maximum 50-ft. (15-m) spacing.
8. Upstream from turning vanes.
9. Control devices requiring inspection.
10. Elsewhere as indicated.
11. Downstream of air terminal units with reheat coils.

J. Install access doors with swing against duct static pressure.

K. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

M. Install flexible connectors to connect ducts to equipment.

N. For fans developing static pressures of 5 inches wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

O. Install duct test holes where required for testing and balancing purposes.

3.03 FLEXIBLE CONNECTOR SCHEDULE

A. Indoor equipment, non-corrosive environment with airstream not in excess of 200 deg F (93 deg C): Indoor system, flexible connector fabric.

3.04 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.

END OF SECTION

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SECTION 233346
FLEXIBLE DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Insulated flexible ducts.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTION

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

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

2.02 INSULATED FLEXIBLE DUCTS

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

   1. Flexmaster U.S.A., Inc; 1M.
   2. JP Lamborn Co.; AMR.
   3. Thermaflex; a Flex-Tek Group company; M-KE.
   4. Atco; UPC 036.

B. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film or polyethylene fabric supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.

2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-Value: R6.

2.03 FLEXIBLE DUCT CONNECTORS

A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect terminal units to supply ducts with maximum24-inch lengths of flexible duct. Do not use flexible ducts to change directions.

D. Connect diffusers to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

E. Connect flexible ducts to metal ducts with draw bands.

F. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

G. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION

SECTION 233416.11
SQUARE IN-LINE CENTRIFUGAL FANS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Square in-line centrifugal fans.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
   2. Rated capacities, operating characteristics, and furnished specialties and accessories.
   3. Certified fan performance curves with system operating conditions indicated.
   4. Certified fan sound-power ratings.
   5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   6. Material thickness and finishes, including color charts.
   7. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Fan room layout and relationships between components and adjacent structural and mechanical elements, drawn to scale, and coordinated with each other, using input from installers of the items involved.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in normal operation, emergency operation, and maintenance manuals with replacement parts listing.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.01 SQUARE 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. Description: Square in-line centrifugal fans.

C. Housing:

1. Housing Material: Reinforced galvanized steel .
2. Housing Coating: None.
3. Housing Construction: Side panels shall be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

E. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosures around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

F. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.

G. Motor Enclosure: Totally enclosed, fan cooled.

H. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
3. Companion Flanges: For inlet and outlet duct connections.
4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
6. Side Discharge: Flange connector and attachment hardware to provide right-angle discharge on side of unit.
7. Insulated Housing: Fiberglass duct liner for the interior of unit to provide a reduction in noise.

2.02 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.03 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. AMCA Compliance: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.

C. Fan Sound Ratings: Comply with AMCA 311 and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.

D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.

E. Operating Limits: Classify fans according to AMCA 99.

PART 3 - EXECUTION

3.01 INSTALLATION OF CENTRIFUGAL HVAC FANS

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:
   1. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
   2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.02 DUCTWORK AND PIPING CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.03 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.04 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 250523 "Control-Voltage Electrical Power Cables."

3.05 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 there is adequate maintenance and access space.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
6. Adjust belt tension.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

10. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.06 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.

3.07 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION

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SECTION 233423.13
CENTRIFUGAL ROOF VENTILATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Centrifugal ventilators - roof upblast.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
   2. Rated capacities, operating characteristics, and furnished specialties and accessories.
   3. Certified fan performance curves with system operating conditions indicated.
   4. Certified fan sound-power ratings.
   5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   6. Material thickness and finishes, including color charts.
   7. Dampers, including housings, linkages, and operators.
   8. Prefabricated roof curbs.
   9. Fan speed controllers.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.05 CLOSEOUT SUBMITTALS

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

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.01 CENTRIFUGAL VENTILATORS - ROOF UPBLAST

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: Removable spun-aluminum dome top and outlet baffle; square, one-piece aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
2. Grease-Laden Air Exhaust Applications: Provide grease collector.]

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings; minimum ABMA9, L(10) of 100,000 hours.
4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
6. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Spark-resistant, all-aluminum wheel construction.
6. Restaurant Kitchen Exhaust: UL 762 listed for grease-laden air exhaust.
7. Extended Lubrication Lines.

F. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange.
2. Overall Height: 12 inches.
3. Sound Curb: Curb with sound-absorbing insulation.

4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
5. Pitch Mounting: Manufacture curb for roof slope.
6. Metal Liner: Galvanized steel.

G. Prefabricated Kitchen Exhaust Roof Curbs: Galvanized steel; mitered and welded corners; ventilation openings on all sides to ventilate curb interstitial space. Size as required to suit roof opening and fan base.

1. Configuration: Built-in raised cant and mounting flange manufactured to accommodate roof slope.
2. Overall Height: 12 inches.
3. Hinged sub-base to provide access to damper or as cleanout for grease applications.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Vented Curb: For kitchen exhaust; 12-inch-high galvanized steel; unlined, with louvered vents in vertical sides.
6. NFPA 96 code requirements for commercial cooking operations.
7. Kitchen Hood Exhaust: UL 762 listed for grease-laden air.

2.02 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.03 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. AMCA Certification: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.

C. Fan Sound Ratings: Comply with AMCA 311, and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.

D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.

E. Operating Limits: Classify according to AMCA 99.

F. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.01 INSTALLATION OF HVAC POWER VENTILATORS

A. Install power ventilators level and plumb.

B. Secure roof-mounted fans to roof curbs with zinc-plated hardware. See Division 07 for installation of roof curbs.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.02 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

3.03 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.04 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 250523 "Control-Voltage Electrical Power Cables."

3.05 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 there is adequate maintenance and access space.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
6. Adjust belt tension.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
11. Shut unit down and reconnect automatic temperature-control operators.
12. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.06 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.

3.07 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION

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SECTION 233423.15
SIDEWALL PROPELLER FANS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Sidewall propeller fans.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
   2. Rated capacities, operating characteristics, and furnished specialties and accessories.
   3. Certified fan performance curves with system operating conditions indicated.
   4. Certified fan sound-power ratings.
   5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   6. Material thickness and finishes, including color charts.
   7. Dampers, including housings, linkages, and operators.
   8. Fan speed controllers.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.05 CLOSEOUT SUBMITTALS

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

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

   1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.01 SIDEWALL PROPELLER 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: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.

C. Fan Wheel: Replaceable, cast-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

D. Fan Drive: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

E. Fan Drive:

1. Belt drive.
2. Resiliently mounted to housing.
3. Statically and dynamically balanced.
4. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
5. Extend grease fitting to accessible location outside of unit.
6. Service Factor Based on Fan Motor Size: 1.4.
7. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
8. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

    a. Ball-Bearing Rating Life: ABMA 9, L(5) of 200,000 hours.

9. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
10. 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.
11. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
12. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

F. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Dampers: Counterbalanced, parallel-blade, backdraft dampers factory set to close when fan stops.
3. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
4. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
5. Wall Sleeve: Galvanized steel to match fan and accessory size.

2.02 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.03 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. AMCA Certification: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.

C. Fan Sound Ratings: Comply with AMCA 311, and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.

D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.

E. Operating Limits: Classify according to AMCA 99.

F. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.01 INSTALLATION OF HVAC POWER VENTILATORS

A. Install power ventilators level and plumb.

B. Equipment Mounting:
1. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.02 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

3.03 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.04 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 250523 "Control-Voltage Electrical Power Cables."

3.05 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 there is adequate maintenance and access space.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
6. Adjust belt tension.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
11. Shut unit down and reconnect automatic temperature-control operators.
12. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.06 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.

3.07 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION

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SECTION 233600
AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Shutoff, single-duct air terminal units.
   2. Casing liner.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For air terminal units.

   1. Include plans, elevations, sections, and mounting details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

   1. Ceiling suspension assembly members.
   2. Size and location of initial access modules for acoustic tile.
   3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

1.05 CLOSEOUT SUBMITTALS

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

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan-Powered-Unit Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.02 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

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

1. Carrier Corporation; a unit of United Technologies Corp.
2. ENVIRO-TEC; by Johnson Controls, Inc.
3. METALAIRE, Inc.
4. Price Industries.
5. Titus.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch- thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.

E. Velocity Sensors: Multi-point, multi-axis flow ring or cross sensor in air inlet. Single point or flow bar sensors are not acceptable. Sensor shall be capable of maintaining airflow to within plus or

minus 5 percentof rated unit airflow setpoint with 1.5 duct diameters straight duct upstream from the unit.

F. Hydronic Heating Coils: Minimum of two rows. Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

G. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
1. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
2. Disconnect Switch: Factory-mounted, fuse type.
3. Damper actuator, differential pressure transmitter, transformer, and microprocessor-based application specific controller shall be provided by the Division 25 contractor to the air terminal unit manufacturer for factory installation prior to shipment to the project.

H. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

I. Control devices shall be compatible with temperature controls system specified in Division 25.

2.03 CASING LINER

A. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Minimum Thickness: 1/2 inch.
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

a. Adhesive shall have a VOC content of 80 g/L or less.

2.04 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.02 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.03 CONNECTIONS

A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Comply with requirements in Section 233113.11 "Metal Ducts for General HVAC", for connecting ducts to air terminal units.

3.04 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.06 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.07 DEMONSTRATION

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

END OF SECTION

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SECTION 233713.13
AIR DIFFUSERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Rectangular and square ceiling diffusers.
   2. Ceiling integral continuous diffuser (slot)

B. Related Requirements:

   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
   2. Section 233713.23 " Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.

B. Source quality-control reports.

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PART 2 - PRODUCTS

2.01 RECTANGULAR AND SQUARE CEILING DIFFUSERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries; SPD or a comparable product by one of the following:

1. Carnes Company.
2. METALAIRE, Inc.
3. Nailor Industries Inc.
4. Titus.
5. Tuttle & Bailey.

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: Aluminum.

D. Finish: Baked enamel, white.

E. Face Size: 24 by 24 inches.

F. Face Style: Plaque.

G. Pattern: Adjustable.

H. Dampers: Radial opposed blade.

I. Insulation: Factory applied, foil faced, R-6 insulation formed to fit contour of diffuser back, continuously glued and sealed around perimeter of outer cone to form vapor seal.

J. Accessories:

1. Equalizing grid.
2. Plaster ring.
3. Safety chain.
4. Wire guard.
5. Sectorizing baffles.
6. Operating rod extension.

2.02 CEILING-INTEGRAL CONTINUOUS DIFFUSERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries; CFC – Adjusta Slot (supply) or RT (return) or a comparable product by one of the following:

1. Carnes Company.
2. METALAIRE, Inc.
3. Nailor Industries Inc.
4. Titus.
5. Tuttle & Bailey.

B. Slot Width: As indicated on plans.

C. Straight and curved sections as required to accommodate layout.

D. Mitered tees and corners.

E. Material: Aluminum, extruded, heavy wall.

F. Finishes:

1. Exterior: Standard white UNLESS NOTED OTHERWISE ON PLANS
2. Interior: Standard black.

G. Throw: High.

H. Plenum: Insulated.

I. Other Features:

1. Painted interior.
2. Blank-offs.
3. Insulated light shield on return slots.

J. Frame Style:
1. Drywall (hard) ceiling: mud flange
2. Lay-in Ceiling: exposed flange

2.03 SOURCE QUALITY CONTROL

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

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.02 INSTALLATION

A. Install diffusers level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

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3.03 ADJUSTING

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

END OF SECTION

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SECTION 233713.23
REGISTERS AND GRILLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Fixed face registers and grilles.

B. Related Requirements:

   1. Section 233300 "Air Duct Accessories" for fire volume-control dampers not integral to registers and grilles.
   2. Section 233713.13 "Air Diffusers" for various types of air diffusers.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.

PART 2 - PRODUCTS

2.01 REGISTERS

A. Fixed Face Register:

   1. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries; 630 (no filter) and 630FF (with filter) or a comparable product by one of the following:

a. Carnes Company.
b. METALAIRE, Inc.
c. Nailor Industries Inc.
d. Titus.
e. Tuttle & Bailey.

2. Material: Aluminum.
3. Finish: Baked enamel, white.

4. Face Blade Arrangement: Vertical spaced 3/4 inch apart.

5. Core Construction: Removable.
6. Frame: 1 inch wide.

7. Mounting: Countersunk screw.

8. Damper Type: Adjustable, aluminum, opposed blade.

2.02 GRILLES

A. Fixed Face Grille:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries; 630 (no filter) and 630FF (with filter) or a comparable product by one of the following:

a. Carnes Company.
b. METALAIRE, Inc.
c. Nailor Industries Inc.
d. Titus.
e. Tuttle & Bailey.

2. Material: Aluminum.
3. Finish: Baked enamel, white.

4. Face Blade Arrangement: Horizontal; spaced3/4 inch apart.

5. Core Construction: Removable.
6. Frame: 1 inch wide.

7. Mounting: Countersunk screw or Lay in, as required by ceiling type.

2.03 SOURCE QUALITY CONTROL

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

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas where registers and grilles are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.02 INSTALLATION

A. Install registers and grilles level and plumb.

B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.03 ADJUSTING

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

END OF SECTION

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SECTION 234100
PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Pleated panel filters.
2. Filter gauges.

1.03 DEFINITIONS

A. HIPS: High-impact polystyrene.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.06 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. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.07 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean, dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
3. Replace installed products damaged during construction.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

B. Comply with NFPA 90A and NFPA 90B.

C. Comply with UL 900.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 PLEATED PANEL FILTERS - STANDARD

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil; AP-Thirteen or comparable product by one of the following:

a. AAF / Flanders.
b. Airguard.
c. Purafil, Inc.

B. Source Limitations: Obtain from single source from single manufacturer.

C. Capacities and Characteristics:

1. Depth: 1 inch, 2 inches, or 4 inches nominal, as indicated in Equipment Schedules.
2. Maximum or Rated Face Velocity: 625 fpm.
3. Initial Resistance: 0.25-inch wg at 350 fpm.
4. Recommended Final Resistance: 1.0 inches wg.
5. Minimum Efficiency Reporting Value: MERV 13, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.

D. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.

1. Separators shall be bonded to the media to maintain pleat configuration.
2. Welded-wire grid shall be on downstream side to maintain pleat.
3. Media shall be bonded to frame to prevent air bypass.
4. Support members on upstream and downstream sides to maintain pleat spacing.

E. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.

2.03 PLEATED PANEL FILTERS – MOISTURE RESISTANT

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil; Opti-Pac Durable or comparable product by one of the following:

a. AAF / Flanders; PrecisionCell III.

B. Source Limitations: Obtain from single source from single manufacturer.

C. Capacities and Characteristics:

1. Depth: 2 inches or 4 inches nominal, as indicated in Equipment Schedules.
2. Maximum or Rated Face Velocity: 625 fpm.
3. Initial Resistance: 0.25-inch wg at 350 fpm.
4. Recommended Final Resistance: 1.5 inches wg.
5. Minimum Efficiency Reporting Value: MERV 13, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.

D. Media: Synthetic polypropylene fibers coated with nonflammable adhesive.

1. Separators shall be bonded to the media to maintain pleat configuration.
2. Media shall be bonded to frame to prevent air bypass.

E. Filter-Media Frame: Plastic frame bonded to the entire periphery of media.

2.04 FILTER GAUGES

A. Diaphragm-type gauge with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Dwyer Instruments, Inc; Series 2000 or comparable product by one of the following:

a. Airguard.

B. Source Limitations: Obtain from single source from single manufacturer.

1. Diameter: 4-1/2 inches.
2. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg or Less: 0- to 2.0-inch wg.

C. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.02 INSTALLATION OF FILTERS

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gauge for each filter bank.

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. Coordinate filter installations with duct and air-handling-unit installations.

3.03 INSTALLATION OF FILTER GAUGES

A. Install filter gauge for each filter bank.

B. Install filter-gauge, static-pressure tips upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

3.04 FILTER SCHEDULE

A. Indoor equipment with outside airflow less than 100 percent of supply airflow:

1. Pleated panel filters - standard.

B. Indoor equipment with outside airflow equal to 100 percent of supply airflow:

1. Pleated panel filters – moisture resistant.

C. Outdoor equipment:

1. Pleated panel filters – moisture resistant.

3.05 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between pressure sensors and DDC system.

C. Connect control wiring between controlled devices.

D. Connect control wiring according to Section 250523 "Control-Voltage Electrical Power Cables."

3.06 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION

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SECTION 237313.16
INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulated, double-wall-casing, indoor, semi-custom air-handling units that are factory assembled using multiple section components, including the following:

1. Casings.
2. Fans, drives, and motors.
3. Coils.
4. Air filtration.
5. Dampers.

1.03 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:

    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings for discharge, radiated, and return positions by octave band.
    c. Include fan construction and accessories.
    d. Include motor ratings, electrical characteristics, and motor accessories.

6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include psychrometric chart for each cooling coil with both design and final operating points.
8. Include calculations for required base rail heights to satisfy condensate trapping requirements of cooling coil.
9. Include filters with performance characteristics.
10. Include dampers, including housings, linkages, and operators.
11. Include installation instructions.

B. Shop Drawings: For each type and configuration of indoor, semi-custom air handling unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of indoor, semi-custom air-handling units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Startup service reports.

1.05 CLOSEOUT SUBMITTALS

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

1.06 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.

1.07 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of indoor, semi-custom air-handling units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Entire Unit: Manufacturer's standard but not less than one year(s) from date of Substantial Completion.

1.08 COORDINATION

A. Provide air handling unit(s) that will not exceed the allocated space shown on the drawings, including required clearances for service and future overhaul or for removal of unit components. All structural, piping, wiring, and ductwork alterations of unit(s) which are dimensionally different than those specified shall be the responsibility of the Contractor at no additional cost to the Owner.

B. Provide knockdown capable air handling unit(s), if required, to accommodate any installation limitations. The knockdown and re-assembly of the air handling unit(s) shall be performed by personnel approved by the equipment manufacturer, such as not to void the equipment warranty. The equipment warranty shall not be voided by the knockdown and re-assembly process of the air handling unit(s).

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

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

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Structural Performance: Casing panels shall be self-supporting and capable of withstanding the greater of positive/negative 6-inch wg (1500 Pa) or 125 percent of internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch of panel span.

F. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 6 inch wg (1500 Pa).

G. Acoustical Performance: Unit shall be tested by accredited independent laboratory for sound transmission per ASTM E90-85 and E413-73 and sound absorption per ASTM C423-84A and E795-83. 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.

H. 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.

2.02 CAPACITIES AND CHARACTERISTICS

A. Supply Fan:

1. Type: SWSI, airfoil unhoused centrifugal fan.
2. Class II: AMCA 99-2408.
3. Drive: Direct.

B. Preheat Coil:
1. Maximum Air-Side, Static-Pressure Drop: 0.25inches wg.
2. Maximum Water Pressure Drop: 5 feet of head.

C. Heating Coil:
1. Maximum Air-Side, Static-Pressure Drop: 0.25 inches wg.
2. Maximum Water Pressure Drop: 5 feet of head

D. Cooling Coil:
1. Maximum Face Velocity: 500 fpm.
2. Maximum Air-Side, Static-Pressure Drop: 1.0 inches wg.
3. Maximum Water Pressure Drop: 10 feet of head

2.03 MANUFACTURERS

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

1. Daikin Applied.

2. Trane.

3. YORK; a Johnson Controls company.

2.04 UNIT CASINGS

A. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.

B. Base Rail:

1. Material: Galvanized steel or Welded structural steel.
2. Height: 8 inches (200 mm) full perimeter.
3. Include integral lifting lugs.
4. Include welded or bolted cross members as required for lateral stability.

C. Casing Joints: Hermetically sealed at each corner and around entire perimeter.

D. Double-Wall Construction:

1. Outside Casing Wall:

a. Material, G90 Galvanized Steel: Minimum 18 gauge thick.
b. Factory Finish: Provide manufacturer's standard finish.

2. Inside Casing Wall:

a. Material, G90 Galvanized Steel: Solid or Perforated, minimum 18 gauge thick.

E. Floor Plate:

1. Material, G90 Galvanized Steel: minimum 16 gauge thick.

F. Casing Insulation:

1. Materials: Injected polyurethane foam insulation.
2. Casing Panel R-Value: Minimum R-13.
3. Insulation Thickness: 2 inches.
4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

G. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

H. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 6-inch wg.

2. For Unit Sections Downstream and Including Fans: 8-inch wg (2000 Pa) .

I. Doors and Windows:

1. Doors:

   a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
   b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
   c. Gasket: Neoprene, applied around entire perimeters of panel frames.
   d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 24 inches wide by full height of unit casing up to a maximum height of 72 inches.

2. Windows:
   a. None

3. Locations and Applications:

   a. Fan Section: Doors
   b. Access Section: Doors.
   c. Access Sections Immediately Upstream and Downstream of Coil Sections: Doors.
   d. Damper Section: Doors.
   e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
   f. Mixing Section: Doors.

4. Service Lights: 100-watt LED vaporproof luminaire with individual switched junction box located outside, adjacent to each access door and panel.

   a. Locations: Each section accessed with door or panel.

5. Convenience Outlets: One 20-A duplex GFCI receptacle per location with junction box located on outside casing wall.

   a. Locations: Fan section.

J. Condensate Drain Pans:

1. Construction:
   a. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.

2. Drain Connection:

   a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
   b. Minimum Connection Size: NPS 2.

3. Slope: Minimum 0.125-in./ft. slope, to comply with ASHRAE 62.1, 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.

4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
5. Width: Entire width of water producing device.
6. Depth: A minimum of 2 inches deep.
7. Formed sections.
8. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.05 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.

B. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.

1. Performance: Select at a maximum total static pressure of 90% of the fan's peak static pressure capability at the specified fan / motor speed.
2. Shafts: With field-adjustable alignment.

    a. Turned, ground, and polished hot-rolled steel with keyway.

3. Shaft Bearings:
    a. 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 and an L-50 rated life of 200,000.

4. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

    a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

5. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
6. Plenum Fan Arrays: Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of multiple fans. Provide backdraft dampers at each fan to prevent short circuiting of flow if one fan is not operating.

    a. Each motor shall be wired to a control panel with integral disconnect, individual motor protection, and control terminals or separate variable frequency drive, as indicated on the Drawings.
    b.
7. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
8. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard restrained spring vibration isolation mounting devices having a minimum static deflection of 2 inches.
9. Shaft Lubrication Lines: Extended to a location outside the casing.
10. Flexible Connector: Factory fabricated with a fabric strip minimum 5-3/4 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet or 0.032-inch-thick, aluminum sheets.

a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

1) Fabric Minimum Weight: 26 oz./sq. yd..
2) Fabric Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F.

C. Drive, Direct: Factory-mounted, direct drive.

D. Drive, Belt: Factory-mounted, V-belt drive, 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 the factory.
2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.

E. Motors:

1. 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."
2. 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.
3. Enclosure Type: Totally enclosed, fan cooled.
4. 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.
5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
6. Mount unit-mounted disconnect switches on exterior of unit.
7. Electrically commutated motors: Provide hand-off-auto (H-O-A) single point switch on control panel.

F. Variable-Frequency Motor Controller: Comply with Section 232923 "Variable-Frequency Motor Controllers."

2.06 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with AHRI 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 the 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.

B. Preheat Coils:

1. Hot-Water Coils: Self-draining.

a. Piping Connections: Threaded, same end of coil.
b. Tube Material: Copper.
c. Tube Thickness: 0.025 inches.
d. Tube Diameter: 0.625 inches
e. Fin Type: Plate.
f. Fin Material: Aluminum.
g. Fin Spacing: Maximum 12 fins per inch.
h. Fin Thickness0.0075 inches.
i. Fin and Tube Joint: Mechanical bond.
j. Headers:
1) Seamless copper tube with brazed joints, prime coated.

k. Frames: Channel frame, 0.0625-inch-thick, stainless steel.
l. Coil Working-Pressure Ratings: 200 psig, 325 deg F.
m. Coating: None.

C. Heating Coils:

1. Hot-Water Coils: Self-draining.

a. Piping Connections: Threaded, same end of coil.
b. Tube Material: Copper.
c. Tube Thickness: 0.025 inches.
d. Tube Diameter: 0.625 inches
e. Fin Type: Plate.
f. Fin Material: Aluminum.
g. Fin Spacing: Maximum 12 fins per inch.
h. Fin Thickness: 0.0075 inches.
i. Fin and Tube Joint: Mechanical bond.
j. Headers:
1) Seamless copper tube with brazed joints, prime coated.

k. Frames: Channel frame, 0.0625-inch-thick, stainless steel.
l. Coil Working-Pressure Ratings: 200 psig, 325 deg F.
m. Coating: None.

D. Cooling Coils:

1. Chilled-Water Coil: Self-draining.

a. Piping Connections: Threaded, same end of coil.
b. Tube Material: Copper.
c. Tube Thickness: 0.025inches.
d. Tube Diameter: 0.625 inches
e. Maximum Number of Rows: 10.
f. Fin Type: Plate.
g. Fin Material: Aluminum.
h. Fin Spacing: Maximum 12 fins per inch .
i. Fin Thickness: 0.0075 inches.
j. Fin and Tube Joint: Mechanical bond.
k. Headers:

1) Seamless copper tube with brazed joints, prime coated.

l. Frames: Channel frame, 0.0625-inch-thick, stainless steel.
m. Coatings: None.
n. Working-Pressure Ratings: 200 psig, 325 deg F.

2.07 AIR FILTRATION SECTION

A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

B. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Aluminum track.
   a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.08 ADDITIONAL SECTIONS

A. Combination Filter and Mixing Section:

1. Cabinet support members shall hold 2-inch- thick, pleated, flat, permanent or throwaway filters.

B. Access Sections: Provide to allow access between coils and as otherwise required or indicated. Access section shall be a minimum of 30 inches (762 mm) deep.

C. Custom Section(s): Provided by the air handler manufacturer as an integral section of the unit for field installation of special components.

2.09 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B 09.

2.10 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.

B. AHRI 1060 Certification: Air-handling units that include air-to-air energy recovery devices shall be factory tested according to AHRI 1060 and shall be listed and labeled by AHRI.

C. AMCA 301 or AHRI 260: Air-handling unit fan sound ratings shall comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or AHRI 260, "Sound Rating of Ducted Air Moving and Conditioning Equipment."

D. 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.

E. 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."

F. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.01 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 steam, 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.

3.02 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.

D. Knockdown and re-assemble air handling unit(s), as required, to accommodate any installation limitations. The knockdown and re-assembly of the air handling unit(s) shall be performed by personnel approved by the equipment manufacturer, such as not to void the equipment warranty.

3.03 INSTALLATION

A. Equipment Mounting:

1. Install air-handling units on cast-in-place concrete equipment bases with elastomeric mounts. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Division 03
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. 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.

D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
1.

3.04 PIPING CONNECTIONS

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

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using, ASTM B88, Type M 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" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

3.05 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.06 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 250523 "Control-Voltage Electrical Power Cables."

3.07 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- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
7. Comb coil fins for parallel orientation.
8. Verify that proper thermal-overload protection is installed for electric coils.
9. Install new, clean filters.
10. Verify that manual and automatic volume control and fire and smoke dampers 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. Replace fan and motor pulleys as required to achieve design conditions.
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.

3.08 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.

3.09 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.

3.10 FIELD QUALITY CONTROL

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

B. Perform the following tests and inspections:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports.

3.11 DEMONSTRATION

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

END OF SECTION

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SECTION 238126.11
AIR-COOLED, SPLIT-SYSTEM AIR-CONDITIONERS (5 TONS AND SMALLER)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes small capacity, air-cooled, split-system air-conditioning and heat-pump units (5 tons and smaller) consisting of separate evaporator-fan and compressor-condenser components.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.04 CLOSEOUT SUBMITTALS

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

1.05 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.

1.06 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.07 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03.

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.08 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: Five year(s) from date of Substantial Completion.
b. For Parts: One year(s) from date of Substantial Completion.
c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Carrier Corporation; a unit of United Technologies Corp.

2. Daikin Industries, Ltd.

3. Lennox Industries, Inc.; Lennox International.

4. Mitsubishi Electric & Electronics USA, Inc.

5. Trane.

6. YORK; a Johnson Controls company.

2.02 INDOOR UNITS (5 TONS OR LESS)

A. Concealed Evaporator-Fan Components:

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
4. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
5. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
6. Fan Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
    c. Wiring Terminations: Connect motor to chassis wiring with plug connection.

7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
8. Air Filtration Section:

    a. General Requirements for Air Filtration Section:

        1) Comply with NFPA 90A.
        2) Comply with Section 234100 "Particulate Air Filtration" for filters
        3) Filter-Holding Frames: Arranged for flat or angular orientation. Filters shall be removable from one side.

    b. Extended-Surface, Disposable Panel Filters:

        1) Factory-fabricated, dry, extended-surface type.
        2) Thickness: 1 inch.
        3) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

9. Condensate Drain Pans:

    a. 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 humidifiers, and to direct water toward drain connection.

        1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
        2) Depth: A minimum of 1 inches deep.

    b. Single-wall, galvanized-steel sheet or rust-resistant, polycarbonate.
    c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

        1) Minimum Connection Size: NPS 3/4.

    d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
    e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

B. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal.
5. Fan Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
    c. Enclosure Type: Totally enclosed, fan cooled.
    d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
    e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
    f. Mount unit-mounted disconnect switches on interior of unit.

6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
7. Condensate Drain Pans:

    a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.

        1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
        2) Depth: A minimum of 1 inch deep.

    b. Single-wall, galvanized-steel sheet.
    c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

        1) Minimum Connection Size: NPS 3/4 .

    d. Pan-Top Surface Coating: Asphaltic waterproofing compound.

8. Air Filtration Section:

    a. General Requirements for Air Filtration Section:

        1) Comply with NFPA 90A.
        2) Comply with Section 234100 "Particulate Air Filtration" for filters.
        3) Filter-Holding Frames: Arranged for flat. Filters shall be removable from one side.

    b. Extended-Surface, Disposable Panel Filters:

        1) Factory-fabricated, dry, extended-surface type.

2) Thickness: 1 inch.
3) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.03 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

    a. Compressor Type: Scroll.
    b. Single-stage or two-stage compressor motor (as indicated on Drawings) with manual-reset high-pressure switch and automatic-reset low-pressure switch.
    c. Refrigerant: R-410A.
    d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.

[redacted]

2.04 ACCESSORIES

A. Control equipment are specified in Section 250923 "Direct Digital Control (DDC) System"

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on 4-inch (100-mm) cast-in-place concrete equipment base(s) that is 4 inches larger, on each side, than unit. Comply with requirements for equipment bases and foundations specified in Division 03.

2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.02 CONNECTIONS

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

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.03 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, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

E. Prepare test and inspection reports.

3.04 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.05 DEMONSTRATION

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

END OF SECTION

SECTION 250100
GENERAL PROVISIONS FOR INSTRUMENTATION AND CONTROL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Provisions of this Section apply to all Division 25 Specification Sections.

1.02 SUMMARY

A. Section includes basic requirements for Instrumentation and Control systems.

B. Related Work:

1. Division 02 – Existing Conditions

    a. Refer to Division 02 for demolition and for abatement of hazardous materials.
    b. Comply with the requirements of Division 02 for selective demolition.

2. Division 03 – Concrete

    a. Refer to Division 03 for all concrete work.

3. Division 05 – Metals

    a. Refer to Division 05 for framed openings for equipment.
    b. Comply with the requirements of Division 05 for supports for work.

4. Division 06 – Wood, Plastics, and Composites

    a. Refer to Division 06 for framed openings for equipment.

5. Division 07 – Thermal and Moisture Protection

    a. Refer to Division 07 for installation of roof curbs and roof supports and for caulking and waterproofing of wall- and roof-mounted work.
    b. Comply with the requirements of Division 07 for penetration firestopping and furnishing roof curbs and roof supports for equipment and piping.

6. Division 08 – Openings

    a. Refer to Division 08 for installation of access doors and frames.
    b. Comply with the requirements of Division 08 for access doors and frames, unless otherwise included in the Contract Documents.

7. Division 09 – Finishes

    a. Refer to Division 09 for paint products and applications in finished spaces.

b. Comply with the requirements of Division 09 for paint products and applications identified in the Contract Documents.

8. Division 10 – Specialties

a. Refer to Division 10 for fire protection cabinets and fire extinguishers.

9. Division 11 – Equipment

a. Refer to Division 11 for to be provided.
b. Comply with the requirements of Division 11 for connections and related devices to make these systems operational.

10. Division 21 – Fire Suppression

a. Refer to Division 21 for all suppression work.

11. Division 22 – Plumbing

a. Refer to Division 22 for all plumbing work.
b. Coordinate with Division 22 for related equipment and components and for connections to systems.

12. Division 23 – Heating, Ventilation, and Air-Conditioning

a. Refer to Division 23 for all heating, ventilation, and air-conditioning work.
b. Coordinate with Division 23 for related equipment and components and for connections to systems.

13. Division 26 – Electrical

a. Refer to Division 26 for all electrical work.
b. Comply with requirements of Division 26 for related equipment and components and for connections to systems.

14. Division 27 – Communications

a. Refer to Division 27 for all communications work.
b. Coordinate with Division 27 for related equipment and components and for connections to systems.

15. Division 28 – Electronic Safety and Security

a. Refer to Division 28 for all electronic safety and security work.
b. Coordinate with Division 28 for integration with security systems.

16. Division 29 – Fire Safety and Emergency Communications

a. Refer to Division 29 for all fire safety and emergency communications work.
b. Coordinate with Division 29 for integration with fire safety and emergency communications systems.

17. Division 31 – Earthwork

a. Refer to Division 31 for all site related work greater than five feet outside the building, unless noted otherwise in the Contract Documents.
b. Comply with the requirements of Division 31 for site clearing, earth moving, and dewatering within five feet outside the building and otherwise as indicated in the Contract Documents.

18. Division 33 – Utilities

a. Refer to Division 33 for all utility related work greater than five feet outside the building, unless noted otherwise in the Contract Documents.
b. Comply with the requirements of Division 33 for utility work within five feet outside the building and otherwise as indicated in the Contract Documents.

1.03 DEFINITIONS

A. Experienced: When used with an entity or individual, “experienced” unless otherwise further described 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.

B. Furnish: Supply and deliver to project site, ready for subsequent requirements.

C. Install: Operations at project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar requirements.

D. Provide: Furnish and install, complete and ready for intended use.

E. Cutting: Removal of in-place construction necessary to permit installation or performance of subsequent work.

F. Patching: Fitting and repair work required to restore construction to original conditions after installation of subsequent work.

G. Concealed Work: Work hidden from view, including inside chases, furred spaces, or above ceilings.

H. Exposed Work: Work open to view, including inside mechanical and equipment rooms.

1.04 QUALITY ASSURANCE

A. General:

1. It is the intent of the plans and specifications to obtain a complete, operable and satisfactory installation.
2. All materials shall be new, be properly labeled and/or identified and be in full compliance with the contract documents.
3. All work shall comply with applicable Codes and Standards.
4. Manufacturer's model names and numbers used in these specifications are subject to change per manufacturer's action. Contractor shall therefore verify them with manufacturer's representative before ordering any product or equipment

B. Furnish new and unused materials and equipment manufactured in the U.S.A. Where two or more units of the same type or class of equipment are required provide units of a single manufacturer.

1.05 CODES AND STANDARDS

A. Perform work in accordance with the following codes and any applicable statutes, ordinances, codes, and regulations of governmental authorities having jurisdiction.

1. ASHRAE

   a. Standard 15 Safety Standard for Refrigeration Systems - 2019
   b. Standard 55 Thermal Environmental Conditions for Human Occupancy – 2017
   c. Standard 62.1 Ventilation Standard for Acceptable Indoor air Quality - 2019
   d. Standard 90.1 Energy Standard for Buildings Except Low Rise Residential Buildings - 2019

2. ASME

   a. ASME A17.1 Safety Code for Elevators and Escalators - 2019
   b. ASME A17.3 Safety Code for Existing Elevators and Escalators - 2020

3. Occupational Safety and Health Regulations (OSHA).
4. National Fire Codes

   a. NFPA 1 Uniform Fire Code – 2021 (Florida Edition)
   b. NFPA 70 National Electrical Code – 2020
   c. NFPA 72 National Fire Alarm and Signaling Code - 2019
   d. NFPA 90A Standard for the Installation of Air Conditioning and Ventilation Systems - 2021
   e. NFPA 90B Standard for the Installation of Warm Air Heating and Air Conditioning Systems - 2021
   f. NFPA 91 Standard for the Installation of Blower and Exhaust Systems - 2020
   g. NFPA 101 Life Safety Code – 2021 (Florida Edition)

5. Florida Building Code, 2023 Edition

   a. Building Code
   b. Existing Building Code
   c. Energy Conservation Code
   d. Mechanical Code
   e. Plumbing Code
   f. Fuel Gas Code
   g. Accessibility Code

6. Florida Statutes

   a. Chapter 471 Engineering
   b. Chapter 533.80 Building Construction Standards; Florida Building Code - Enforcement

7. Florida Administrative Code

a. Chapter 9B-7 Florida Building Commission Handicapped Accessibility Standards
b. Chapter 61C-5 Florida Elevator Safety Code
c. Chapter 61G15-34 Responsibility Rules of Professional Engineers Concerning the Design of Mechanical Systems
d. Chapter 69A-3 Fire Prevention – General Provisions
e. Chapter 69A-47 Uniform Fire Safety Standards for Elevators
f. Chapter 69A-60 The Florida Fire Prevention Code

B. Resolve, in writing, any code violation discovered in contract documents with the Engineer prior to bidding. After award of the contract, make any correction or addition necessary for compliance with applicable codes at no additional cost to Owner.

C. The Contractor shall include in the Work, without extra cost to the Owner, any labor, materials, services, apparatus, and drawings required to comply with all applicable laws, ordinances, rules, and regulations.

D. Where there is conflict between the Contract Documents and the applicable Codes, the Codes shall govern, except where the requirements of the Contract Documents are more stringent.

1.06 REFERENCE SPECIFICATIONS AND STANDARDS

A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, or AWWA Specifications; Federal Standards; or other standard specifications must comply with latest editions, revisions, amendments, or supplements in effect on date bids are received. Specifications and standards are minimum requirements for all equipment, material and work. In instances where capacities, size or other feature of equipment, devices or materials exceed these minimums, meet listed or shown capacities.

B. Whenever a reference is made to a standard, installation and materials shall comply with the latest published edition of the standard at the time project is bid unless otherwise specified herein

1.07 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1.08 PERMITS FEES AND INSPECTIONS

A. Obtain and pay for all permits, fees, tap fees, connection charges, demand charges, systems charges, impact fees, and inspections.

B. Deliver all certificates of inspection issued by authorities having jurisdiction to the Engineer.

1.09 CONFLICTING REQUIREMENTS

A. Conflicting Standards and Other Requirements: If compliance with two or more standards or requirements are specified and the standards or requirements 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 direction before proceeding.

1. If discrepancies or conflicts occur between drawings, or between drawings and specifications, notify the Engineer in writing prior to bid date; however, the most stringent requirement shall govern.

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.

1.10 REQUEST FOR INFORMATION (RFI)

A. General: Immediately on discovery of the need for additional information, clarification, or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.

1. Engineer will return without response those RFIs submitted to Engineer by other entities controlled by Contractor.
2. Coordinate and submit RFIs in a prompt manner to avoid delays in Contractor's work or work of subcontractors.

B. Prepare RFIs as PDF electronic files and electronically transmit to Engineer through email or web-based project software site, in accordance with Division 01 Specification Sections. **All electronic files shall ONLY be transmitted to inbox@h2engineering.com and shall not be transmitted to any individual email addresses for H2Engineering personnel.** Submittals shall be in searchable PDF format and not a scanned copy.

C. Engineer’s Action: Engineer will review each RFI, determine action required, and respond. Allow seven days for Engineer’s response for each RFI. RFIs received by Engineer after 1:00 p.m. Eastern Time will be considered as received the following working day.

1. The following Contractor-generated RFIs will be returned without action:

   a. Requests for approval of submittals.
   b. Requests for approval of substitutions.
   c. Requests for approval of Contractor's means and methods.
   d. Requests for coordination information already indicated in the Contract Documents.
   e. Requests for adjustments in the Contract Time or the Contract Sum.
   f. Requests for interpretation of Engineer’s actions on submittals.
   g. Incomplete RFIs or inaccurately prepared RFIs.

2. Engineer’s action may include a request for additional information, in which case Engineer’s time for response will date from time of receipt by Engineer of additional information.

1.11 SUBMITTALS

A. Submittals (including Product Data, Shop Drawings, and any other Action Submittal or Information Submittal) will only be reviewed if they are submitted in full accordance with the General and Supplementary Conditions, Division 01, and the following:

1. Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are approved by the Engineer.
3. Submittals shall only contain relevant product data. Remove or strikeout irrelevant product data.
4. Prepare submittals as PDF electronic files and electronically transmit to Engineer through email or web-based project software site, in accordance with Division 01 Specification Sections. **All electronic files shall ONLY be transmitted to inbox@h2engineering.com and shall not be transmitted to any individual email addresses for H2Engineering personnel.** Submittals shall be in searchable PDF format and not a scanned copy.
5. Options: Identify options requiring selection by Engineer.
6. Deviations: Clearly identify deviations from requirements in the Contract Documents, including minor variations and limitations.
7. Revisions: Include relevant additional information and revisions, other than those specifically requested by Engineer on previous submittals. Indicate by highlighting on each submittal or noting on attached submittal sheet.
8. Contractor's Review:

    a. Submittals shall have been reviewed and approved by the General Contractor / Construction Manager. Include approval stamp, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.
    b. Engineer will not review submittals received from Contractor that do not have Contractor's review and approval.

9. Electrical Modifications:

    a. The electrical design indicated on the plans supports the Basis of Design specifications for the Instrumentation and Control systems at the time of design.
    b. If Instrumentation and Control equipment is submitted with different electrical requirements, it is the responsibility of the Contractor to resolve all required electrical design changes, including, but not limited to: wire and conduit size, type or size of disconnect or overload protection, breaker coordination, point(s) of connection, etc. Any corrections required shall be provided at no additional cost.
    c. Submittal shall clearly show the electrical design revisions with a written statement that this change will be provided at no additional cost. Submittals made with no written reference to the electrical design revisions will be presumed to work with the electrical design.

B. Processing Time: Time of review shall commence on Engineer's receipt of submittal. No extension of the Contract Time will be authorized because of the failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Allow not less than 15 days for submittal review. Allow not less than 21 days for review of large or complex submittals. Submittals received by Engineer after 1:00 p.m. Eastern Time will be considered as received the following working day.
2. If Contractor transmits more than five submittals over two consecutive business days, review time shall increase by no less than 7 days for submittal review.
3. Allow additional time if coordination with subsequent submittals is required. Engineer will advise Contractor when a submittal being processed must be delayed for coordination.

4. Engineer reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received. Time of review shall commence on receipt of all other related submittals.

C. The Contractor shall not be relieved of responsibility for deviations from requirements of the contract documents by the Engineer's approval of shop drawings, product data, samples, or similar submittals unless the Contractor has specifically informed the Engineer in writing of such deviation at the time of submittal, and the Engineer has given written approval to the specific deviation. The Contractor shall not be relieved of responsibility for errors or omissions in shop drawings, product data, samples, or similar submittals by the Engineer's approval thereof.

1.12 SUSTAINABLE DESIGN REQUIREMENTS

A. Sustainable Certification Program: Comply with requirements for Project to obtain certification based on FGBC's "Commercial Building Standard" (hereafter, "Certification Program"). Compliance with requirements needed to obtain Certification Program prerequisites and credits may be used as one criterion to evaluate substitution requests and comparable product requests.

B. Related Requirements:

1. General and Supplementary Conditions
2. Division 01 for general sustainable design certification and reporting requirements.
3. Comply with requirements in various Division 21 Sections specifying sustainable products and methods.

C. Sustainable design submittals are in addition to other submittals.

1. Comply with "Submittals" article in this Section.
2. If submitted item is identical to that submitted to comply with other requirements, include an additional copy with other submittal as a record of compliance with indicated Certification Program requirements instead of separate sustainable design submittal. Mark additional copy "Sustainable design submittal."

D. Sustainable Design Documentation Submittals

1. Environmental management system documents.
2. Environmental product declarations.
3. Third-party certifications based on multiple attribute standards.
4. Product Data and laboratory test reports for adhesives and sealants indicating VOC content and compliance with requirements for low-emitting materials.
5. Product Data and laboratory test reports for paints indicating VOC content and compliance with requirements for low-emitting materials.

1.13 COORDINATION DRAWINGS (NOT REQUIRED)

A. Should the Contractor elect to provide Coordination Drawings when not expressly required by the Engineer, such Drawings shall be considered for informational purposes only. The Engineer will not conduct a review of these Drawings, and their submission or any implied approval shall not relieve the Contractor of the obligation to fully comply with the requirements set forth in the Construction Documents. The Contractor remains solely responsible for ensuring that all work meets the contract specifications and standards, regardless of the content or status of the Coordination Drawings.

1.14 SUBSTITUTIONS

A. By submitting a bid, the Bidder represents that its bid is based on materials and equipment described in the Procurement and Contracting Documents, including Addenda. Bidders are encouraged to request approval of qualifying substitute materials and equipment when the Specifications Sections list materials and equipment by product or manufacturer name.

B. Substitution Requests shall include, at a minimum:

1. Statement indicating why specified material, equipment, or installation method cannot be provided, if applicable.
2. Coordination of information, including a list of changes and revisions needed to other parts of the Work and to construction performed by Owner and separate contractors that will be necessary to accommodate proposed substitution.
3. Detailed comparison of significant qualities of proposed substitutions with those of the Work specified. Include an annotated copy of applicable Specification Section. Significant qualities may include attributes, such as performance, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements indicated. Indicate deviations, if any, from the Work specified.
4. Product Data, including drawings and descriptions of products and fabrication and installation procedures.
5. Detailed comparison of Contractor's construction schedule using proposed substitutions with products specified for the Work, including effect on the overall Contract Time. If specified product or method of construction cannot be provided within the Contract Time, include letter from manufacturer, on manufacturer's letterhead, stating date of receipt of purchase order, lack of availability, or delays in delivery.
6. Cost information, including a proposal of change, if any, in the Contract Sum.
7. Contractor's certification that proposed substitution complies with requirements in the Contract Documents, except as indicated in substitution request, is compatible with related materials and is appropriate for applications indicated.
8. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.

C. Procurement Substitution Requests submitted prior to receipt of bids will be received and considered by Owner when the following conditions are satisfied, as determined by Engineer; otherwise, requests will be returned without action:

1. Requests for substitution of materials and equipment are received no later than 10 days prior to date of bid opening.
2. Extensive revisions to the Contract Documents are not required.
3. Proposed changes are in keeping with the general intent of the Contract Documents, including the level of quality of the Work represented by the requirements therein.
4. The request is fully documented and properly submitted.

D. Substitutions for Cause, as required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms will be received and considered by Engineer, only when the following conditions are satisfied; otherwise, requests will be returned without action, except to record noncompliance with these requirements:

1. Requested substitution is consistent with the Contract Documents and will produce indicated results.
2. Substitution request is fully documented and properly submitted.
3. Requested substitution has received necessary approvals of authorities having jurisdiction.
4. Requested substitution is compatible with other portions of the Work.
5. Requested substitution has been coordinated with other portions of the Work.

6. Requested substitution provides specified warranty.
7. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

E. Substitutions for Convenience, not required in order to meet other Project requirements but may offer advantage to Contractor or Owner, will be received and considered by Owner, as determined by Engineer, only when the following conditions are satisfied; otherwise, requests will be returned without action, except to record noncompliance with these requirements:

1. Requested substitution is received within 60 days after the Notice of Award.
2. Requested substitution offers Owner a substantial advantage in cost, time, energy conservation, or other considerations, after deducting additional responsibilities Owner must assume. Owner's additional responsibilities may include compensation to Engineer for redesign and evaluation services, increased cost of other construction by Owner, and similar considerations.
3. Requested substitution does not require extensive revisions to the Contract Documents.
4. Requested substitution is consistent with the Contract Documents and will produce indicated results.
5. Substitution request is fully documented and properly submitted.
6. Requested substitution has received necessary approvals of authorities having jurisdiction.
7. Requested substitution is compatible with other portions of the Work.
8. Requested substitution has been coordinated with other portions of the Work.
9. Requested substitution provides specified warranty.
10. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

F. If a requested substitution is approved but contains differences or omissions not specifically identified to the attention of the Engineer in the substitution request, the Owner reserves the right to require equal or similar features to be added to the substituted products or to have the substituted products replaced at the Contractor's expense.

1.15 PROJECT RECORD DOCUMENTS

A. Recording: Maintain one copy of the Contract Documents and Shop Drawings during the construction period for project record document purposes. Post changes and revisions to project record documents as they occur; do not wait until end of Project.

B. Preparation:

1. Contract Drawings and Shop Drawings:

a. Mark revisions to show where the actual installation varies from that shown originally.
b. Mark record sets completely and accurately, including important information that was either shown schematically or omitted from original Drawings.
c. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
d. Record underground and under-slab piping installed, dimensioning exact location and elevation of piping.

2. Mark Specifications to indicate the actual product installation where installation varies from that indicated in Specifications, addenda, and contract modifications.
3. Mark Product Data to indicate the actual product installation where installation varies substantially from that indicated in Product Data submittal.

C. Deliver: Prior to Final Completion, provide record documents to Owner as indicated below:

1. Record Drawings: Submit PDF electronic files of scanned record prints and one set of prints.
2. Record Specifications: Submit annotated PDF electronic files of Project's Specifications, including addenda and contract modifications.
3. Record Product Data: Submit annotated PDF electronic files and directories of each submittal.
4. Miscellaneous Record Submittals: Submit annotated PDF electronic files directories of each submittal.

1.16 OPERATION AND MAINTENANCE MANUALS

A. Prepare and submit a comprehensive manual of emergency, operation, and maintenance data and materials in full accordance with the General and Supplementary Conditions, Division 01, and the following:

1. Operations and Maintenance Manuals: Assemble a complete set of data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system, including:

   a. Information required for daily operation and management, operating standards, and routine and special operating procedures.
   b. Manufacturers' maintenance documentation, preventative maintenance procedures and frequency, repair procedures, wiring and systems diagrams, list of spare parts, and warranty information.

2. Submit manuals as PDF electronic files and electronically transmit to Engineer through email or web-based project software site, in accordance with Division 01 Specification Sections. Submittals shall be in searchable PDF format and not a scanned copy.

1.17 DEMONSTRATION AND TRAINING

A. Prepare and provide services of qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not a part of a system in accordance with the General and Supplementary Conditions, Division 01, individual Specification Sections, and the following:

1. Demonstration and training shall occur upon completion of the Work and at a time designated by the Owner's representative.
2. Provide a high-resolution, digital video recording of each training session to the Owner.

1.18 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft and vandalism. Comply with manufacturer's written instructions.

B. Inspect products on delivery to determine compliance with the Contract Documents and to determine that products are undamaged and properly protected.

1.19 WARRANTY

A. Warranty work and equipment within specified warranty period. During the warranty period, provide labor and materials to make good any faults or imperfections that may arise due to defects or omissions in materials or workmanship without expense to the Owner.

1. Warranty Period: One year from date of Substantial Completion.

B. Warranties specified in other Sections shall be in addition to, and run concurrent with, other warranties required by the Contract Documents. Manufacturer’s disclaimers and limitations on product warranties do not relieve Contractor of obligations under requirements of Contract Documents.

C. Owner reserves the right to make emergency repairs as required to keep equipment in operation without voiding Contractor’s Guarantee Bond nor relieving the Contractor of responsibilities during the warranty period.

PART 2 - PRODUCTS (NONE)

PART 3 - EXECUTION

3.01 CONTRACT DOCUMENTS

A. Examine all drawings and specifications carefully before submitting a bid. Architectural drawings take precedence over mechanical or electrical drawings with reference to building construction.

B. For purposes of clearness and legibility, drawings are essentially diagrammatic and, although size and location of equipment are drawn to scale wherever possible, Contractor shall make use of all data in all of the contract documents and shall verify this information at the building site.

C. The drawings indicate required size and points of termination of pipes, conduits, and ducts and suggest proper routes to conform to structure avoid obstructions and preserve clearances. However, it is not intended that drawings indicate all necessary offsets, and it shall be the responsibility of the Contractor to make the installation in such a manner as to conform to structure, avoid obstructions, preserve headroom and keep openings and passageways clear, without further instructions or cost to the Owner.

D. Furnish, install and/or connect with appropriate services all items shown on any drawing without additional compensation.

E. Any and all questions about a subcontractor's scope of work responsibility shall be addressed to and answered by the General Contractor / Construction Manager.

F. Questions About Construction Documents: Any and all questions shall be submitted through the proper channels IN WRITING and, in turn, shall be answered by the Engineer in writing. All telephone conversations shall be considered unofficial and, as such, shall not be considered official or binding responses to Contractor's questions.

G. Drawings, specifications, or other documents issued by the Engineer in electronic format and/or electronic media are provided for convenience only and are not intended for use as Contract Documents.

1. The electronic files are provided merely as a convenience to the Recipient.
2. The electronic files do not replace or supplement the paper copies of any drawings, specifications, or other documents included in the Contract Documents for use on the project.
3. The Engineer makes no representation, warranty, or guarantee that electronic files:

    a. Are suitable for any other usage or purpose.
    b. Have any particular durability.
    c. Will not damage or impair the Recipient's computer or software.
    d. Contain no errors or mechanical flaws or other discrepancies that may render them unsuitable for the purpose intended by the Recipient.

4. Due to the unsecured nature of the electronic files and the inability of Engineer or the Recipient to establish controls over their use, the Engineer assumes no responsibility for any consequences arising out of the use of the data. It is the sole responsibility of the Recipient to check the validity of all information contained therein. The Recipient shall at all times refer to the signed and sealed drawings, specification or other documents for the project during all phases of the project. The Recipient shall assume all risks and liabilities resulting from the use of the electronic files.

3.02 SUPERVISION OF WORK

A. Perform all work under the direct supervision of an experienced, qualified superintendent. The Engineer has the right to remove a superintendent who, in the Engineer's opinion, is not satisfactory.

3.03 EXAMINATION

A. Existing Conditions: The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning sitework, investigate and verify the existence and location of underground utilities, mechanical and electrical systems, and other construction affecting the Work.

B. Examination and Acceptance of Conditions: Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Examine roughing-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
2. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.
3. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.

C. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

3.04 PREPARATION

A. Existing Utility Information: Furnish information to Owner that is necessary to adjust, move, or relocate existing utility structures, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.

B. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

C. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.

D. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for clarification of the Contract Documents caused by differing field conditions outside the control of Contractor, submit a request for information to Engineer.

E. Interruption of Service: Before any existing equipment or system is shut down for disconnecting or tie-ins, coordinate with Engineer and Owner regarding acceptable dates and times for this Work to be performed. Work shall be performed at the time best suited for the Owner, which typically is either on weekends, holidays, and/or after normal working hours. Services shall be restored the same day unless prior arrangements are made. All overtime or premium costs associated with this Work shall be included in the Contractor's bid.

3.05 INSTALLATION

A. Install materials and equipment in a professional manner. The Engineer may direct replacement of items which, in the Engineer's opinion, do not present a professional appearance or do not allow adequate space for maintenance. Replace or reinstall items at the expense of the Contractor.

B. General: Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.

1. Make vertical work plumb and make horizontal work level.
2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
3. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.
4. Maintain minimum headroom clearance of 96 inches in occupied spaces and 90 inches in unoccupied spaces.

C. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.

D. Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.

E. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.

F. Sequence the Work and allow adequate clearances to accommodate movement of construction items on site and placement in permanent locations.

G. Obstructions

1. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.
2. Before any cutting or trenching operations are begun, verify with Owner's representative, utility companies, municipalities, and other interested parties that all available information has been provided. Verify locations given.
3. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.
4. Assume total responsibility for and repair any damage to existing utilities or construction, whether or not such existing facilities are shown.

H. Where "rated" walls, floor, roofs and ceilings are penetrated or cut to install equipment, materials, devices, etc. the Contractor shall provide and install all materials required to re-establish the rating of the wall, floor, roof, or ceiling to the satisfaction of the authority having jurisdiction.

I. Structural Elements: Do not cut structural elements without written approval from Engineer. Notify Engineer of locations and details of cutting and await directions from Engineer before proceeding. If approved by Engineer:

1. Shore, brace, and support structural elements during cutting and patching.
2. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection.

J. Space Requirements: Consider space limitations imposed by contiguous work in selection and location of equipment and material. Do not provide equipment or material which is not suitable in this respect.

K. Tools and Equipment: Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions without cost to the Owner.

L. Phasing: Provide all temporary valves, piping, ductwork, equipment, and devices as required. Maintain temporary services to areas as required. Remove all temporary material and equipment on completion of work unless Engineer concurs that such material and equipment would be beneficial to the Owner on a permanent basis.

3.06 OWNER-INSTALLED PRODUCTS

A. Coordination: Coordinate construction and operations of the Work with work performed by Owner's construction personnel.

3.07 PROTECTION OF EXISTING FINISHES, CARPET, AND FURNISHING

A. Protect existing finishes, carpet, casework, furnishing, and other building components against damage and soiling throughout construction activities. Take care during construction not to damage existing items. Contractor shall be responsible for replacing damaged material or restoring damaged materials to the Owner’s satisfaction.

B. When permitted by Engineer, items may be removed to a suitable, protected storage location during construction and cleaned and reinstalled in their original locations after construction operations are complete.

C. Furniture may be relocated during construction and reinstalled in their original locations after construction operations are complete.

D. Means and methods for protection are the responsibility of the Contractor. Utilize plywood, polyethylene sheeting, dust cloths, and other means as required.

3.08 UTILITY SERVICES AND INSTRUMENTATION AND CONTROL SYSTEMS

A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.

B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off utility services and mechanical/electrical systems serving areas to be selectively demolished.

1. Owner will arrange to shut off indicated services/systems when requested by Contractor.
2. Arrange to shut off utilities with utility companies.
3. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
4. Disconnect, demolish, and remove Instrumentation and Control connections for fire-suppression systems, plumbing, and HVAC systems, equipment, and components indicated on Drawings to be removed.

    a. Conduit to Be Removed: Remove portion of conduit indicated to be removed and cap or plug remaining piping with same or compatible conduit material.
    b. Conduit to Be Abandoned in Place: Remove wiring and cap or plug conduit with same or compatible conduit material and leave in place.
    c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
    d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
    e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

3.09 CUTTING AND PATCHING

A. Cutting and Patching, General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.

1. Cut in-place construction to provide for installation of other components or performance of other construction, and subsequently patch as required to restore surfaces to their original condition.

B. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during installation or cutting and patching operations, by methods and with materials so as not to void existing warranties.

C. Temporary Support: Provide temporary support of work to be cut.

D. Protection: Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.

E. Structural Elements: When cutting and patching structural elements, notify Engineer of locations and details of cutting and await directions from Engineer before proceeding. Shore, brace, and support structural elements during cutting and patching. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection.

F. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety.

G. Other Construction Elements: Do not cut and patch other construction elements or components in a manner that could change their load-carrying capacity, that results in reducing their capacity to perform as intended, or that result in increased maintenance or decreased operational life or safety.

H. Visual Elements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch exposed construction in a manner that would, in Engineer's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.

I. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.

1. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots neatly to minimum size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
2. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
3. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
4. Excavating and Backfilling: Comply with requirements in applicable Sections where required by cutting and patching operations.
5. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.
6. Proceed with patching after construction operations requiring cutting are complete.

J. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other work. Patch with durable seams that are as invisible as practicable. Provide materials and comply with installation requirements specified in other Sections, where applicable or with in-place materials.

1. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.
2. If identical materials are unavailable or cannot be used, use materials that, when installed, will provide a match acceptable to Engineer for the visual and functional performance of in-place materials.

K. Cleaning: Clean areas and spaces where cutting and patching are performed. Remove paint, mortar, oils, putty, and similar materials from adjacent finished surfaces.

3.10 PAINTING

A. Comply with requirements with General and Supplementary Conditions, Division 01, Division 09, and individual Specification Sections.

B. Touch-up factory finishes on equipment provided under Division 25. Obtain matched color coatings from the manufacturer and apply as directed. If corrosion if found during inspection on the surface of any equipment, clean, prime, and paint, as required.

C. Paint the following work where exposed to view:

1. Metal conduit
2. Plastic conduit

D. Paint the following work where exposed in occupied spaces:

1. Other items as directed by Engineer.

3.11 REPAIR OF WORK

A. Complete repair and restoration operations before requesting inspection for determination of Substantial Completion.

B. Repair or remove and replace defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specified condition.

1. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that that already show evidence of repair or restoration.

    a. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.

2. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.

3.12 FIELD QUALITY CONTROL

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

B. Furnish a letter from the control manufacturer stating that all controls have been checked for operation and calibration, and the system is operating as designed.

C. Furnish a letter from an authorized factory representative of the air conditioning unit manufacturer stating that the complete refrigeration installation including pipe sizing and routing and operating and safety controls has been checked and is operating properly.

D. Tests

1. Include all tests specified and/or required under laws, rules and regulations of all departments having jurisdiction. Tests shall also be performed as indicated herein and other sections of the specifications.
2. After all systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation. Make adjustments as required to ensure proper functioning of all systems.
3. All parts of the work and associated equipment shall be tested and adjusted to work properly and be left in perfect operating condition.
4. Correct defects disclosed by these tests without any additional cost to the Owner. Repeat tests on repaired or replaced work.
5. Maintain a log of all tests being conducted and have it available for review by the Engineer. Log to indicate date, type of tests, duration, and defects noted and when corrected.
6. Special tests on individual systems are specified under individual Specification Sections.

E. 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.

3.13 CLEANING

A. Progress Cleaning: Clean Project site and work areas daily, including common areas. Enforce requirements strictly. Dispose of materials lawfully.

1. Comply with requirements in NFPA 241 for removal of combustible waste materials and debris.
2. Do not hold waste materials more than seven days during normal weather or three days if the temperature is expected to rise above 80 deg F.
3. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately and dispose of legally, according to regulations.

B. Final Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.

1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a designated portion of Project:

    a. Remove tools, construction equipment, machinery, and surplus material from Project site.
    b. Remove labels that are not permanent.
    c. Wipe surfaces of equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.

END OF SECTION

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SECTION 250528
PATHWAYS FOR CONTROL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes pathways for control-voltage cables and communication cables for control systems:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Optical-fiber-cable pathways and fittings.
4. Metal wireways and auxiliary gutters.
5. Nonmetallic wireways and auxiliary gutters.
6. Hooks.
7. Boxes, enclosures, and cabinets.

1.03 DEFINITIONS

A. FMC: Flexible metal conduit.

B. GRC: Galvanized rigid conduit.

C. IMC: Intermediate metal conduit.

D. LFMC: Liquid-tight flexible metal conduit.

E. RNC: Rigid non-metallic conduit.

PART 2 - PRODUCTS

2.01 METAL CONDUITS AND FITTINGS

A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.

B. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2. Comply with TIA-569-D.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
   1. Fittings for EMT:
      a. Material: Steel or die cast.
      b. Type: Set screw or compression.

I. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.02 NONMETALLIC CONDUITS AND FITTINGS

A. Description: Nonmetallic raceway of circular section with manufacturer-fabricated fittings.

B. General Requirements for Nonmetallic Conduits and Fittings:

   1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
   2. Comply with TIA-569-D.

C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.

E. Solvents and Adhesives: As recommended by conduit manufacturer.

2.03 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for plenum, riser, or general-use installation unless otherwise indicated.

B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with TIA-569-D.

2.04 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Description: Sheet metal trough of rectangular cross section fabricated to required size and shape, without holes or knockouts, and with hinged or removable covers.

B. General Requirements for Metal Wireways and Auxiliary Gutters:

1. Comply with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.
2. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
3. Comply with TIA-569-D.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.05 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

B. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Comply with TIA-569-D.

C. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

2.06 HOOKS

A. Description: Prefabricated sheet metal cable supports for telecommunications cable.

B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with TIA-569-D.

D. Galvanized steel.

E. J shape.

2.07 BOXES, ENCLOSURES, AND CABINETS

A. Description: Enclosures for communications.

B. General Requirements for Boxes, Enclosures, and Cabinets:

1. Comply with TIA-569-D.

2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
4. Device Box Dimensions: 4 inches by 2-1/8 inches by 2-1/8 inches deep.

C. Sheet Metal Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

E. Nonmetallic Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.01 PATHWAY APPLICATION

A. Outdoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC or IMC.
2. Concealed Conduit, Aboveground: GRC or IMC.
3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.

B. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Gymnasiums

4. Concealed in Ceilings and Interior Walls and Partitions: EMT .
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric-Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC or IMC.Use plenum type hooks, unless specifically requested to put on controls cables in conduits

7. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: EMT.
8. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: EMT.
9. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: EMT .
10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel units in institutional and commercial kitchens and damp or wet locations.

C. Minimum Pathway Size: 3/4-inch trade size for copper and aluminum cables, and 1 inch for optical-fiber cables.

D. Pathway Fittings: Compatible with pathways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use set-screw or compression, steel fittings. Comply with NEMA FB 2.10.

E. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.02 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.
4. NECA 101
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

C. Comply with requirements in Division 07 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

D. Comply with requirements in Section 250529 "Hangers and Supports for Control Systems" for hangers and supports.

E. Comply with requirements in Section 250544 "Sleeves and Sleeve Seals for Control Pathways and Cabling" for sleeves and sleeve seals.

F. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

G. Complete pathway installation before starting conductor installation.

H. Arrange stub-ups so curved portions of bends are not visible above finished slab.

I. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.

J. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches of enclosures to which attached.

L. Stub-ups to Above Recessed Ceilings:

1. Use EMT for pathways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

M. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

N. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.

O. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.

P. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.

Q. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.

R. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

S. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.

T. Pathways for Optical-Fiber and Communications Cable: Install pathways as follows:

1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

U. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway-sealing fittings according to NFPA 70.

V. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.

2. Where an underground service pathway enters a building or structure.
3. Where otherwise required by NFPA 70.

W. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage.

Y. Hooks:

1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
3. Hook spacing shall allow no more than 6 inches of slack. The lowest point of the cables shall be no less than 6 inches adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
4. Space hooks no more than 5 feet o.c.
5. Provide a hook at each change in direction.

Z. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

AA. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

BB. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.03 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 for "Earth Moving" for pipe of less than 6 inches in nominal diameter.
2. Install backfill as specified in Division 31 for "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches

of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 for "Earth Moving."

4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete around conduit for a minimum of 12 inches on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

3.04 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

E. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.05 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 250544 "Sleeves and Sleeve Seals for Controls Pathways and Cabling."

3.06 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07 for "Penetration Firestopping."

3.07 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

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SECTION 250529
HANGERS AND SUPPORTS FOR CONTROL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Steel slotted support systems for control raceways.
2. Aluminum slotted support systems for control raceways.
3. Conduit and cable support devices.
4. Support for conductors in vertical conduit.
5. Structural steel for fabricated supports and restraints.
6. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
7. Fabricated metal equipment support assemblies.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D 635.

2.02 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
2. Material for Channel, Fittings, and Accessories: Galvanized steel.
3. Channel Width: Selected for applicable load criteria.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
7. Channel Dimensions: Selected for applicable load criteria.

B. Aluminum Slotted Support Systems: Extruded aluminum channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
   1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
   2. Channel Material: 6063-T6 aluminum alloy.
   3. Fittings and Accessories Material: 5052-H32 aluminum alloy.
   4. Channel Width: Selected for applicable load criteria.
   5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
   7. Channel Dimensions: Selected for applicable load criteria.

C. Conduit and Cable Support Devices: Steel clamps, hangers, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored communications conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

   1. Powder-Actuated Fasteners: Threaded-steel stud for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   2. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
   4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
   5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F 3125/F 3125M,Grade A325.
   6. Toggle Bolts: All-steel springhead type.
   7. Hanger Rods: Threaded steel.

2.03 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.
4. NECA 101.
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Comply with requirements in Division 07 for "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for pathways specified in Section 250528 "Pathways for Control Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slottedsupport system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Raceway Support Methods: In addition to methods described in NECA 1, EMT IMC and RMC may be supported by openings through structure members, according to NFPA 70.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten communications items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

4. To Existing Concrete: Use expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated-driven threaded studs, provided with lock washers and nuts, may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

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

B. Field Welding: Comply with AWS D1.1/D1.1M.

3.04 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

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

END OF SECTION

SECTION 250910
INTEGRATION WITH EXISTING DDC SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. DDC system for monitoring and controlling of systems.
2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to systems installers for field installation.

1.03 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet / IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet / IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-Over Cable Service Interface Specifications.

K. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

L. HLC: Heavy load conditions.

M. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

N. LAN: Local area network.

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

P. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

Q. Modbus TCP/IP: An open protocol for exchange of process data.

R. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

S. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers that communicates on peer-to-peer network for transmission of global data.

T. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

U. Peer to Peer: Networking architecture that treats all network stations as equal partners.

V. POT: Portable operator's terminal.

W. PUE: Performance usage effectiveness.

X. RAM: Random access memory.

Y. RF: Radio frequency.

Z. Router: Device connecting two or more networks at network layer.

AA. Server: Computer used to maintain system configuration, historical and programming database.

BB. TCP/IP: Transport control protocol/Internet protocol.

CC. UPS: Uninterruptible power supply.

DD. USB: Universal Serial Bus.

EE. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

FF. WLED: White light emitting diode.

1.04 ACTION SUBMITTALS

A. Multiple Submissions:

1. Submit Product Data and Shop Drawings in separate submittals. Incorporate approved Product Data into Shop Drawings.

B. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:

1. Cross-referenced listing of software to be loaded on each DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
3. Operating interface and programming software, color graphic software, DDC controller software, and third-party software.

D. Shop Drawings:

1. General Requirements:

a. Include cover drawing with Project name, location, Owner, Engineer, Contractor and issue date with each Shop Drawings submission.
b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
c. Drawings Size: 11”x17”.

2. Include plans, elevations, sections, and mounting details where applicable.
3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail means of vibration isolation and show attachments to rotating equipment.
5. Plan Drawings indicating the following:

a. Screened backgrounds of walls, structural grid lines, controlled equipment, ductwork, and piping.
b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
e. Network communication cable and raceway routing.
f. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.

6. Schematic drawings for each controlled system indicating the following:

a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
c. A graphic showing location of control I/O in proper relationship to system.
d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
f. Elementary wiring diagrams of controls for equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
g. Narrative sequence of operation.
h. Graphic sequence of operation, showing all inputs and output logical blocks.

7. Control panel drawings indicating the following:

a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
c. Front, rear, and side elevations and nameplate legend.
d. Unique drawing for each panel.

8. DDC system network riser diagram indicating the following:

a. Each device connected to network with unique identification for each.
b. Interconnection of each different network in DDC system.

c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

9. DDC system electrical power riser diagram indicating the following:

a. Each point of connection to field power with requirements (volts / phase / hertz / amperes / connection type) listed for each.
b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
c. Each product requiring power with requirements (volts / phase / hertz / amperes / connection type) listed for each.
d. Power wiring type and size, race type, and size for each.

10. Monitoring and control signal diagrams indicating the following:

a. Control signal cable and wiring between controllers and I/O.
b. Point-to-point schematic wiring diagrams for each product.
c. Control signal tubing to sensors, switches and transmitters.

11. Color graphics indicating the following:

a. Itemized list of color graphic displays to be provided.
b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
c. Intended operator access between related hierarchical display screens.

E. System Description:
1. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
2. Description of testing plans and procedures.
3. Description of Owner training.

F. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule for control-damper actuators.
a. Actuator selection indicating torque provided.
b. Actuator signal to control damper (on, close or modulate).
c. Actuator position on loss of power.
d. Actuator position on loss of control signal.

3. Schedule and design calculations for control valves and actuators.

a. Flow at Project design and minimum flow conditions.
b. Pressure-differential drop across valve at Project design flow condition.
c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.

e. Maximum close-off pressure.
f. Actuator selection indicating torque provided.
g. Actuator signal to control damper (on, close or modulate).
h. Actuator position on loss of power.
i. Actuator position on loss of control signal.

4. Schedule and design calculations for selecting flow instruments.

a. Instrument flow range.
b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
d. Pressure-differential loss across instrument at Project design flow conditions.
e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Systems Provider Qualification Data:

a. Resume of project manager assigned to Project.
b. Resumes of application engineering staff assigned to Project.
c. Resumes of installation and programming technicians assigned to Project.
d. Resumes of service technicians assigned to Project.
e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity and building's primary function.
f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
h. Owner contact information for past project including name, phone number, and e-mail address.
i. Contractor contact information for past project including name, phone number, and e-mail address.
j. Engineer contact information for past project including name, phone number, and e-mail address.

1.06 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.

d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.07 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of 10 years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least three past projects.
4. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

a. Product research and development.
b. Product and application engineering.
c. Product manufacturing, testing and quality control.
d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.
e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.

2. In-place facility located within 100 miles of Project.
3. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
4. Demonstrated past experience on 10 projects of similar complexity, scope and value.
5. Each person assigned to Project shall have demonstrated past experience.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support on-going DDC system operation for a period of not less than 10 years after Substantial Completion.
9. DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

1.08 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer warrants DDC 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 and materials.
    d. Update of operator workstation software, project specific software, graphics, database, and firmware.

2. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
3. Install updates to software, graphics, database, or firmware only after receiving Owner's written authorization.
4. Warranty service shall occur during normal business hours by qualified factory trained technician(s) and commence within 24 hours of Owner's verbal or written warranty service request, 24 hours a day, 7 days a week, 365 days a year, including holidays and weekends.
5. Warranty Period: Two year(s) from date of Final Completion, or as listed below, whichever comes first.
    a. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of warranty.

6. Extended Warranty: Provide warranty on system programming for an additional three (3) years.
7. Extended Warranty: Provide alternate pricing along with project warranty letter to extend all provisions of warranty for an additional two (2) years.

1.09 SYSTEM COMMISSIONING ALLOWANCE

A. Testing and Inspection Allowance: Include the sum of $5,000.00 to meet with the Engineer for the purpose of testing and validating the system, as outlined in “Final Review” Article of this Section.

1. Time for the Engineer shall be charged at the Engineer's standard billing rates and billed directly to the DDC contractor from the Engineer.
2. At Project closeout, credit unused amounts remaining in the Allowance to Owner by Change Order.

PART 2 - PRODUCTS

2.01 DDC SYSTEM MANUFACTURERS

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 25 specifications are not required to be manufactured by the above manufacturers. Subject to compliance with requirements, provide products by one of the following:

1. Siemens Building Technologies, Inc. (Desigo CC System)

2.02 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. The existing operator interface is an Apogee product manufactured by Siemens.

D. The BAS system specified herein is an expansion of an existing BAS system manufactured by Siemens. The existing system does not utilize BACnet network protocols. Provide hardware routers or gateways to translate specified BACnet protocol to the existing system's proprietary or non-specified BACnet protocol.

2.03 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

B. DDC System Speed:

1. Response Time of Connected I/O:

a. AI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
b. BI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.

2. Display of Connected I/O:

a. Analog point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
b. Binary point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
c. Alarms of analog and digital points connected to DDC system shall be displayed within 15 seconds of activation or change of state.
d. Graphic display refresh shall update within eight seconds.
e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

C. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

D. DDC System Data Storage:

1. Include capability to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
2. Local Storage:

a. Provide server and/or workstation with data storage indicated. Server(s) shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

E. Future Expandability:

1. DDC system size shall be expandable to an ultimate capacity of at least four times total I/O points indicated.
2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

F. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Energy:

    a. Thermal: Within 5 percent of reading.
    b. Electric Power: Within 1 percent of reading.
    c. Requirements indicated on Drawings for meters not supplied by utility.

2. Flow:

    a. Air: Within 5 percent of design flow rate.
    b. Air (Terminal Units): Within 10 percent of design flow rate.
    c. Water: Within 5 percent of design flow rate.

3. Gas:

    a. Carbon Dioxide: Within 50 ppm.
    b. Carbon Monoxide: Within 5 percent of reading.

4. Moisture (Relative Humidity):

    a. Air: Within 2 percent RH.
    b. Space: Within 2 percent RH.
    c. Outdoor: Within 2 percent RH.

5. Level: Within 5 percent of reading.
6. Pressure:

    a. Air, Ducts and Equipment: Within 0.1 inch wg .
    b. Space: Within 0.01 inch wg .
    c. Water: Within 2 percent of instrument reading.

7. Speed: Within 10 percent of reading.
8. Temperature, Dew Point:

    a. Air: Within 1 deg F.
    b. Space: Within 1 deg F.
    c. Outdoor: Within 3 deg F.

9. Temperature, Dry Bulb:

    a. Air: Within 1 deg F.
    b. Space: Within 1 deg F.
    c. Outdoor: Within 2 deg F.
    d. Chilled Water: Within 1 deg F.
    e. Heating Hot Water: Within 1 deg F.
    f. Temperature Difference: Within 0.25 deg F.
    g. Other Temperatures Not Indicated: Within 1 deg F.

10. Temperature, Wet Bulb:

    a. Air: Within 1 deg F.
    b. Space: Within 1 deg F.
    c. Outdoor: Within 2 deg F.

G. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:

1. Current:

    a. Milliamperes: Nearest 1/100th of a milliampere.
    b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

2. Energy:

    a. Electric Power:
        1) Demand (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
        2) Consumption (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.

    b. Thermal:

        1) Heating Demand (Mbh): Nearest Mbh up to 1000 Mbh; nearest 10 Mbh between 1000 and 10,000 Mbh; nearest 100 Mbh above 10,000 Mbh.
        2) Cooling Demand (Tons): Nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons).

        3) Heating Consumption (Mbtu): Nearest Mbtu up to 1000 Mbtu; nearest 10 Mbtu between 1000 and 10,000 Mbtu; nearest 100 Mbtu above 10,000 Mbtu.
        4) Cooling Consumption (Ton-Hours): Nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons .

3. Flow:

    a. Air: Nearest cfm through 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
    b. Water: Nearest gpm through 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.

4. Gas:

    a. Carbon Dioxide (ppm): Nearest ppm.
    b. Carbon Monoxide (ppm): Nearest ppm.

5. Moisture (Relative Humidity):

    a. Relative Humidity (Percentage): Nearest 1 percent.
6. Speed:
    a. Velocity: Nearest 1/10th fpm through 100 fpm; nearest fpm between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.

7. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
8. Pressure:

    a. Air, Ducts and Equipment: Nearest 1/10th in. w.c..
    b. Space: Nearest 1/100th in. w.c..
    c. Water: Nearest 1/10 psig through 100 psig; nearest psig above 100 psig.

9. Temperature:

    a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
    b. Outdoor: Nearest degree.
    c. Space: Nearest 1/10th of a degree.
    d. Chilled Water: Nearest 1/10th of a degree.
    e. Heating Hot Water: Nearest degree.
10. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.

H. Control Stability: Control variables indicated within the following limits:

1. Flow:

    a. Air, Ducts and Equipment, except Terminal Units: Within 5 percent of design flow rate.
    b. Air, Terminal Units: Within 5 percent of design flow rate.
    c. Water: Within 5 percent of design flow rate.

2. Gas:

    a. Carbon Dioxide: Within 50 ppm.
    b. Carbon Monoxide: Within 5 percent of reading.

3. Moisture (Relative Humidity):

    a. Air: Within 5 percent RH.
    b. Space: Within 5 percent RH.
    c. Outdoor: Within 5 percent RH.

4. Level: Within 5 percent of reading.
5. Pressure:

    a. Air, Ducts and Equipment: Within 0.2 inch wg .
    b. Space: Within 0.01 inch wg.
    c. Water: Within 1.5 psi .
    d. Steam: Within 2 psi .

6. Temperature, Dew Point:

    a. Air: Within 1 deg F.
    b. Space: Within 1 deg F.

7. Temperature, Dry Bulb:

    a. Air: Within 2 deg F.
    b. Space: Within 2 deg F.
    c. Chilled Water: Within 1 deg F.
    d. Heating Hot Water: Within 2 deg F.
    e. Energy Recovery Runaround Liquid: Within 1 deg F.

8. Temperature, Wet Bulb:

    a. Air: Within 1 deg F.
    b. Space: Within 1 deg F.

I. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

    a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

    a. Outdoors, Non-Corrosive Environment: Type 4.
    b. Outdoors, Corrosive Environment: Type 4X.
    c. Indoors, Heated with Filtered Ventilation: Type 1.
    d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
    e. Indoors, Heated and Air Conditioned: Type 1.
    f. Mechanical Equipment Rooms:

        1) Chiller and Boiler Rooms: Type 4.
        2) Air-Moving Equipment Rooms: Type 1.

    g. Localized Areas Exposed to Washdown: Type 4.
    h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
    i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.
    j. Hazardous Locations: Explosion-proof rating for condition.

J. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

    a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and ventilated as required by instrument and application.

2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

    a. Outdoors, Non-Corrosive Environment: Type 4.
    b. Outdoors, Corrosive Environment: Type 4X.
    c. Indoors, Heated with Filtered Ventilation: Type 1.
    d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
    e. Indoors, Heated and Air-conditioned: Type 1.

f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: Type 4.
2) Air-Moving Equipment Rooms: Type 1.

g. Localized Areas Exposed to Washdown: Type 4.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.
j. Hazardous Locations: Explosion-proof rating for condition.

K. Electric Power Quality:

1. Power-Line Surges:

a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
b. Do not use fuses for surge protection.
c. Test protection in the normal mode and in the common mode, using the following two waveforms:

1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

a. Protect susceptible DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:

1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

L. Backup Power Source:

1. Controlled systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

M. UPS:

1. DDC system products powered by UPS units shall include the following:
a. Gateways.

b. Network controllers.
c. .

N. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.04 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than three levels of LANs.

1. Level one LAN shall connect network controllers and operator workstations.
2. Level two LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
3. Level three LAN shall connect application-specific controllers to programmable application controllers and network controllers.
4. Level three LAN shall connect application-specific controllers to application-specific controllers.

B. DDC system shall consist of dedicated and separated LANs that are not shared with other building systems and tenant data and communication networks.

C. System architecture shall be modular and have inherent ability to expand to not less than three times system size indicated with no impact to performance indicated.

D. System architecture shall perform modifications without having to remove and replace existing network equipment.

E. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

F. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

G. Special Network Architecture Requirements:

1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and air terminal units, include a dedicated LAN of application-specific controllers serving air terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

2.05 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.
3. Portable operator workstation with wireless connection through LAN router.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room.
2. Each boiler room.
3. Each chiller room or outdoor chiller yard.
4. Security system command center.
5. Fire-alarm system command center.

D. Portable Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Connect to DDC system Level two LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
4. Connect to system through a wireless router connected to Level one LAN.
5. Connect to system through a cellular data service.
6. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
7. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
8. Have dynamic graphic displays that are identical to desktop workstations.

E. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

F. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.06 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:
1. IP.
2. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:
1. IP.
2. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:

1. ATA 878.1, ARCNET.
2. EIA-485A.

2.07 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. Industry Standard Protocols:

1. DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:

    a. ASHRAE 135.
    b. Modbus Application Protocol Specification V1.1b.
2. Portions of DDC system networks using ASHRAE 135 communication protocol shall be an open implementation of network devices complying with ASHRAE 135. Network devices shall be tested and listed by BACnet Testing Laboratories.
3. Portions of DDC system networks using Modbus Application Protocol Specification V1.1b communication protocol shall be an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b.
4. Gateways shall be used to connect networks and network devices using different protocols.

2.08 SYSTEM SOFTWARE

A. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

    a. Room layouts with room identification and name.
    b. Locations and identification of all monitored and controlled equipment and other equipment being monitored and controlled by DDC system.
    c. Location and identification of each hardware point being controlled or monitored by DDC system.

3. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation.
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways operator workstations and other network devices.
6. Graphic display for each major system showing all configuration parameters presented in a tabular format. (The type of data on these pages are not changed frequently, but the operator may wish to view it frequently). Configuration parameters include:

a. Set points.
b. Tuning parameters.
c. Calibration parameters.
d. Timing parameters.
e. Application parameters.
f. Reset schedules.
g. Lead / lag information.
h. Time schedules.

B. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Each report shall be definable as to data content, format, interval and date.
3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstationand/or serverfor historical reporting.
4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Reports and logs shall be stored on workstation and/or server hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

C. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

a. Alarm history.
b. System messages.
c. System events.
d. Trends.

D. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

E. Tenant Override Reports: Prepare Project-specific reports.

1. Weekly report showing daily total time in hours that each tenant has requested after-hours HVAC.
2. Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC.
3. Annual summary report that shows after-hours HVAC usage on a monthly basis.

F. HVAC Equipment Reports: Prepare Project-specific reports.

G. Utility Reports: Prepare Project-specific reports.

1. Electric Report:

    a. Include weekly report showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
    b. Include monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each meter.
    c. Include annual report showing the monthly electrical consumption and peak electrical demand with time and date stamp for each meter.
    d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as lighting, receptacles and HVAC equipment showing daily electrical consumption and peak electrical demand.
    e. For each weekly, monthly and annual report, include sum total of all submeters in building showing electrical consumption and peak electrical demand.

2. Natural Gas Report:

    a. Include weekly report showing daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
    b. Include monthly report showing the daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
    c. Include annual report showing the monthly natural gas consumption and peak natural gas demand with time and date stamp for each meter.
    d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as boilers and service water heaters showing daily natural gas consumption and peak natural gas demand.
    e. For each weekly, monthly and annual report, include sum total of all submeters in building showing natural gas consumption and peak natural gas demand.

3. Service Water Report:

    a. Include weekly report showing daily service water consumption and peak service water demand with time and date stamp for each meter.
    b. Include monthly report showing the daily service water consumption and peak service water demand with time and date stamp for each meter.
    c. Include annual report showing the monthly service water consumption and peak service water demand with time and date stamp for each meter.
    d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as cooling tower makeup and irrigation showing daily service water consumption and peak service water demand.
    e. For each weekly, monthly and annual report, include sum total of all submeters in building showing service water consumption and peak service water demand.

H. Energy Reports: Prepare Project-specific daily, weekly, monthly and annual energy reports.

1. Prepare report for each purchased energy utility, indicating the following:

    a. Time period being reported with beginning and end date, and time indicated.
    b. Consumption in units of measure commonly used to report specific utility consumption over time.
    c. Gross area served by utility.
    d. Consumption per unit area served using utility-specific unit of measure.
    e. Cost per utility unit.
    f. Utility cost per unit area.
    g. Convert all utilities to a common energy consumption unit of measure and report for each utility.
    h. Consumption per unit area using common unit of measure.

I. HVAC System Efficiency Reports: Prepare Project-specific weekly, monthly, and annual HVAC system efficiency reports.

1. Prepare report forchilled-water system, indicating the following:

a. Time period being reported with beginning and end date, and time indicated.
b. Cooling energy supplied during time period.
c. Power energy consumed during time period by cooling equipment used to produce cooling energy supplied.
d. Energy efficiency coefficient of performance determined by dividing power energy consumed into cooling energy supplied.
e. Energy efficiency determined by dividing cooling energy supplied into power energy consumed.
f. Units of measure used in report shall be consistent with units indicated for system.

2. Prepare report forhot-water system, indicating the following:

a. Time period being reported with beginning and end date, and time indicated.
b. Cooling energy supplied during time period.
c. Fuel consumed during time period by boilers used to produce heating energy supplied.
d. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
e. Units of measure used in report shall be consistent with units indicated for system.

J. Weather Reports:

1. Include weekly report showing the following:

a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
b. Daily minimum, maximum, and average relative humidity.

2. Include monthly report showing the following:

a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
b. Daily minimum, maximum, and average relative humidity.

3. Include annual (12-month) report showing the following:

a. Monthly minimum, maximum, and average outdoor dry-bulb temperature.
b. Monthly minimum, maximum, and average relative humidity.

K. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

L. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

1. Each trend shall include interval, start time, and stop time.
2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation and/or server hard drives.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

M. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software shall be one of the following:

a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.

1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
2) Programming tools shall be viewable in real time to show present values and logical results of each function block.

b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

2.09 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, packaged air-conditioning equipment, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.

2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.10 ASHRAE 135 PROTOCOL ANALYZER

A. Analyzer and required cables and fittings for connection to ASHRAE 135 network.

B. Analyzer shall include the following minimum capabilities:

1. Capture and store to a file data traffic on all network levels.
2. Measure bandwidth usage.
3. Filtering options with ability to ignore select traffic.

2.11 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F.
3. Controllers located outdoors shall be rated for operation at 40 to 150 deg F.

F. Power and Noise Immunity:

1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

a. Network Controllers: 75 percent.
b. Programmable Application Controllers: Not less than 75 percent.
c. Application-Specific Controllers: Not less than 75 percent.

2. Memory shall support DDC controller's operating system and database and shall include the following:

a. Monitoring and control.
b. Energy management, operation and optimization applications.
c. Alarm management.
d. Historical trend data of all connected I/O points.
e. Maintenance applications.
f. Operator interfaces.
g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:

a. 10 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Two.
2) AOs: Two.
3) BIs: Three.
4) BOs: Three .

2. Programmable Application Controllers:

a. 10 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: Two.
2) AOs: Two.
3) BIs: Three.
4) BOs: Three.

3. Application-Specific Controllers:

a. 10 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: One.
2) AOs: One.
3) BIs: One.
4) BOs: One.

I. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

    a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
    b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
    c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
    d. Signal conditioning including transient rejection shall be provided for each AI.
    e. Capable of being individually calibrated for zero and span.
    f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.

5. AOs:

    a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
    b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to include proper control of output device.
    c. Capable of being individually calibrated for zero and span.
    d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

6. BIs:

    a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
    b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
    c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
    d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
    e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.

7. BOs:

    a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.

        1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference

suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.

2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
c. BOs shall be selectable for either normally open or normally closed operation.
d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.
e. Limit use of three-point floating devices to air terminal unit control applications,. Control algorithms shall operate actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.12 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
2. Local Keypad and Display:

a. Equip controller with local keypad and digital display for interrogating and editing data.
b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.

2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.13 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers that perform scheduling shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
2. Local Keypad and Display:

    a. Equip controller with local keypad and digital display for interrogating and editing data.
    b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.14 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.

2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.15 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. I/O points shall be identified by point name and point descriptor. Same names shall be used at operator workstations.
3. Control functions shall be executed within controllers using DDC algorithms.
4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

a. Include separate schedules for each day of week.
b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
c. Each schedule may consist of up to 10 events.
d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

a. Include ability for operator to designate any day of the year as an exception schedule.
b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

a. Include capability for operator to define up to 99 special or holiday schedules.
b. Schedules may be placed on scheduling calendar and will be repeated each year.
c. Operator shall be able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.
2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Remote Communication:

1. System shall have ability to dial out in the event of an alarm.

I. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

J. Control Loops:

1. Support any of the following control loops, as applicable to control required:

a. Two-position (on/off, open/close, slow/fast) control.
b. Proportional control.
c. Proportional plus integral (PI) control.
d. Proportional plus integral plus derivative (PID) control.

1) Include PID algorithms with direct or reverse action and anti-windup.

2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Controlled variable, set point, and PID gains shall be operator-selectable.

e. Adaptive (automatic tuning) is NOT permitted. The gains on PI or PID control loops may be reset between user-established limits based on deviation from control set point.

K. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

L. Energy Calculations:

1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

M. Anti-Short Cycling:

1. BO points shall be protected from short cycling.
2. Feature shall allow minimum on-time and off-time to be selected.

N. On and Off Control with Differential:

1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

O. Run-Time Totalization:

1. Include software to totalize run-times for all BIpoints.
2. A high run-time alarm shall be assigned, if required, by operator.

2.16 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in anenclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Do not house more than one controller in a single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Individual wall-mounted single-door enclosures shall not exceed 36 inches wide and 48 inches high.
5. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.

6. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect electric and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 10 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch-high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.

D. Wall-Mounted, NEMA 250, Type 1:
1. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
2. Construct enclosure of steel, not less than:

a. Enclosure size less than 24 in.: 0.053 in. or 0.067 in. thick.
b. Enclosure size 24 in. and larger: 0.067 in. thick.

3. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

a. Exterior color shall be manufacturer's standard.

b. Interior color shall be manufacturer's standard.

4. Hinged door full size of front face of enclosure and supported using:

   a. Enclosures sizes less than 36 in. tall: Multiple butt hinges.
   b. Enclosures sizes 36 in. tall and larger: Continuous piano hinges.

5. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

   a. Size less than 24 in.: Solid or Perforated steel, 0.053 in. thick.
   b. Size 24 in. and larger: Solid aluminum, 0.10 in. or steel, 0.093 in. thick.

6. Internal panel mounting hardware, grounding hardware and sealing washers.
7. Grounding stud on enclosure body.
8. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall Mounted NEMA 250, Types 4 and 12:
   1. Enclosure shall be NRTL listed according to UL 508A.
   2. Seam and joints are continuously welded and ground smooth.
   3. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
   4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
   5. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
   6. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
   7. Construct enclosure of steel, not less than the following:

      a. Size Less Than 24 Inches: 0.053 inch or 0.067 inch thick.
      b. Size 24 Inches and Larger: 0.067 inch thick.

   8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

      a. Exterior color shall be manufacturer's standard.
      b. Interior color shall be manufacturer's standard.

   9. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

      a. Sizes through 24 Inches Tall: Two hinges.
      b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
      c. Sizes Larger 48 Inches Tall: Four hinges.

   10. Double-door enclosures with overlapping door design to include unobstructed full-width access.

      a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.

   11. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

      a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.
      b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch or steel, 0.093 inch thick.

12. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
13. Grounding stud on enclosure body.
14. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Wall-Mounted, NEMA 250, Type 4X SS:
1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
4. Construct enclosure of Type 316L stainless steel, not less than the following:

    a. Size Less Than 24 Inches: 0.053 inch thick.
    b. Size 24 Inches and Larger: 0.067 inch thick.

5. Outside body and door of enclosure with brushed No. 4 finish.
6. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

    a. Sizes through 24 InchesTall: Two hinges.
    b. Sizes between 24 Inchesthrough 48 InchesTall: Three hinges.
    c. Sizes Larger 48 InchesTall: Four hinges.

7. Corner-formed door, full size of enclosure face, supported using continuous piano hinge full length of door.
8. Doors fitted with three-point (top, middle, and bottom) latch system with single, heavy-duty, liquid-tight Type 316 stainless-steel handle with integral locking mechanism.
9. Removable internal panel shall be 0.093-inch solid steel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
10. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
11. Install corrosion-resistant polyester vent drain in a stainless-steel sleeve at the bottom of enclosure.
12. Include enclosure with stainless-steel mounting brackets.

G. Accessories:

1. Electric Heater:

    a. Aluminum housing with brushed finish.
    b. Thermostatic control with adjustable set point from zero to 100 deg F.
    c. Capacity: 100, 200, 400, and 800 W as required by application.
    d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.

2. Ventilation Fans, Filtered Intake and Exhaust Grilles:

    a. Number and size of fans, filters and grilles as required by application.
    b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
    c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
    d. Thermostatic control with adjustable set point from 32 to 140 deg F.

    e. Maximum operating temperature of 158 deg F.

f. 4-inch fan thermally protected and provided with permanently lubricated ball-bearings.
g. 6- and 10-inch fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
h. Dynamically balanced impellers molded from polycarbonate material.
i. Fan furnished with power cord and polarized plug for power connection.
j. Fan brackets, finger guards and mounting hardware provided with fans to complete installation.
k. Removable Intake and Exhaust Grilles: ABS plastic or stainless steel of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.
l. Filters for NEMA 250, Type 1 Enclosures: Washable aluminum, of a size to match intake grille.
m. Filters for NEMA 250, Type 12 Enclosures: Disposable, of a size to match intake grille.

3. Bar handle with keyed cylinder lock set.

2.17 RELAYS

A. Current Sensing Relay:
1. Monitors ac current.
2. Independent adjustable controls for pickup and dropout current.
3. Energized when supply voltage is present and current is above pickup setting.
4. De-energizes when monitored current is below dropout current.
5. Dropout current is adjustable from 50 to 95 percent of pickup current.
6. Include a current transformer, if required for application.
7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.
8. Positive indication of belt failure.

B. Control Relay:
1. Description:
a. LED status indication of activated relay and current trigger.
b. Closed-Open-Auto override switch located on the load side of the relay.

2. Performance:

a. Ambient Temperature: Minus 30 to 140 deg F.
b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.

3. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
4. Enclosure: NEMA 250, Type 1 enclosure (plenum rated) for indoors and NEMA 250, Type 4X for outdoors.

2.18 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall be at least 40 VA.

3. Transformer shall have both primary and secondary fuses.

B. Power-Line Conditioner:
1. General Power-Line Conditioner Requirements:

a. Design to ensure maximum reliability, serviceability and performance.
b. Overall function of the power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. The power-line conditioner shall provide isolated, regulated, transient and noise-free sinusoidal power to loads served.

2. Standards: NRTL listed per UL 1012.
3. Performance:

a. Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.

1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.

c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.
d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.
e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.
f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
h. Attenuate load-generated odd current harmonics 23 dB at the input.
i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.
k. Common-mode noise attenuation of 140 dB.
l. Transverse-mode noise attenuation of 120 dB.
m. With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.
n. Reliability of 200,000 hours' MTBF.
o. At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.
p. Approximately 92 percent efficient at full load.

4. Transformer Construction:

    a. Ferroresonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.
    b. Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.
    c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
    d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
    e. Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.
    f. Electrically isolate the transformer secondary windings from the primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.
    g. Include interface terminals for output power hot, neutral and ground conductors.
    h. Label leads, wires and terminals to correspond with circuit wiring diagram.
    i. Vacuum impregnate transformer with epoxy resin.

5. Cabinet Construction:

    a. Design for panel or floor mounting.
    b. NEMA 250, Type 1, general-purpose, indoor enclosure.
    c. Manufacture the cabinet from heavy gauge steel complying with UL 50.
    d. Include a textured baked-on paint finish.

C. Transient Voltage Suppression:

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

    a. Current Technology Inc.
    b. Liebert Corporation.
    c. Surge Suppression, Inc.

2. The maximum continuous operating voltage shall be at least 125 percent.
3. The operating frequency range shall be 47 to 63 Hz.
4. Protection modes according to NEMA LS-1.
5. The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:

    a. Line to Neutral: 45,000 A.
    b. Neutral to Ground: 45,000 A.
    c. Line to Ground: 45,000 A.
    d. Per Phase: 90,000 A.

6. Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:

    a. Line to Neutral: 360 V.
    b. Line to Ground: 360 V.
    c. Neutral to Ground: 360 V.

7. Unit shall have LED status indicator that extinguishes to indicate a failure.
8. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449.
9. Unit shall not generate any appreciable magnetic field.
10. Unit shall not generate an audible noise.

11. Applications:

    a. Control Power:

        1) Description: Series connected, Type 2 SPD. (Type 1 and Type 4 are NOT permitted).
        2) Connections: 3-position screw terminal strips.
        3) Current Rating: 30 A.
        4) Basis of Design: Surge Suppression, Inc.; S-SPT###-30.

    b. BAS Hardwired Points:

        1) Description: Series connected SPD.
        2) Connections: Screw terminal strips.
        3) Current Rating: 500 mA.
        4) Maximum Data Rate: 2 Mbps.
        5) Basis of Design: Surge Suppression, Inc.; CLP24Ax-B.

    c. BAS Communication Interface:

        1) Description: Series connected SPD.
        2) Connections: RJ45 modular connectors.
        3) Current Rating: 500 mA.
        4) Maximum Data Rate: 100 Mbps.
        5) Basis of Design: Surge Suppression, Inc.; DRJ45##C8-B.

D. DC Power Supply:
    1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
    2. Enclose circuitry in a housing.
    3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
    4. Performance:

        a. Output voltage nominally 25-V dc within 5 percent.
        b. Output current up to 100 mA.
        c. Input voltage nominally 120-V ac, 60 Hz.
        d. Load regulation within 0.5 percent from zero- to 100-mA load.
        e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
        f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.19 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

A. 750 through 1000 VA:
    1. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
    2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

        a. Larger-capacity units shall be provided for systems with larger connected loads.
        b. UPS shall provide 15 minutes of battery power.
        c. UPS shall be at least 750 VA.

    3. Performance:

a. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
d. On Battery Output Voltage: Sine wave.
e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
g. Transfer Time: 6 ms.
h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.

4. UPS shall be automatic during fault or overload conditions.
5. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.
6. Include front panel with power switch and visual indication of power, battery, fault and temperature.
7. Unit shall include an audible alarm of faults and front panel silence feature.
8. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
9. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.
10. Include tower models installed in ventilated cabinets to the particular installation location.

2.20 PIPING AND TUBING

A. Pressure Instrument Signal Air, Tubing and Piping:

1. Products in this paragraph are intended for use with the following:
   a. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers and accessories.

2. Copper Tubing:

   a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties according to ASTM B 75.
   b. Performance, dimensions, weight and tolerance according to ASTM B 280.
   c. Diameter, as required by application, not less than nominal 0.25 inch.
   d. Wall thickness, as required by the application, but not less than 0.030 inch.

3. Copper Tubing Connectors and Fittings:

   a. Brass, solder-joint type.

4. Polyethylene Tubing:

   a. Fire-resistant black virgin polyethylene according to ASTM D 1248, Type 1, Class C and Grade 5.
   b. Tubing shall comply with stress crack test according to ASTM D 1693.
   c. Diameter, as required by application, of not less than nominal 0.25 inch.

5. Polyethylene Tubing Connectors and Fittings:

   a. Brass, barbered fittings.

b. Brass, compression type.

B. Process Tubing:

1. Products in this paragraph are intended for signals to instruments connected to liquid and steam systems.
2. Copper Tubing:

a. Seamless phosphor deoxidized copper, drawn tempered with chemical and physical properties according to ASTM B 75.
b. Performance, dimensions, weight and tolerance according to ASTM B 280.
c. Diameter, as required by application, of not less than nominal 0.25 inch.
d. Wall thickness, as required by application, but not less than 0.030 inch.

3. Copper Tubing Connectors and Fittings:

a. Brass, solder-joint type.

4. Stainless-Steel Tubing:

a. Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale.
b. Chemical and physical properties according to ASTM A 269.
c. Diameter, as required by application, of not less than nominal 0.25 inch.
d. Wall thickness, as required by application, but not less than 0.035 inch.
e. Furnish stainless-steel tubing in [**20-foot**] straight random lengths.

5. Stainless-Steel Tubing Connectors and Fittings:

a. Connectors and fittings shall be stainless steel, with stainless-steel collets, flareless type.

b. Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.

2.21 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire size shall be at least No. 18 AWG.
2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.

6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be balanced twisted pair.
2. Comply with the following requirements and for balanced twisted pair cable described in Section 250523 "Control-Voltage Electrical Power Cables."

a. Cable shall be plenum rated.
b. Cable shall have a unique color that is different from other cables used on Project.

2.22 RACEWAYS

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

B. Comply with requirements in Section 250528 "Pathways for Control Systems" for raceways for balanced twisted pair cables and optical fiber cables.

2.23 OPTICAL FIBER CABLE AND CONNECTORS

A. Comply with requirements in Section 271323 "Communications Optical Fiber Backbone Cabling" for optical fiber backbone cabling and connectors.

B. Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber horizontal cabling and connectors.

2.24 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Self-adhesive label and Laminated acrylic or melamine plastic sign bearing unique identification.

a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Legend shall consist of white lettering on black background.
3. Laminated acrylic or melamine plastic sign shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer and shall be fastened with drive pins.
4. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tags shall be at least 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

D. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inchbeyond white border.

PART 3 - EXECUTION

3.01 EXAMINATION

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

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

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

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.02 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
2. Equipment to Be Connected: As indicated on Drawings.

B. Communication Interface to Other Building Systems:

1. DDC system shall have a communication interface with systems having a communication interface.
2. Systems to Be Connected: As indicated on Drawings.

3.03 DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS

A. Interface with Existing Systems:

1. DDC systems shall interface existing systems to achieve integration.
2. Upgrade and otherwise modify existing system software to integrate new control sequences into existing system as appropriate to sequence of operation.
3. Monitoring and Control of DDC System by Existing Control System:

    a. DDC system performance requirements shall be satisfied when monitoring and controlling DDC system by existing control system.
    b. Operator of existing system shall be able to upload, download, monitor, trend, control and program every input and output point in DDC system from existing control system using existing control system software and operator workstations.
    c. Remote monitoring and control from existing control system shall not require operators of existing control system to learn new software.
    d. Interface of DDC system into existing control system shall be transparent to operators of existing control system and allow operators to program, monitor, and control DDC system from any operator workstation connected to existing control system.

4. Integration of Existing Control System into DDC System:

    a. Existing control system performance requirements shall be satisfied when monitoring and controlling existing control system through DDC system.
    b. Operator shall be able to upload, download, monitor, alarm, report, trend, control and program every input and output point in existing system from DDC system

using operator workstations and software provided. The combined systems shall share one database.

c. Interface of existing control system I/O points into DDC system shall be transparent to operators. All operational capabilities shall be identical regardless of whether I/O already exists or I/O is being installed.

B. Integration with Existing Enterprise System:

1. DDC system shall interface with an existing enterprise system to adhere to Owner standards already in-place and to achieve integration.

2. Upgrade and otherwise modify existing system software to integrate new control sequences into existing system as appropriate to sequence of operation.
3. Engage Owner's control system integrator to provide the following services:

a. Enterprise system expansion and development of graphics, logs, reports, trends and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.
b. Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.
c. Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.

4. Attend meetings with control system integrator to integrate DDC system.

3.04 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
1. Airflow sensors and switches, which are specified in Section 250923.14 "Flow Instruments."
2. Pressure sensors, which are specified in Section 250923.23 "Pressure Instruments."

C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control valves, which are specified in Section 250923.11 "Control Valves."
2. Pipe-mounted flow meters, which are specified in Section 250923.14 "Flow Instruments."
3. Pipe-mounted sensors, switches and transmitters. Flow meters are specified in Section 250923.14 "Flow Instruments." Liquid and steam temperature sensors, switches, and transmitters are specified in Section 250923.27 "Temperature Instruments."
4. Tank-mounted sensors, switches and transmitters. Pressure sensors, switches, and transmitters are specified in Section 250923.23 "Pressure Instruments." Liquid and steam temperature sensors, switches, and transmitters are specified in Section 250923.27 "Temperature Instruments."
5. Pipe- and tank-mounted thermowells. Liquid and steam thermowells are specified in Section 250923.27 "Temperature Instruments."

D. Deliver the following to electrical installers for installation in electrical circuits. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. Relays and/or motor-rated 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).

3.05 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

A. Deliver the following to air terminal unit manufacturer for factory installation. Include installation instructions to air terminal unit manufacturer.

1. Application-specific controller.
2. Electric damper actuator. Dampers actuators are specified in Section 250923.12 "Control Dampers."
3. Unit-mounted flow and pressure sensors, transmitters and transducers. Flow sensors, transmitters, and transducers are specified in Section 250923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 250923.23 "Pressure Instruments."
4. Relays.

B. Deliver the following to fan-coil unit manufacturer for factory installation. Include installation instructions to fan-coil unit manufacturer.

1. Application-specific controller.
2. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 250923.27 "Temperature Instruments."
3. Flow and pressure switches. Air and liquid flow sensors, transmitters, and transducers are specified in Section 250923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 250923.23 "Pressure Instruments."
4. Leak-detection switches, which are specified in Section 250923.18 "Leak-Detection Instruments."
5. Relays.

3.06 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."

H. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

I. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

K. Corrosive Environments:

1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:
   a. Process exhaust-air streams.

2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.07 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface.

B. Test gateway to verify that communication interface functions properly.

3.08 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface.

B. Test router to verify that communication interface functions properly.

3.09 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

1. Provide a separate controller for each major HVAC system.
2. Controller shall be located within the same room as equipment.
3. 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.
4. Route all controllers for air terminal units through the controller for the air handling unit associated with the air terminal units.
5. 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.

B. Connect controllers to field power supply and to UPS units where indicated.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:

1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

G. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.10 PROGRAMMING

A. Provide software programming for the system as per specifications and adhere to the sequences of operation provided on the Drawings.

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.

3.11 BUILDING AUTOMATION GRAPHICS

A. Color Graphics Application:
1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Engineer's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's and Engineer’s review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

B. 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 precise than the device can measure. Comply with “Performance Requirements” Article of this Section for “Precision of I/O Reported Values.” 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.

C. 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: A visual representation of the site (map). One page of multiple linked pages depending on the size of the site plan.

1) Link to individual building graphic pages.
2) Display outdoor weather conditions.

b. Utility Management Page: A summary of data on the utility consumption for the site:

1) Link to the site plan.
2) Display

a) Utility consumption data.
b) Demand data.
c) Voltages, current, and power factors.
d) Demand control actions current in effect.

3) Presenting the utility management data may require more than one graphic page to effectively report the data from multiple meters.

c. Building Graphic Page: Typically a picture of the building. One page per building.

1) Link to floor plans within the building.
2) Link to central plant graphics where the plant serves the entire building.
3) Link to delivery systems if the delivery system serves the entire building.
4) Link up to the site plan.

d. Floor Plan Page: This shall be a two-dimensional plan of a floor area. A minimum of one page per floor per building is required. Where floor plans are large, multiple linked pages are required. For each control zone, the value of the controlled parameters shall be displayed. This will typically be the lighting status, temperature, temperature setpoints, zone discharge air temperatures, and relative humidity.

1) Link up to the Building page.
2) Link up to the Site page.
3) Link to any delivery system that serves the floor plan area (air handling unit is typical).
4) Link to time schedules that affect the systems that serve the area.
5) Link to a Terminal Unit Summary page where multiple zones on the floor are served by unitary control devices, such as air terminal units or fan coil units.
6) Individual control zones shall be identified.
7) The location of terminal equipment serving each zone shall be shown.
8) The location of sensors installed in the occupied space shall be shown.
9) Where room numbers are available, they shall be shown.

e. Central Plant Page: A graphical representation of the equipment that makes up the plant such as chillers, pumps, boilers, towers, etc. If the plant is small, this graphic

shall display the values of process variables and commands to end devices. If the plant is complex, this graphic shall just contain links to equipment graphics. A page for each plant is required.

1) Link up to the Building page.
2) Link up to the Site Plan page.
3) Link to Central Plant Equipment Component page (chiller, pumps, tower, etc).
4) Display:

    a) Process variables.
    b) Commands to end devices.
    c) Status of end devices.
    d) Alarm points if this is the only central plant graphic.
    e) Plant status (enabled/disabled).
    f) Demand control status.

5) Link to any time schedules that affect the operation of the plant.
6) Link to any preconfigured trend charts associated with the performance of the plant.
7) Link to a Central Plant Configuration page.

f. Central Plant Equipment Component: A graphical representation of an element of equipment such as a chiller, pumps, boiler, or tower or some combination of all of these. A page for each primary equipment item per plant is required.

1) Link up to the Central Plant page.
2) Link up to the Building page.
3) Link up to the Site Plan page.
4) Display:

    a) Process variables.
    b) Commands to end devices.
    c) Status of end devices.
    d) Alarm points.
    e) Equipment status (enabled/disabled).
    f) Demand control status.

5) Link to any time schedules that affect the operation of the equipment component.
6) Link to any preconfigured trend charts associated with the performance of the equipment component.
7) Link to a Central Plant Configuration page.

g. Central Plant Configuration Page: On this page, the operator is given access to the configuration parameters for the entire plant of a piece of equipment in the plant. Data shall be presented in a tabular format. The type of data on this page is not changed frequently, but the operator may wish to view it frequently. One page per plant for small plants and one page per primary equipment item per plant for larger plants are required.

1) Setpoints.
2) Tuning parameters.
3) Calibration parameters.
4) Timing parameters.

5) Application parameters.
6) Reset schedules.
7) Lead Lag information.
8) Time Schedules.
9) Link up to the Equipment of Central Plant page.
10) Link up to the Building page.

h. Delivery System Page: A graphical representation of an air or water delivery system, such as an air handling unit, roof top air handling unit, computer room air conditioning unit. One page for each delivery system.

1) If the Delivery System serves a specific floor area, link up to the Floor Area page.
2) Link up to the Building page.
3) Link up to the Site Plan page.
4) Link to the Central Plant page if the Delivery System is served by a Central Plant.
5) If the Delivery System supplies multiple terminal devices, link to a Terminal Equipment Summary page.
6) Link to a Delivery Systems Configuration page.
7) The graphical representation of the equipment shall represent the true physical characteristics of the installed system.
8) Display:

a) Process variables.
b) Commands to end devices.
c) Status of end devices.
d) Status of different modes.
e) Alarm points.

9) Link to any time schedules that affect the system operation.
10) Link to any pre-configured trend charts for the system.

i. Delivery System Configuration Page: On this page, the operator is given access to the configuration parameters for the delivery system. Data shall be presented in a tabular format. The type of data on this page is not changed frequently but the operator may wish to view it frequently. One page per Delivery System is required.

1) Display:

a) Setpoints.
b) Tuning parameters.
c) Calibration parameters.
d) Application parameters.
e) Reset schedules.
f) Lead /Lag information.
g) Time schedules.

2) Link up to the Delivery System page.
3) Link up to the Building page.
4) Link up to the Site Plan page.

j. Terminal Equipment Summary Page: On this page, the dynamic data and setpoints that are associated with multiple terminal units shall be presented in tabular format. The objective is to present a summary of terminal unit performance for an area of

the facility. One page is required for each group of terminal units. Multiple linked pages may be used if there are a large number of terminals served by one delivery system.

1) Display in the table:

a) Process variables.
b) Setpoints for each process.
c) Command to each end device.
d) Status of each end device.
e) Load factors such as terminal load for an air terminal unit.

2) Link to the page for each Terminal Unit.
3) Link up to the Delivery System page.
4) Link up to the Floor Plan page.
5) Link up to the Building page.
6) Link up to the Site Plan page.

k. Terminal Unit Page: A graphical representation of a terminal unit such as an air terminal or fan coil terminal. One page for each terminal.

1) Link up to the Terminal Summary page.
2) Link up to the Floor Plan page.
3) Link up to the Building page.
4) Link up to the Site Plan page.
5) The graphical representation of the equipment shall represent that actual installed terminal unit.
6) Display:

a) Process variables.
b) Setpoints for each process.
c) Command to each end device.
d) Status of each end device.
e) Modes (auto, heat, cool, etc.)
f) Capacity indicators (terminal load, %heat, %cool, etc.).
g) Reset schedules.
h) Occupancy commands and status.
i) Alarm points.

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 per building.
2) Up to 20 additional global pages.

3.12 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. UPS units.
6. Accessories.

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use galvanized-steel or corrosion-resistant-coated steel strut and hardware.
2. For NEMA 250, Type 4 Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Align top of adjacent enclosures.

D. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.13 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.

3.14 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.15 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

[redacted]

B. Install laminated acrylic or melamine plastic signs with unique identification on face for each of the following:
   1. Gateway.
   2. Router.
   3. Protocol analyzer.
   4. DDC controller.
   5. Enclosure.
   6. Electrical power device.
   7. UPS unit.
   8. Accessory.

C. Install self-adhesive labels with unique instrument identification on face of each instrument connected to a DDC controller.

D. Install self-adhesive labels with unique identification on face of each control damper and valve actuator connected to a DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G. Warning Labels and Signs:

   1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
   2. Shall be located in highly visible location near power service entry points.

3.16 NETWORK INSTALLATION

A. Install optical fiber cable when connecting between the following network devices when distance between devices exceeds 300 feet:
   1. Network controllers.

B. Install balanced twisted pair or optical fiber cable when connecting between the following network devices:
   1. Network controllers.

C. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:

1. Programmable application controllers and application-specific controllers.
2. Application-specific controllers.

D. Install cable in continuous raceway.

1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.17 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

1. MAC Address:

a. Every network device shall have an assigned and documented MAC address unique to its network.
b. Ethernet Networks: Document MAC address assigned at its creation.
c. ARCNET or MS/TP networks: Assign from 00 to 64.

2. Network Numbering:

a. Assign unique numbers to each new network.
b. Provide ability for changing network number through device switches or operator interface.
c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

3. Device Object Identifier Property Number:

a. Assign unique device object identifier property numbers or device instances for each device network.
b. Provide for future modification of device instance number by device switches or operator interface.
c. LAN shall support up to 4,194,302 unique devices.

4. Device Object Name Property Text:

a. Device object name property field shall support 32 minimum printable characters.
b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

5. Object Name Property Text for Other Than Device Objects:

a. Object name property field shall support 32 minimum printable characters.
b. Assign object name properties with plain-English names descriptive of application.

1) Example 1: "Zone 1 Temperature."

2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

a. Assign object identifier property numbers according to Drawings indicated.
b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

3.18 PIPING AND TUBING INSTALLATION

A. Above-Grade Air Signal Piping and Tubing Installation:

1. Material Application:

a. Install copper tubing, except as follows:

1) Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing.
2) Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when concealed behind accessible ceilings.

b. Install copper tubing, unless other accessible materials are indicated, for air signals to instruments including, but not limited to, the following:

1) Sensors.
2) Switches.
3) Transmitters.

c. Install drawn-temper copper tubing, except within 36 inches of device terminations tubing shall be annealed-tempered copper tubing.
d. Install compression fittings to connect copper tubing to instruments, control devices, and accessories.
e. Install barbed fittings to connect polyethylene tubing to instruments, control devices, and accessories.

2. Routing:

a. Do not expose tubing in finished spaces, such as spaces with ceilings; occupied spaces, offices, and conference rooms, unless expressly approved in writing by Architect. Tubing may be exposed in areas without ceilings.
b. Where tubing is installed in finished occupied spaces, install the tubing in surface metal raceway with appropriate fittings only where not feasible to conceal in wall, above ceiling or behind architectural enclosures or covers.
c. Install piping and tubing plumb and parallel to and at right angles with building construction.
d. Install multiple runs of tubing or piping in equally spaced parallel lines.
e. Piping and tubing shall not interfere with access to valves, equipment, duct and equipment access doors, or obstruct personnel access and passageways of any kind.
f. Coordinate with other trades before installation to prevent proposed piping and tubing from interfering with pipe, duct, terminal equipment, light fixtures, conduit and cable tray space. If changes to Shop Drawings are necessary due to field coordination, document changes on record Drawings.

g. Install vibration loops in copper tubing when connecting to instrument and actuators that vibrate.

3. Support:

a. According to MSS SP-69, Table 3, except support spacing shall not exceed 60 inches.
b. Support copper tubing with copper hangers, clips, and tube trays.
c. Do not use tape for support or dielectric isolation.
d. Install supports at each change in direction and at each branch take off.
e. Attached supports to building structure independent of work of other trades. Support from ducts, pipes, cable trays, and conduits is prohibited.
f. Attached support from building structure with threaded rods, structural shapes, or channel strut.
g. Install and brace supports to carry static load plus a safety margin, which will allow tubing to be serviced.
h. Brace supports to prevent lateral movement.
i. Paint steel support members that are not galvanized or zinc coated.
j. Support polyethylene tubing same as copper tubing.

4. Do not attach piping and tubing to equipment that may be removed frequently for maintenance or that may impart vibration and expansion from temperature change.
5. Protect exposed tubing in mechanical equipment rooms from mechanical damage within 84 inches above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.
6. Joining and Makeup:

a. Where joining and mating dissimilar metals where galvanic action could occur, install dielectric isolation.
b. Make threaded joints for connecting to instrument equipment with connectors with a compression tubing connector on one end and threaded connection on other end.
c. Make tubing bends with a tube-bending tool. Hard bends, wrinkled or flattened bends are unacceptable.
d. Install tube fittings according to manufacturer's written instructions.
e. Do not make tubing connections to a fitting before completing makeup of the connection.
f. Align tubing with the fitting. Avoid springing tube into position, as this may result in excessive stress on both tubing and fitting with possible resulting leaks.
g. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
h. Check tubing for correct diameter and wall thickness.
i. Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.
j. Thread pipe on a threading machine. Ream inner edges of pipe ends, file and grind to remove burrs.
k. Wrap pipe threads of fittings on pneumatic lines with a single wrap of PTFE tape.
l. Protect piping and tubing from entrance of foreign matter.

7. Conduit in which nonmetallic tubing is installed shall not exceed 50 percent fill. Support conduit according to NFPA 70 unless otherwise indicated.

B. Identify piping and tubing as follows:
1. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.

2. Mark each instrument tube connection with a number-coded identification. Each unique tube shall have same unique number at instrument connection and termination at opposite end of tube.

3.19 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."
2. Comply with installation requirements in Section 271313 "Communications Copper Backbone Cabling."
3. Comply with installation requirements in Section 271513 "Communications Copper Horizontal Cabling."
4. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

    a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

5. Terminate wiring in a junction box.

    a. Clamp cable over jacket in junction box.
    b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

6. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
7. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
8. Use shielded cable to transmitters.
9. Use shielded cable to temperature sensors.
10. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section "260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.
2. Comply with Section 250528 "Pathways for Control Systems" for balanced twisted pair cabling and optical fiber installation.

3.20 OPTICAL FIBER CABLE SYSTEM INSTALLATION

A. Comply with installation requirements in Section 271323 "Communications Optical Fiber Backbone Cabling."

B. Comply with installation requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling."

3.21 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Testing of Air-Signal Tubing:

    a. Test for leaks and obstructions.
    b. Disconnect each pipe and tubing line before a test is performed, and blowout dust, dirt, trash, condensate and other foreign materials with compressed air. Use commercially pure compressed air or nitrogen as distributed in gas cylinders. Air from an oil-free compressor with an air dryer is an acceptable alternative for the test.
    c. After foreign matter is expelled and line is free from obstructions, plug far end of tubing run.
    d. Connect a pressure source to near end of run with a needle valve between air supply and tubing run.
    e. Connect a pressure gage accurate to within 0.5 percent of test between the shutoff needle valve and tubing run under test.
    f. For system pressures above 30 psig, apply a pressure of 1.5 times operating pressure. Record pressure in tubing run every 10 minutes for one hour. Allowable drop in pressure in one-hour period shall not exceed 1 psig.
    g. For system pressures 30 psig and below, apply a pressure of 2.0 times operating pressure to piping and tubing run. Record pressure in tubing run every 5 minutes for one hour. Allowable drop in pressure in one-hour period shall not exceed 0.5 psig.

C. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.22 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. Control Damper Checkout:
1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

F. Control Valve Checkout:
1. Verify that control valves are installed correctly for flow direction.
2. Verify that valve body attachment is properly secured and sealed.
3. Verify that valve actuator and linkage attachment is secure.
4. Verify that actuator wiring is complete, enclosed and connected to correct power source.
5. Verify that valve ball, disc or plug travel is unobstructed.
6. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

G. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:

    a. Verify sensing element type and proper material.
    b. Verify length and insertion.

3.23 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.

2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.24 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

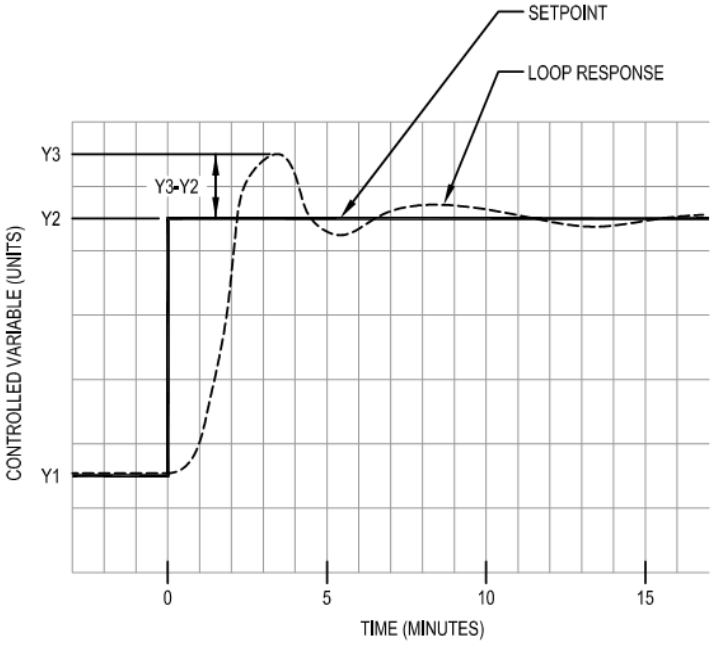
C. Verify that spare I/O capacity is provided.

3.25 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules.

a. Adjust PI or PID actions using either Ziegler-Nichols methods (either ultimate oscillation or first-order-plus-dead-time) or trial and error.
b. Each proportional, integral, and derivative gain shall utilize a linear reset based on error from set point. Contractor shall determine the maximum and minimum range for each gain to achieve specified performance. Model-free adaptive control loops and self-learning control loops shall not be used.
c. Begin with measured value at setpoint (Y1). Adjust set point or manual output of controller to create a step change (Y2-Y1). PI control loops shall exceed no more than a 25% maximum overshoot in a step response [(Y3-Y2)/(Y2-Y1)] ≤ 0.25



d. Initial response, including overshoot and dampening shall occur within approximately 5-7 minutes from step change. Measured value shall achieve set point within approximately 15-17 minutes from step change.
e. Supply graphical trend data output to Engineer showing each DDC loop's response to a set point change representing an end device change of at least 25% of full range.

    1) Trend sampling rate shall be from 10 seconds to 1 minute, depending on loop speed.
    2) Each sample's trend data shall show values for set point, end device response, and controlled variable.

6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.

10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.26 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.

4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 20 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.

    a. Verify analog I/O points at operating value.
    b. Make adjustments to out-of-tolerance I/O points.

        1) Identify I/O points for future reference.
        2) Simulate abnormal conditions to demonstrate proper function of safety devices.
        3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:

    a. Re-check I/O points that required corrections during initial test.
    b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

5. After 24 Hours of Second Validation Test:

    a. Re-check I/O points that required corrections during second test.
    b. Continue validation testing until I/O point is normal on two consecutive tests.

6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Network Bandwidth Test:

1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

3.27 FINAL REVIEW

A. Submit written request to Engineer and Construction Manager when DDC system is ready for final review. Written request shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.

2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review by Engineer and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should additional reviews be required due to a specific start-up or checkout test item, reported to have been successfully completed, but determined during review to be faulty, Construction Manager shall compensate entity performing review for total costs, labor and expenses, associated with subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review. Construction Manager 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. Prepare and submit closeout submittals when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration shall include, but not be limited to, the following:

    a. Accuracy and calibration of 20 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
    b. Controlled equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 20 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
    c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
    d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
    e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
    f. Trends, summaries, logs and reports set-up for Project.
    g. For HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated.

h. Graphical trend data showing each DDC loop’s response to a set point change representing an end device change of at least 25% of full range, as outlined in “DDC Controller I/O Control Loop Tests” Article.
i. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.
j. Software's ability to edit control programs off-line.
k. Data entry to show Project-specific customizing capability including parameter changes.
l. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
m. Execution of digital and analog commands in graphic mode.
n. Spreadsheet and curve plot software and its integration with database.
o. Online user guide and help functions.
p. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
q. System speed of response compared to requirements indicated.
r. For Each Network and Programmable Application Controller:

1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.
2) Operator Interface: Ability to connect directly to each type of digital controller with a portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
4) Electric Power: Ability to disconnect any controller safely from its power source.
5) Wiring Labels: Match control drawings.
6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.
7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.

s. For Each Operator Workstation:

1) I/O points lists agree with naming conventions.
2) Graphics are complete.
3) UPS unit, if applicable, operates.

t. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability for BACnet systems. Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated. Modifications are made with messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.

4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
10) Device and Network Management:

    a) Display of network device status.
    b) Display of BACnet Object Information.
    c) Silencing devices transmitting erroneous data.
    d) Time synchronization.
    e) Remote device re-initialization.
    f) Backup and restore network device programming and master database(s).
    g) Configuration management of routers.

3.28 ADJUSTING

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

3.29 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.30 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for one year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within one year(s) from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.31 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:

    a. Provide not less than three days of training total.
    b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
    c. Total days of training shall be broken into not more than four separate training classes.

C. Training Schedule:
1. Schedule training to provide Owner with at least 20 business days of notice in advance of training.
2. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions.
3. Provide staggered training schedule as requested by Owner.

D. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Preprinted sign-in sheet shall include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session. List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.

E. Attendee Training Manuals:

1. Provide each attendee with a color hard copy of all training materials and visual presentations.
2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.

3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

F. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system.

2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.

G. Training Outline:

1. Submit training outline for Owner review at least 20 business days before scheduling training.
2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

H. On-Site Training:
1. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
2. Provide as much of training located on-site as deemed feasible and practical by Owner.
3. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
4. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

I. Off-Site Training:

1. Provide conditioned training rooms and workspace with ample tables desks or tables, chairs, power and data connectivity for each attendee.
2. Provide capability to remotely access to Project DDC system for use in training.
3. Provide a workstation for use by each attendee.

J. Training Content for Daily Operators:

1. Basic System Understanding

a. Basic operation of system.
b. Understanding DDC system architecture and configuration.
c. Understanding each unique product type installed including performance and service requirements for each.
d. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
e. Operating operator workstations, printers and other peripherals.
f. Logging on and off system.
g. Accessing graphics, reports and alarms.
h. Adjusting and changing set points and time schedules.
i. Recognizing DDC system malfunctions.

j. Understanding content of operation and maintenance manuals including control drawings.
k. Understanding physical location and placement of DDC controllers and I/O hardware.
l. Accessing data from DDC controllers.
m. Operating portable operator workstations.
n. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
o. Running each specified report and log.
p. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
q. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
r. Executing digital and analog commands in graphic mode.
s. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
t. Demonstrating DDC system performance through trend logs and command tracing.
u. Demonstrating scan, update, and alarm responsiveness.
v. Demonstrating spreadsheet and curve plot software, and its integration with database.
w. Demonstrating on-line user guide, and help function and mail facility.
x. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.

2. Operations:

a. All equipment and/or system start-up procedures.
b. All equipment and/or systems shut-down procedures.
c. Routine and normal operating sequences for all systems.
d. Special operating instructions and procedures.
e. Seasonal and weekend operating instructions.
f. Demonstrating the following for systems and equipment controlled by DDC system:

1) Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.
2) For equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
3) Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.
4) Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
5) Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
6) Each control loop responds to set point adjustment and stabilizes within time period indicated.
7) Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

3. Emergencies:

a. Instructions on meanings of warnings, trouble indications, and error messages.
b. Instructions on stopping, manual overrides, and BAS override procedures.
c. Safety device procedures and actions.
d. Operating procedures for system, sub-system, or equipment failures.
e. Shut-down instructions for each type of emergency.
f. Operating instructions for conditions outside of normal limits.
g. Special operating instructions and procedures.
h. Adjustments:

1) Proper adjustment procedures and points intended to be adjusted.
2) Economy and efficiency adjustments.
3) Adjustments for efficient energy use.

4. Troubleshooting:

a. Diagnostic instruction procedures for each typical system installed.
b. Test and inspection procedures for each typical system installed.
c. Maintenance.
d. Inspection procedures.
e. Procedures for preventative maintenance.
f. Procedures for routine maintenance.

K. Video of Training Sessions:

1. Provide a digital video and audio recording of each training session. Create a separate recording file for each session.
2. Stamp each recording file with training session number, session name and date.
3. Provide Owner with two copies of digital files on DVDs or flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION

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SECTION 250923.11
CONTROL VALVES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes control valves and actuators.

1.03 DEFINITIONS

A. Cv: Design valve coefficient.

B. DDC: Direct-digital control.

C. NBR: Nitrile butadiene rubber.

D. PTFE: Polytetrafluoroethylene

E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions, including factors affecting performance.

B. Delegated-Design Submittal:

1. Schedule and design calculations for control valves and actuators, including the following:

    a. Flow at project design and minimum flow conditions.
    b. Pressure differential drop across valve at project design flow condition.

c. Design and minimum control valve coefficient with corresponding valve position.
d. Maximum close-off pressure.
e. Actuator selection indicating torque provided.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control valves to include in operation and maintenance manuals.

1.06 WARRANTY

A. Manufacturer's Warranty: Manufacturer warrants all control valves and actuators free from defects within specified warranty period

1. Warranty Period: Five year(s) from date of production, with the first two years unconditional.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.

E. Environmental Conditions:

1. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

a. Hazardous Locations: Explosion-proof rating for condition.

F. Determine control valve sizes and flow coefficients by ISA 75.01.01.

G. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

H. Selection Criteria:

1. Control valves shall be suitable for operation at following conditions:

a. Chilled Water: 150 psig at 200 deg F.
b. Heat Recovery: 150 psig at 200 deg F.

c. Heating Hot Water: 150 psig at 200 deg F.
d. Makeup Water: 150 psig at 150 deg F.

2. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.
3. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
4. Modulating straight-through pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
5. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
6. Modulating butterfly valves shall have linear or equal percentage flow-throttling characteristics.
7. Fail positions unless otherwise indicated on the Drawings:

   a. Chilled Water: Last position.
   b. Heat Recovery: Last position.
   c. Heating Hot Water: Last position.
   d. Makeup Water: Close.
8. Rotary-type control valves, such as ball and butterfly valves, shall have Cv falling between 65 and 75 degrees of valve full open position and minimum valve Cv between 15 and 25 percent of open position.
9. Selection shall consider viscosity, flashing, and cavitation corrections.
10. Valves shall have stable operation throughout full range of operation, from design to minimum Cv.
11. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 5 psig 4 psig at design flow unless otherwise indicated.

12. Two-position control valves shall be line size unless otherwise indicated.
13. In water systems, use ball- style control valves for two-position control for valves NPS 2 and smaller and butterfly style for valves larger than NPS 2.

2.02 BALL-STYLE CONTROL VALVES

A. Two-Way Ball Valves with Characterized Disk:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

   a. Belimo Aircontrols (USA), Inc.

   b. Siemens

2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: 300 series stainless steel.
9. Stem and Stem Extension:

   a. Material to match ball.
   b. Blowout-proof design.

c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristic: Equal percentage.

B. Three-Way Ball Valves with Characterized Disk:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Belimo Aircontrols (USA), Inc.

b. Siemens

2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: 300 series stainless steel.
9. Stem and Stem Extension:

a. Material to match ball.
b. Blowout-proof design.
c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristics for A-Port: Equal percentage.
13. Flow Characteristics for B-Port: Modified for constant common port flow.

2.03 BUTTERFLY-STYLE CONTROL VALVES

A. Commercial-Grade, Two-Way Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Belimo Aircontrols (USA), Inc.

b. Siemens

2. Performance:

a. Bi-directional bubble tight shutoff at 250 psig.
b. Comply with MSS SP-67 or MSS SP-68.
c. Rotation: Zero to 90 degrees.
d. Linear or modified equal percentage flow characteristic.

3. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: 316 stainless steel.
5. Shaft: 316 or 17-4 PH stainless steel.
6. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Body and trim materials.
d. Flow arrow.

B. Commercial-Grade, Three-Way Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Belimo Aircontrols (USA), Inc.

b. Siemens

2. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
3. Performance:

a. Bi-directional bubble tight shutoff at 250 psig.
b. Comply with MSS SP-67 or MSS SP-68.
c. Rotation: Zero to 90 degrees.
d. Linear or modified equal percentage flow characteristic.

4. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
5. Disc: 316 stainless steel.
6. Shaft: 316 or 17-4 PH stainless steel.
7. Seat: Reinforced EPDM or reinforced PTFE seat with retaining ring.
8. Shaft Bushings: Reinforced PTFE or stainless steel.
9. Replaceable seat, disc, and shaft bushings.
10. Corrosion-resistant nameplate indicating:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Body and trim materials.
d. Flow arrow.
e.

2.04 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Belimo Aircontrols (USA), Inc.

b. Siemens

B. Position indicator and graduated scale on each actuator.

C. Type: Motor operated, with or without gears, electric and electronic.

D. Voltage: Unless otherwise indicated on the Contract Documents, provide

1. 24-V ac for valves NPS 4 and Smaller, where located indoors.
2. 120-V ac for valves NPS 4 and Smaller, where located outdoors.
3. 120-V ac for valves NPS 6 and Larger.

E. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

F. Function properly within a range of 85 to 120 percent of nameplate voltage.

G. Construction:

1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

H. Field Adjustment:

1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

I. Two-Position Actuators: Single direction, spring return or reversing type.

J. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.

b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for 2- to 10-V dc and 4- to 20-mA signals.
c. Programmable Multi-Function:

1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

K. Position Feedback:

1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Where indicated, equip modulating actuators with a position feedback through voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

L. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

M. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

N. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

O. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

P. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.

4. Provide actuator enclosure with heater and control where required by application.

Q. Stroke Time:
1. Select operating speed to be compatible with equipment and system operation.

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 CONTROL VALVE APPLICATIONS

A. Control Valves:

1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
2. Chilled Water System:

a. ValvesNPS 2 and Smaller: Two-Way or Three-Way Ball valves with characterized disk, as required by application.
b. ValvesNPS 2-1/2 and Larger: Two-Way or Three-Way Butterfly-style, commercial-grade valves, as required by application.

3. Heating Hot Water System:

a. ValvesNPS 2 and Smaller: Two-Way or Three-Way Ball valves with characterized disk, as required by application.
b. ValvesNPS 2-1/2 and Larger: Two-Way or Three-Way Butterfly-style, commercial-grade valves, as required by application.

3.03 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could

potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including. but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.04 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.05 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Install pressure temperature taps in piping upstream and downstream of each control valve.

D. Valve Orientation:

1. Where possible, install ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

E. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

F. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

G. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.06 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.07 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with valve identification on valve and on face of ceiling directly below valves concealed above ceilings.

3.08 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.09 CHECKOUT PROCEDURES

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Verify that control valves are installed correctly for flow direction.
5. Verify that valve body attachment is properly secured and sealed.
6. Verify that valve actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that valve ball, disc, and plug travel are unobstructed.
9. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

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SECTION 250923.12
CONTROL DAMPER ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes the following types of control-damper actuators and accessories:
   1. General control-damper actuator requirements.
   2. Electric and electronic actuators.
   3. Damper position switches

B. Related Requirements:

   1. Section 233300 "Air Duct Accessories" for control dampers.

1.03 DEFINITIONS

A. DDC: Direct-digital control.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

   1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
   3. Product description with complete technical data, performance curves, and product specification sheets.
   4. Installation instructions, including factors affecting performance.

B. Delegated-Design Submittal:

   1. Schedule for actuators, including the following.
      a. Actuator selection indicating torque provided.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

1.06 WARRANTY

A. Manufacturer's Warranty: Manufacturer warrants all control-damper actuators free from defects within specified warranty period

1. Warranty Period: Five year(s) from date of production, with the first two years unconditional.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.

E. Environmental Conditions:

1. Provide electric control-damper actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control-damper actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

a. Hazardous Locations: Explosion-proof rating for condition.

2.02 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

I. Actuator Fail Positions: See Drawings.

2.03 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

a. Belimo Aircontrols (USA), Inc.

B. Voltage: Unless otherwise indicated on the Contract Documents, provide:

1. 24-V for Control Dampers (excluding Smoke and Combination Fire/Smoke Dampers).
2. 120-V for Smoke and Combination Fire/Smoke Dampers.
3. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
4. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Electrical Connection: Actuators shall be provided with a conduit fitting and a minimum 3-foot electrical cable and shall be pre-wired to eliminate the necessity for opening the actuator housing to make electrical connections.

D. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

E. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

F. Two-Position Actuators: Single direction, spring return or reversing type.

G. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for 2- to 10-V dc and 4- to 20-mA signals.
c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink or source controller.
d. Programmable Multi-Function:

1) Control input, position feedback, and running time shall be factory or field programmable.
2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
3) Service data, including at a minimum, number of hours powered and number of hours in motion.

H. Position Feedback:

1. Where indicated, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position, as follows. Externally mounted, non-mercury damper position switch, installed directly on damper shaft.
   a. Smoke and Combination Fire/Smoke Dampers: Two, SPDT, auxiliary switches, integral to actuator, with one switch fixed at 10 degrees or less and one switch adjustable between 30 degrees and 90 degrees.
   b. Control Dampers (Smoke Control Systems): Two, SPDT, auxiliary switches, integral to actuator, with one switch fixed at 10 degrees or less and one switch adjustable between 30 degrees and 90 degrees.

2. Where indicated, equip modulating actuators with a position feedback through voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

I. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

J. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

K. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.

3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

L. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature ranges of.
   a. Control Dampers (excluding Smoke and Combination Fire/Smoke Dampers): Minus 20 to plus 120 deg F
   b. Minus 20 to plus 250 deg F

2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

M. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

N. Stroke Time:
1. Select operating speed to be compatible with equipment and system operation.
2. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

2.04 DAMPER POSITION SWITCHES

A. Type: Non-mercury damper position switch, with mechanical roller ball, SPDT.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Kele; TS-475 Series or a comparable product.

B. Switch Angle: Normally open switch makes at 10 degrees above horizontal and breaks at 5 degrees below horizontal.

C. Electrical Connection: Switch shall be provided with minimum 3-foot plenum-rated electrical cable and shall be pre-wired to eliminate the necessity for opening the switch housing to make electrical connections.

PART 3 - EXECUTION

3.01 EXAMINATION

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

B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Seal penetrations made in fire-rated and acoustically rated assemblies.

C. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.03 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.04 CONTROL DAMPERS

A. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

B. Attach actuator(s) to damper drive shaft.

C. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.05 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.06 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.07 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.
4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is unobstructed.

3.08 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

C. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION

SECTION 250923.13
ENERGY METERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes thermal and electric power energy meters that connect to DDC systems.

1.03 DEFINITIONS

A. DDC: Direct-digital control.

B. Ethernet: Local area network based on IEEE 802.3.1 standards.

C. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

D. I/O: Input/output.

E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

F. RS-485: A TIA standard for multipoint communications using two twisted pairs.

G. RTD: Resistance temperature detector.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating electrical power requirements.
3. Product description with complete technical data, performance curves, and product specification sheets.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include diagrams for power, signal, and control wiring.

1.05 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.01 THERMAL ENERGY METERS

A. Performance Requirements: Manufacturer shall certify that each energy meter indicated complies with specified performance requirements and characteristics.

1. Product certificates are required.

B. Insertion-Type Thermal Energy Meters:Basis-of-Design Product: Subject to compliance with requirements, provide ONICON Incorporated; System 10 Series or a comparable product by one of the following:

a. Veris Industries.

2. Description:

a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, keypad user interface, installation hardware, color-coded interconnecting cabling, and installation instructions.
b. Each thermal energy meter shall be individually calibrated and provided with calibration certification traceable to NIST.

3. Alphanumeric display of the following on face of enclosure:

a. Total energy consumption.
b. Energy rate.
c. Flow rate.
d. Supply temperature.
e. Return temperature.
f. Visual indication of power status (on/off) on face of enclosure.

4. Electronics Enclosure:

a. Remote from temperature and flow sensors.
b. NEMA 250, Type 12 or Type 13 for indoor applications and NEMA 250, Type 4 or Type 4X for outdoor applications.
c. Labeled terminal strip for field wiring connections.

5. Programming:

a. Factory programmed for specific application and field programmable through keypad on face of enclosure.
b. Programmed parameters and total energy consumption shall be stored in non-volatile EEPROM memory.

6. Output Signals:

    a. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50-V rating and contact duration of 0.5, 1, 2, or 6 seconds.
    b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero- to 10-V dc for each.
    c. In lieu of hardwired analog signals, a serial communication interface may be used.

7. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
8. Temperature Sensors:

    a. Temperature range matched to application.
    b. Differential temperature accuracy within 0.15 deg F over the calibrated range.
    c. NEMA 250, Type 4 junction box with thermal isolation.
    d. Stainless-steel thermowell with NPS 1/2 NPT connection for each sensor.

9. Flow Sensor:

    a. Insertion Electromagnetic Flow Meter as specified in Section 250923.14 "Flow Instruments."

10. Power Supply:

    a. Field Power: 120-V ac, 60 Hz unless otherwise required by the application.
    b. Internal Power: As required by flow meter.

C. In-Line, Compact-Type Thermal Energy Meters:

1. Basis-of-Design Product: Subject to compliance with requirements, provide ONICON Incorporated; System 40 Series or comparable product.
2. Description:

    a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, operator interface, installation hardware, interconnecting cabling, and installation instructions.
    b. Each thermal energy meter shall be individually calibrated and provided with calibration certifications traceable to NIST.
    c. Meter limited to flow rates between 0.8 and 38 gpm.
    d. Meter mode of operation shall be field configurable to accommodate two pipe systems that change from between heating and cooling.

3. Alphanumeric display of the following on face of enclosure:

    a. Total energy consumption.
    b. Energy rate.
    c. Flow rate.
    d. Supply temperature.
    e. Return temperature.

4. Diagnostic Lights:

    a. Meter equipped with diagnostic indicator lights that confirm the operation of the microprocessor and its input circuitry.
    b. Red LED labeled "BTU" shall flash as energy is transferred.

c. Red LED labeled "FLOW" shall flash at a rate that is proportional to the liquid flow rate. An unlit LED indicates no flow signal.

5. Programming:

a. Meter shall be factory programmed for specific application.
b. Programmed parameters and total energy consumption shall be stored in non-volatile memory.

6. Output Signals:

a. Mode 1 and Mode 2 Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50-V rating and contact duration of 0.5, 1, 2, or 6 seconds.
b. Factory-set isolated analog output for energy rate, flow rate, or temperature difference: 4 to 20 mA, zero to 5 or 10 V.
c. In lieu of hardwired output signals, a serial communication interface may be used.

7. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
8. Temperature Sensors:

a. Temperature range matched to application.
b. Differential temperature accuracy within 0.15 deg F over the calibrated range.
c. Brass thermowell with NPS 1/2 sweat fitting or NPS 1/4 NPT connection for each sensor.

9. Flow Sensor:

a. Inline Ultrasonic Flow Meter as specified in Section 250923.14 "Flow Instruments."

10. Power Supply:

a. Field Power: 24-V ac, 50 or 60 Hz unless otherwise required by the application.

2.02 ELECTRIC POWER METERS

A. Performance Requirements: Manufacturer shall certify that each energy meter indicated complies with specified performance requirements and characteristics.

1. Product certificates are required.

B. Multifunction Electric Power Meter:

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

a. Siemens Building Technologies, Inc.
b. Veris Industries.

2. Hardware:

a. Voltage Inputs: Three voltage inputs capable of measuring from zero- to 400-V rms (line to neutral) or from zero- to 690-V rms (line to line). The instrument shall have provisions for direct connection for wye (Star) systems up to 347/600-V ac. For

higher-voltage systems, PTs with 120-, 277-, or 347-V ac secondaries shall be supported. Voltage inputs shall provide the following:

1) 1500-V ac continuous surge protection.
2) 25 percent of full-scale voltage over range capability.

b. Current Inputs: Three 5-A nominal (6-A full-scale) current inputs. Current inputs shall be transformer coupled and accept CTs with 5-A nominal (6-A full-scale) outputs. Current inputs shall provide the following:

1) 120-A surge protection for one second.
2) 20 percent of nominal current continuous over range capability.

c. Power Supply: 100- to 240-V ac (within 10 percent) at 50 to 60 Hz, 110- to 300-V dc, or 20- to 60-V dc power source. Load shall not exceed 15 W.

d. Onboard I/O:

1) Two Form A solid-state digital (status) outputs with the following features:

a) The ability to be used to provide pulse outputs according to any energy consumption levels.
b) Rated 200-V ac/dc with a maximum current of 100 mA.

e. Communications:

1) Provide the following built-in communication ports of standard technology, as defined by the IEEE:

a) One optically isolated RS-485 communication port, supporting data rates from 1200 to 19200 bits per second.

2) Communication ports shall support the following communication capabilities, independently configurable:

a) PML protocol.
b) Modbus RTU protocol.
c) Shall provide simultaneous access through all communication ports to any measured or derived parameter.
d) Protocols shall be field configurable from the front display, or via communication ports, and be capable of being accomplished without resetting the meter or interrupting its operation in any way.
e) Support time synchronization broadcast messages from a host computer system.

f. Mounting and Display:

1) The instrument shall support the following mounting options:

a) 3.6-by-3.6-inch panel cutout, using sliding clamps tightened by thumbscrews.
b) ANSI 4-inch round cut-out.
c) Transducer-type base unit with a remote LED display with cable for remote display applications.
d) Transducer-type base unit only with no display locally mounted.

e) Allow the operator to remove and replace the display panel without removing the instrument from the equipment in which it is mounted.

g. Enclosure: If installation requires meter to be installed in a dedicated enclosure, install meter in an NRTL-listed enclosure suitable for operating environment at meter location.

1) Indoors: NEMA 250, Type 1 .
2) Outdoors: NEMA 250, Type 4 or Type 4X.

h. Memory: Sufficient non-volatile (RAM) to store setup data and accumulated energy values.

3. The instrument shall measure and calculate the following information:

a. Voltage line-to-neutral and line-to-line for each phase and average of three phases.
b. Current for each phase and average of three phases.
c. Peak current demand.
d. Neutral current.
e. Power (kW).
f. Peak power demand (kW).
g. Energy (kWh) import/export.
h. Power factor total.
i. Frequency.

4. Operator interface features are as follows:

a. Capable of calculating the following information for any reading at one-second intervals:

1) Sliding window demands for any parameter with operator-programmable length of demand period and number of subperiods to match local utility billing method.

b. Support direct display of all parameters on the front panel or remote display in user-programmable groups, using plain language labels. Simultaneous access to all parameters shall be available through any communication port.
c. Field programmable as follows:

1) Basic Parameters: Voltage input scale, voltage mode (wye, delta, single phase), current input scale, auxiliary input and output scales, and communication setup parameters are programmable from the front panel.
2) Using ION modules, support customized configurations of all operating parameters.
3) Provisions to ensure that programming through a computer can be secured by user ID and password.
4) Provisions to ensure that programming through the front panel is secured by password.
5) Digital outputs shall support pulse output relay operation for kWh total, kWh imported, kWh exported, kVARh total, kVARh imported, kVARh exported, and kVAh values.

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 THERMAL ENERGY METER APPLICATIONS

A. Chilled-Water:

1. Piping Smaller than NPS 2-1/2(DN 65): In-Line, Compact-Type Thermal Energy Meters.
2. Piping NPS 3 and Larger: Insertion-Type Thermal Energy Meters.

B. Condenser-Water:

1. Piping Smaller than NPS 2-1/2(DN 65): In-Line, Compact-Type Thermal Energy Meters.
2. Piping NPS 3 and Larger: Insertion-Type Thermal Energy Meters.

C. Heating Hot-Water:

1. Piping Smaller than NPS 2-1/2(DN 65): In-Line, Compact-Type Thermal Energy Meters.
2. Piping NPS 3 and Larger: Insertion-Type Thermal Energy Meters.

3.03 ELECTRIC POWER METER APPLICATIONS

A. Multifunction, electric power meter.

3.04 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

C. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.05 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Division 26.

C. Furnish and install power wiring. Comply with requirements in Division 26.

D. Furnish and install raceways. Comply with requirements in Division 26.

3.06 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION

SECTION 250923.14
FLOW INSTRUMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Airflow measurement stations and sensors.
2. Liquid flow meters.
3. Gas flow meters.

1.03 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. FEP: Fluorinated ethylene propylene.

C. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

D. PTFE: Polytetrafluoroethylene.

E. PPS: Polyphenylene sulfide.

F. RS-485: A TIA standard for multipoint communications using two twisted pairs.

G. RTD: Resistance temperature detector.

H. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical

power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.
5. Product certificates.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.05 CLOSEOUT SUBMITTALS

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

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 AIRFLOW MEASUREMENT STATIONS AND SENSORS

A. Performance Requirements:

1. Adjustable for changes in system operational parameters.
2. Airflow Sensor and Transmitter Range: Extended range of 20 percent above Project design flow and 20 percent below minimum Project flow to signal abnormal flow conditions.
3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

    a. Product certificates are required.

4. Accuracy: Under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, including combined uncertainty of the sensor nodes and transmitter:

    a. For Air-Ducted/Plenum: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications.
    b. For Supply or Return Fan Array: Within 10 percent of reading.
    c. For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans: Within 10 percent of reading.
    d. For Packaged HVAC Units: Within 10 percent of reading.
    e. For Directional Airflow Sensors: Thermal airflow measurement station.

B. Thermal Airflow Measurement Stations:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ebtron, Inc.; Gold Series (ducts and plenums) and Hybrid Series (fan inlets) or a comparable product.
2. Common Performance Requirements:

    a. Provide stations that are adjustable for changes in system operational parameters.
    b. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
    c. Thermal airflow stations with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location.
    d. Sensor Nodes: One self-heated and one zero-power bead-in-glass thermistor, using the principle of thermal dispersion.
    e. Airflow Rate and Temperature of Each Sensor: Equally weighted and averaged by the transmitter prior to output.
    f. Sensor-Node and Probe Assemblies:

        1) Sensor-Node Construction: Two bead-in-glass, hermetically sealed thermistors potted in a marine-grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Construct with only the thermistor located within the sensing node and all other electronic components outside the airstream. Epoxy- or glass-encapsulated chip thermistors or devices with exposed leads are not allowed. Devices that use epoxy- or glass-encapsulated chip thermistors, or electronics in the airstream, are unacceptable. Devices with exposed leads are unacceptable.
        2) Store sensor-node airflow and temperature calibration data in a serial memory chip, in the cable connecting plug. Stored data does not require matching or adjustments to the transmitter in the field.
        3) Sensing-Node Temperature Accuracy: Within 0.15 deg F over an operating range of minus 20 to plus 160 deg F and humidity range of 0 to 100 percent RH.
        4) Sensor-Probe Mounting Bracket Construction: Type 304 stainless steel.
        5) Internal Probe Wiring: Kynar-coated copper between the connecting cable and sensor nodes. PVC-jacketed wiring is unacceptable.
        6) Internal Probe Wiring Connections: Solder joints and spot welds, sealed and protected from the elements, so that direct exposure to water will not affect instrument operation. Connectors within the probe, of any type, are unacceptable. Printed circuit boards within the probe are unacceptable.
        7) Sensor-Probe Jacket: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F, and for continuous and direct UV exposure. Plenum-rated PVC jacket cables are unacceptable.

8) Sensor-Probe Cable Connector Plug: Gold-plated pins for connection to the transmitter.

g. Transmitter Features and Functions:

1) High and/or low airflow alarm with user-defined set point and percent of set-point tolerance.
2) Manual or automatic alarm reset, and low-limit cutoff value may be selected to disable the alarm.
3) Alarm delay function, field defined.
4) Sensor-node malfunction via the system status alarm and ignore the sensor node that is in a fault condition.
5) Field configuration, diagnostics, and field output adjustment wizard that allow for a one- or two-point field adjustment to factory calibration for installations that require adjustment.
6) Automatic reset after power disruption, transients, and brown-outs through a watchdog timer circuit.
7) Operating temperature range of minus 20 to plus 120 deg F and humidity range of 5 to 95 percent RH.
8) Electrical Power Requirement: 24 V ac (between 22.8 and 26.4 V ac under load) at 20 VA maximum, using a switching power supply that is overcurrent and overvoltage protected.
9) Printed Circuit Board Interconnects: Gold-plated edge fingers, receptacle plug pins, and printed circuit board test points.
10) Printed Circuit Boards: Electroless nickel immersion gold (ENIG) plated.
11) Integrated Circuitry: Temperature-rated, industrial-grade. Commercial-grade integrated circuitry is not acceptable.
12) Integration Buffers: Separate integration buffers for display of airflow output, airflow signal output (analog and network), and individual sensor output (IR-interface).
13) User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.

[redacted]

3. For Directional Airflow:

a. Bi-directional airflow measurement station with temperature output and integral airflow alarming to determine the exfiltration or infiltration airflow rate, and its direction and temperature at each measurement location.
b. Bi-directional airflow, or equivalent differential pressure date, is provided to the BAS, with system status indication, configurable airflow alarm, and internal diagnostics routine.
c. Sensor-Node Calibration:

1) Individually calibrated at a minimum of nine calibration points to NIST-traceable volumetric standards from minus 3000 to plus 3000 fpm (minus 15.2 to plus 15.2 m/s).
2) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
3) Probe to Transmitter Cables: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F (minus 55 to plus 200 deg C), and UV tolerant, with terminal plug for connection to the remotely mounted transmitter.

d. Transmitter:

1) Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.
2) User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.
3) Model EF-A Transmitter, Analog Capability: Two field-selectable 2- to 10-V dc, scalable and protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature low and/or high airflow set-point alarm (user-defined) or system status alarm.
4) Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed during set up.

2.03 GAS FLOW METERS

A. General Requirements for Gas Flow Meters:

1. Adjustable for changes in system operational parameters.
2. Gas Sensors, Meters, and Transmitters: Extended range of 20 percent above Project design flow and 20 percent below Project minimum flow to signal abnormal flow conditions.
3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
4. Product certificates are required.

B. Inline Thermal Mass Flow Meter:

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

a. ONICON Incorporated; F-5100 Series.
b. Sage; 300.

2. Meters shall have a microprocessor to display totalizer flow, flow rate, temperature, pressure, time, and date; alarms for high and low flow rate and temperature.

a. Computer shall have 4- to 20-mA or 2- to 10-V output for temperature, pressure, and contact closure for flow increments.
b. Independent timers to store four peak flow rates and total flow.
c. Interface compatible with data acquisition logging system, as indicated on the plans.
d. Microprocessor Enclosure: NEMA 250, Type 4.
e. Display: Local, LCD.
f. Connections: ANSI Class 300 flanged.
g. Body: 316 Stainless Steel.
h. Communications: BACnet MS/TP

3. Sensors:

a. Flow: Mass flow type with stainless-steel wetted parts and flange connections; and with a piezoelectric sensor removable and serviceable without shutting down the process.

1) Accuracy: ± 1.0% of flow rate.
2) Repeatability: ± 0.2% of flow rate.

b. Temperature: Integral 1,000 ohm, platinum RTD.
c. Pressure: Integral pressure transducer.

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.
2. Do not begin installation without submittal approval of mounting location.

E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 INSTRUMENT APPLICATIONS

A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

B. Airflow Measurement Stations:

1. For Air-Ducted/Plenum: Thermal airflow measurement station.

2. For Supply or Return Fan Array: Thermal airflow measurement station.

3. For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans: Thermal airflow measurement station.

4. For Directional Airflow Sensors: Thermal airflow measurement station.

C. Gas Flow Meters:

1. Natural Gas System: Inline Thermal Mass Flow Meter.

3.03 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.04 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.05 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.

2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.06 FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Gas Flow Meters:

1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.
3. Install in-line meters with flanges or unions to provide drop-in and -out installation.

3.07 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at

points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.08 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.09 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an

installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION

SECTION 250923.16
GAS INSTRUMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes the Following Gas Instruments:

1. Carbon-dioxide sensors and transmitters.

1.03 DEFINITIONS

A. NDIR: Nondispersive infrared.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Installation instructions, including factor affecting performance.
3. Product description with complete technical data, performance curves, product specification sheets.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include diagrams for power, signal, and control wiring.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 CARBON-DIOXIDE SENSORS AND TRANSMITTERS

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

1. Building Automation Products Inc.; BAPI.
2. Ebtron, Inc.
3. INTEC Controls.
4. QEL; Quatrosense Environmental Limited.
5. Telaire; a brand of Amphenol Thermometrics Inc.
6. Vaisala.

B. Description:

1. NDIR technology or equivalent technology providing long-term stability and reliability.
2. Two-wire, 4-20 mA output signal, linearized to carbon-dioxide concentration in ppm.

C. Construction:

1. House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.
2. Equip with digital display for continuous indication of carbon-dioxide concentration.

D. Performance:

1. Measurement Range: Zero to 2000 ppm.
2. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
3. Repeatability: Within 1 percent of full scale.
4. Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F.
5. Long-Term Stability: Within 5 percent of full scale after more than five years.
6. Response Time: Within 60 seconds.
7. Warm-up Time: Within five minutes.

E. Provide calibration kit. Turn over to Owner at start of warranty period.

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.03 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.04 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inchesabove the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 48 inches (1.2 m).

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.05 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.06 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.07 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

E. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

F. Switches: Calibrate switches to make or break contact at set points indicated.

G. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.08 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION

SECTION 250923.18
LEAK DETECTION INSTRUMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes the following types of leak-detection switches:

1. Point-type, leak-detection switches.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Operating characteristics, electrical characteristics, and furnished accessories indicating control signal, default control signal with loss of power, and electrical power requirements.
2. Product description with complete technical data and product specification sheets.
3. Installation operation and maintenance instructions including factors affecting performance.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 LEAK-DETECTION SWITCHES

A. Point-Type, Leak-Detection Switches:

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

a. Veris Industries.
b. W. E. Anderson; Dwyer Instruments, Inc.

2. Features: Audible and visual alarm with relay output for remote indication.
3. Alarm activated based on change in resistance.
4. Performance:

a. Service: Water.
b. Temperature Limits: 32 to 122 deg F (zero to 50 deg C).
c. Switch Type: SPDT relay.
d. Electric Connection: Cable attached.

5. Construction: Acrylic, ABS plastic.
6. Field Power: 24-V ac or dc.

PART 3 - EXECUTION

3.01 EXAMINATION

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

B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 LEAK-DETECTION INSTRUMENT APPLICATION

A. Condensate Drain Pans: Leak-detection switches (point type). As indicated on Drawings.

B. Equipment Room Floors: Leak-detection switches (cable type). As indicated on Drawings.

3.03 INSTALLATION, GENERAL

A. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

B. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force, or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

C. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.04 CONNECTIONS

A. Comply with requirements in Division 26 for electrical power connections.

3.05 INSTALLATION

A. Mount switches not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

3.06 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Division 26.

3.07 CHECKOUT PROCEDURES

A. Check installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation for applicable considerations that impact performance.

3.08 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. Equipment and procedures used for calibration shall meet instrument manufacturer's written recommendations.
4. Provide diagnostic and test equipment for calibration and adjustment.
5. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
6. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
7. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

C. Switches: Calibrate switches to make or break contact at set points indicated.

3.09 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION

SECTION 250923.19
MOISTURE INSTRUMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes moisture switches, sensors, and transmitters.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Product description with complete technical data, performance curves, and product specification sheets.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: To include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 MOISTURE SENSORS AND TRANSMITTERS

A. Wall-Mounted Humidity Sensors and Transmitters with Digital Display:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Vaisala; HMW90 Series or comparable product by one of the following:

a. MAMAC Systems, Inc.
b. Siemens.

2. Performance:

a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent relative humidity when operating between 60 to 77 deg F.
b. Relative Humidity Range: Zero to 100 percent.
c. Factory calibrated and NIST traceable with certificate included.

3. Construction:

a. Provide housing with integral sensor for room applications.
b. Provide housing with remote sensor probe for ducted applications.

1) Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least 2 inches long for duct-mounted applications.
2) Provide sensor with cable for field installation in conduit.
3) For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.

c. Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless-steel filter for duct applications.
d. Housing shall be ABS/PC plastic or powder-coated aluminum.
e. Housing Classification: NEMA 250, Type 4 or 4X.
f. Provide housing with wall-mounting plate.

4. Output Signal: 2-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24-V dc.
5. Provide unit with a digital display of relative humidity in percent.

B. Duct Mounted Humidity Sensor and Transmitter without Display:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Vaisala; HMD60 Series or comparable product by one of the following:

a. General Eastern Instruments.
b. Siemens.

2. Performance:

a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 3 percent from 90 to 95 percent relative humidity when operating at 68 deg F.
b. Relative Humidity Range:

1) Duct: Zero to 100 percent.
2) Space: Zero to 95 percent relative.

c. Factory calibrated and NIST traceable with certificate included.

3. Construction for Space Applications:

a. Housing with integral sensor.
b. Housing shall be ABS plastic or powder-coated aluminum.

c. Enclosure: NEMA 250, Type 4.
d. Provide housing with a wall-mounting plate.

4. Construction for Duct and Equipment Applications:

a. Housing with integral sensor.
b. Duct Sensor Body: 300 series stainless steel.
c. Provide sensor with sintered stainless-steel filter for duct applications.
d. Housing shall be cast aluminum.
e. Enclosure: NEMA 250, Type 4.

5. Output Signal: Two-wire, 4- to 20-mA output signal with drive capacity of at least 500 ohms at 24-V dc.

PART 3 - EXECUTION

3.01 EXAMINATION

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

B. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 MOISTURE INSTRUMENT APPLICATIONS

A. Space Humidity Applications: Wall-mounted humidity sensor and transmitter with digital display.

B. Duct Humidity Applications: Duct-mounted humidity sensor and transmitter without display.

3.03 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.04 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.05 MOISTURE INSTRUMENTS INSTALLATION

A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and Federal accessibility requirements within a range of 42 to 72 inchesabove the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 48 inches (1.2 m).

3.06 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.07 CHECKOUT PROCEDURES

A. Check installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.08 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.09 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION

SECTION 250923.22
POSITION INSTRUMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes position limit switches for use in direct-digital control systems for HVAC.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include operating characteristics, electrical characteristics, and furnished accessories indicating default control signal with loss of power and electrical power requirements.
2. Include product description with complete technical data and product specification sheets.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring.

PART 2 - PRODUCTS

2.01 POSITION LIMIT SWITCHES

A. Description: Select type of actuating head (plunger, roller lever, or rod) to suit application.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Performance:

1. Life expectancy: Not less than 30 million mechanical operations and 750,000 electrical operations.
2. Operating Frequency: 300 mechanical operations per minute and 30 electrical operations per minute.
3. Voltage: 125-, 250-, 480-, and 600-V ac or 8-, 12-, 14-, 24-, 30-, 48-, 125-, and 250-V dc, as required by application.
4. Current Rating: As required by application.

5. Temperature Rise: 50 deg C.
6. Ambient Temperature: 14 to 175 deg F.
7. Ambient Relative Humidity: 35 to 95 percent.

C. Construction:

1. NEMA 250, Type 4X enclosure.
2. Switch Type: SPDT or DPDT, as required by application.
3. Status indicator integral to switch. Field switchable to light when contacts are actuated and operating, or contacts are free and not operating.
4. Electrical Connection: Screw or plug-in terminals.
5. Conduit Connection: NPS 1/2.

PART 3 - EXECUTION

3.01 EXAMINATION

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

B. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to:

a. Laboratory exhaust airstreams.
b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.03 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Division 26.

C. Furnish and install power wiring. Comply with requirements in Division 26.

D. Furnish and install raceways. Division 26.

3.04 POSITION INSTRUMENTS INSTALLATION

A. Mounting Location:

1. Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, and conduit to final location.
2. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.05 ADJUSTMENT, CALIBRATION, AND TESTING

A. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

B. Switches: Calibrate switches to make or break contact at set points indicated.

END OF SECTION

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SECTION 250923.23
PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure switches.
5. Liquid-pressure transmitters.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.04 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.01 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Dwyer Instruments, Inc ; Model A 301 Series or a comparable product by one of the following:

    a. MAMAC Systems, Inc.
    b. Setra System.
2. Insertion length shall be at 4 inches.
3. Sensor with four radial holes of 0.04-inch diameter.
4. Brass or stainless-steel construction.
5. Sensor with threaded end support, sealing washers and nuts.
6. Connection: NPS 1/4 compression fitting.
7. Suitable for flat oval, rectangular, and round duct configurations.

B. Outdoor Static Pressure Sensor:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Dwyer Instruments, Inc ; Model A420. or a comparable product by one of the following:

    a. MAMAC Systems, Inc.
    b. Setra System.
2. Provides average outdoor pressure signal.
3. Sensor with no moving parts.
4. NEMA 250, Type 4X enclosure.
5. Pressure Connection: Brass barbed fitting for NPS 1/4tubing.
6. Conduit fitting around pressure fitting for sensor support and protection to pressure connection.

C. Space Static Pressure Sensor for Wall Mounting:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Dwyer Instruments, Inc ; Model A420. or a comparable product by one of the following:

    a. MAMAC Systems, Inc.
    b. Setra System.
    c. TSI.
    d. Veris.
2. 100-micron filter mounted in stainless-steel wall plate senses static pressure.
3. Wall plate provided with gasket and screws, and sized to fit standard single-gang electrical box.
4. Back of sensor plate fitted with brass barbed fitting for tubing connection.

2.02 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:
1. Diaphragm operated to actuate an SPDT snap switch.

    a. Fan safety shutdown applications: Switch with manual reset.

2. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
3. Enclosure Conduit Connection: Knock out or threaded connection.
4. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
5. High and Low Process Connections: Threaded, NPS 1/8.
6. Enclosure:

    a. Dry Indoor Installations: NEMA 250, Type 1.
    b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
    c. Hazardous Environments: Explosion proof.

7. Operating Data:

    a. Electrical Rating: 15 A at 120- to 480-V ac.
    b. Pressure Limits:

        1) Continuous: 45 inches wg.
        2) Surge: 10 psig.

    c. Temperature Limits: Minus 30 to 180 deg F.
    d. Operating Range: Approximately 2 times set point.
    e. Repeatability: Within 3 percent.
    f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.03 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Setra System; Model 267. or a comparable product by one of the following:

    a. MAMAC Systems, Inc.
    b. Vaisala.

2. Performance:

    a. Range: Approximately 2 times set point.
    b. Accuracy: Within 1 percent of the full-scale range.
    c. Hysteresis: Within 0.10 percent of full scale.
    d. Repeatability: Within 0.05 percent of full scale.
    e. Stability: Within 1 percent of span per year.
    f. Overpressure: 10 psig.
    g. Temperature Limits: Zero to 150 deg F.
    h. Compensate Temperature Limits: 40 to 150 deg F.
    i. Thermal Effects: 0.033 percent of full scale per degree F.
    j. Shock and vibration shall not harm the transmitter.

3. Output Signals:

    a. Analog Current Signal:

        1) Two-wire, 4- to 20-mA dc current source.
        2) Signal capable of operating into 800-ohm load.

4. Display: Four-digit digital display with minimum 0.4-inch-high numeric characters.
5. Operator Interface: Zero and span adjustments located behind cover.
6. Construction:

    a. Plastic casing with removable plastic cover.
    b. Threaded, NPS 1/4 swivel fittings for connection to copper tubing or NPS 3/16 barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
    c. Screw terminal block for wire connections.
    d. Vertical plane mounting.
    e. NEMA 250, Type 4.
    f. Provide mounting bracket suitable for installation.

2.04 LIQUID-PRESSURE SWITCHES

A. Liquid-Pressure Differential Switch with Set-Point Indicator:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Dwyer Instruments, Inc ; Series DP. or a comparable product by one of the following:

    a. Setra System.
2. Description:

    a. Type 316 stainless-steel double opposing bellows operate to actuate a SPDT snap switch.
    b. Electrical Connections: Screw terminal.
    c. Enclosure Conduit Connection: Knock out or threaded connection.
    d. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
    e. High and Low Process Connections: Threaded, NPS 1/8.
    f. Enclosure:

        1) Dry Indoor Installations: NEMA 250, Type 1.
        2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.

    g. Operating Data:

        1) Electrical Rating: 15 A at 120- to 240-V ac.
        2) Pressure Limits: At least 5 times full-scale range, but not less than system design pressure rating.
        3) Temperature Limits: Minus 10 to 180 deg F.
        4) Operating Range: Approximately 2 times set point.
        5) Deadband: Adjustable or fixed as required by application.

2.05 LIQUID-PRESSURE TRANSMITTERS

A. Liquid-Pressure Differential Sensor and Transmitter:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Setra System ; Model 230. or a comparable product by one of the following:

    a. Ashcroft.
    b. Veris.

2. Performance:

    a. Range: Approximately 2 times the set point.
    b. Span: Adjustable plus or minus one milliamp, noninteractive.
    c. Accuracy: Within 0.25 percent of full scale.
    d. Hysteresis: Within 0.1 percent of full scale.
    e. Repeatability: Within 0.05 percent of full scale.
    f. Maximum Working Pressure: 250 psig.
    g. Temperature Limits: Zero to 175 deg F.
    h. Compensate Temperature Limits: 30 to 150 deg F.
    i. Thermal Effects: 0.02 percent of full scale per degree F.
    j. Response Time: 30 to 50 ms.
    k. Shock and vibration shall not harm the transmitter.

3. Analog Output Current Signal:

    a. Two-wire, 4- to 20-mA dc current source.
    b. Signal capable of operating into 1000-ohm load.

4. Operator Interface:

    a. Zero and span adjustments located behind cover.
    b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.

5. Construction:

    a. Aluminum and stainless-steel enclosure with removable cover.
    b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
    c. Threaded, NPS 1/4 process connections on side of instrument enclosure.
    d. Knock out for 1/2-inch nominal conduit connection on side of instrument enclosure.
    e. Screw terminal block for wire connections.
    f. NEMA 250, Type 4.
    g. Mounting Bracket: Appropriate for installation.

6. Provide transmitter with five-valve manifold. Construct manifold of brass, bronze, or stainless steel. Provide manifold with NPS 1/4 NPT process connections.

2.06 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 PRESSURE INSTRUMENT APPLICATIONS

A. Duct-Mounted Static Pressure Sensors:

1. Duct insertion static pressure sensor.

B. Space Static Pressure Sensors:

1. Space static pressure sensor for wall mounting.

C. Air-Pressure Differential Switches:

1. Air-pressure differential switch.

D. Air-Pressure Differential Transmitters:

1. Duct Applications: Air-pressure differential transmitter.
2. Space and Building Applications: Air-pressure differential transmitter.

E. Liquid Gage Pressure Switches:

1. Liquid gage pressure switch, diaphragm operated, low pressure.

F. Liquid-Pressure Differential Switches:

1. Liquid-pressure differential switch.

G. Liquid-Pressure Differential Sensors and Transmitters:

1. Liquid-pressure differential sensor and transmitter.

3.03 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment.

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.04 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.05 PRESSURE INSTRUMENT INSTALLATION

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
7. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

C. Duct Pressure Sensors:

1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Unless indicated on Drawings, locate sensors approximately 67 percent of distance of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
3. Install mounting hardware and gaskets to make sensor installation airtight.
4. Route tubing from the sensor to transmitter.
5. Use compression fittings at terminations.
6. Install sensor in accordance with manufacturer's instructions.
7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Outdoor Pressure Sensors:

1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
2. Locate wall-mounted sensor in an inconspicuous location.
3. Submit sensor location for approval before installation.
4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

E. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet; otherwise, locate switch in vicinity of system connection.

F. Liquid-Pressure Differential Switches:

1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 1/2. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to switch.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each switch connection.
8. Do not mount switches on rotating equipment.
9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
10. Install switches in an easily accessible location serviceable from floor.

G. Liquid-Pressure Transmitters:

1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 1/2. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each transmitter connection.
8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

3.06 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.07 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.08 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values.

3.09 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

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SECTION 250923.27
TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Air temperature sensors.
2. Air temperature switches.
3. Air temperature RTD transmitters.
4. Liquid temperature sensors.
5. High-end, commercial-grade, liquid and steam temperature sensors.
6. Commercial-grade, liquid and steam temperature transmitters.

1.03 DEFINITIONS

A. RTD: Resistance temperature detector.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

PART 2 - PRODUCTS

2.01 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

    a. Range: Minus 50 to 275 deg F (Minus 46 to 135 deg C).
    b. Interchangeable Accuracy: At 32 deg F (zero deg C) within 0.5 deg F (0.3 deg C).
    c. Repeatability: Within 0.5 deg F (0.3 deg C).
    d. Self-Heating: Negligible.

4. Transmitter Requirements:

    a. Transmitter required for each 100-ohm RTD.
    b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches (450 mm) long.
4. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
5. Gasket for attachment to duct or equipment to seal penetration airtight.
6. Conduit Connection: 1/2-inch (16-mm) trade size.

C. Platinum RTD, Air Temperature Averaging Sensors:

1. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
2. Multiple sensors to provide average temperature across entire length of sensor.
3. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
4. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.
5. Length: As required by application to cover entire cross section of air tunnel. Minimum of 5 ft. (1.5 m) long per 10 sq. ft. (1 sq. m) of cross section.
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch (16-mm) trade size.)

D. Platinum RTD Outdoor Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Solar Shield: Stainless steel.
4. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.

5. Conduit Connection: 1/2-inch (16-mm) trade size.

E. Platinum RTD Space Air Temperature Sensors:

1. Temperature Range: Minus 50 to 212 deg F (Minus 45 to 100 deg C).
2. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
3. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
4. Concealed wiring connection.

F. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:

1. Platinum RTD.
2. Temperature Transmitter Requirements:

   a. Mating transmitter required with each 100-ohm RTD.
   b. Mating transmitters optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

3. Provide digital display of sensed temperature.
4. Provide sensor with local control.

   a. Local override to turn HVAC on.
   b. Local adjustment of temperature set point.
   c. Both features shall be capable of manual override through control system operator.

2.02 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Description:

   a. Two-position control.
   b. Field-adjustable set point.
   c. Manual reset.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:

   a. Operating Temperature Range: 15 to 55 deg F (Minus 9 to 13 deg C).
   b. Temperature Differential: 5 deg F (2.8 deg C), non-adjustable and additive.
   c. Enclosure Ambient Temperature: Minus 20 to 140 deg F (Minus 11 to 60 deg C).
   d. Sensing Element Maximum Temperature: 250 deg F (121 deg C).
   e. Voltage: 120-V ac.
   f. Current: 16 FLA.
   g. Switch Type: Two SPDT snap switches operate on coldest 12-inch (300-mm) section along element length.

3. Construction:

   a. Vapor-Filled Sensing Element: Nominal 20 feet (6 m) long. Minimum of 5 ft. (1.5 m) long per 10 sq. ft. (1 sq. m) of cross section.

b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
c. Set-Point Adjustment: Screw.
d. Enclosure: Painted metal, NEMA 250, Type 1.
e. Electrical Connections: Screw terminals.
f. Conduit Connection: 1/2-inch (16-mm) trade size.

B. Thermostat and Switch for High Temperature Control in Duct Applications:

1. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
2. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Manual reset.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

a. Temperature Range: 100 to 160 deg F (38 to 71 deg C).
b. Temperature Differential: 5 deg F (2.8 deg C).
c. Ambient Temperature: Zero to 260 deg F (Minus 18 to 127 deg C).
d. Voltage: 120-V ac.
e. Current: 16 FLA.
f. Switch Type: SPDT snap switch.

4. Construction:

a. Sensing Element: Helical bimetal.
b. Enclosure: Metal, NEMA 250, Type 1.
c. Electrical Connections: Screw terminals.
d. Conduit Connection: 1/2-inch (16-mm) trade size.

2.03 AIR TEMPERATURE RTD TRANSMITTERS

A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

B. House electronics in NEMA 250 enclosure.

1. Duct: Type 1.
2. Outdoor: Type 4 or Type 4X.
3. Space: Type 1.

C. Conduit Connection: 1/2-inch (16-mm) trade size.)

D. Functional Characteristics:

1. Input:

a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

2. Span (Adjustable):

a. Space: 40 to 90 deg F (4 to 32 deg C).
b. Supply Air: 40 to 120 deg F (4 to 49 deg C).
c. Exhaust Air: 50 to 100 deg F (10 to 38 deg C).
d. Return Air: 50 to 100 deg F (10 to 38 deg C).
e. Mixed Air: Minus 40 to 140 deg F (Minus 40 to 60 deg C).
f. Outdoor: Minus 40 to 140 deg F (Minus 40 to 60 deg C).

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc .
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F (28 deg C).
5. Match sensor with temperature transmitter and factory calibrate together.

E. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

2.04 LIQUID TEMPERATURE SENSORS, COMMERCIAL GRADE

A. RTD:

1. Description:

a. Platinum with a value of 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
b. Encase RTD in a stainless-steel sheath with a 0.25-inch (6-mm) OD.
c. Sensor Length: Minimum insertion length of 2-1/2 inches (64 mm) or as required by application.
d. Process Connection: Threaded, NPS 1/2 (DN 15).
e. Two-stranded copper lead wires.
f. Powder-coated steel enclosure, NEMA 250, Type 4.
g. Conduit Connection: 1/2-inch (16-mm) trade size.)
h. Performance Characteristics:

1) Range: Minus 40 to 210 deg F (Minus 40 to 99 deg C).
2) Interchangeable Accuracy: Within 0.54 deg F (0.3 deg C) at 32 deg F (zero deg C).

B. Thermowells:

1. Stem: Straight or stepped shank formed from solid bar stock.
2. Material: Stainless steel.
3. Process Connection: Threaded, NPS 3/4 (DN 20).
4. Sensor Connection: Threaded, NPS 1/2 (DN 15).
5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
6. Furnish thermowells installed in insulated pipes and equipment with an extended neck.
7. Length: Minimum insertion length of 2-1/2 inches (64 mm) or as required by application.

8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

2.05 LIQUID AND STEAM TEMPERATURE SENSORS, HIGH-END COMMERCIAL GRADE

A. RTD:

1. Resistance temperature sensors shall comply with IEC 60751, Class B requirements.
2. Platinum with a value of 100 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
3. Encase RTD in a Type 316 stainless-steel sheath with a 0.25-inch (8-mm) OD.
4. Provide two-wire, PTFE-insulated, nickel-coated, 22-gage, stranded copper leads.
5. Provide spring-loaded RTDs for thermowell installations.
6. Performance Characteristics:

    a. Range: Minus 328 to 743 deg F (Minus 200 to 395 deg C).
    b. Interchangeable Accuracy: Within 0.54 deg F (0.3 deg C) at 32 deg F (zero deg C).
    c. Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F (400 deg C).
    d. Hysteresis: Within 0.04 percent of range.
    e. Response Time: 62.8 percent of change in 4 seconds with water flowing across sensor at 3 fps (0.9 m/s).

B. Thermowells:

1. Stem: Straight or stepped or tapered shank formed from solid bar stock.
2. Material: Type 316 stainless steel.
3. Process Connection: Threaded, NPS 3/4 (DN 20)
4. Sensor Connection: Threaded, NPS 1/2 (DN 15)
5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
6. Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.
7. Length: As required by application and pipe size.
8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

C. Connection Heads:

1. Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.
2. Terminals: Six or eight as required by sensor.
3. Conduit Connection: 1/2-inch (16-mm) trade size.
4. Sensor Connection: NPS 1/2 (DN 15).

D. Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.

2.06 LIQUID TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE

A. House electronics in NEMA 250, Type 4 or Type 4X enclosure.

B. Enclosure Connection: 1/2-inch (16-mm) trade size.

C. Functional Characteristics:

1. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
2. Default Span (Adjustable):

    a. Chilled Water: Zero to 100 deg F (Minus 18 to 38 deg C).
    b. Heating Hot Water: 32 to 212 deg F (Zero to 100 deg C).

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F (28 deg C).
5. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

D. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.02 TEMPERATURE INSTRUMENT APPLICATIONS

A. Air Temperature Sensors: Platinum RTD.

B. Air Temperature Transmitters: RTD transmitter.

C. Liquid and Steam Temperature Sensors:
1. Chilled-Water System: Commercial grade.
2. Domestic Water System: Commercial grade
3. Heating Hot-Water System: Commercial grade.
4. Steam System: High-end commercial grade.
5. Steam Condensate System: High-end commercial grade.

D. Liquid and Temperature Transmitters: Commercial grade.

3.03 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.04 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Division 26.

C. Furnish and install power wiring. Comply with requirements in Division 26.

D. Furnish and install raceways. Comply with requirements in Division 26.

3.05 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:

1. Roughing In:

a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.

2) Do not begin installation without submittal approval of mounting location.

c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches (1.1 to 1.6 m) above the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 48 inches (1200 mm).

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Temperature Sensor Installation:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.

5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches (610 mm) in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 9 sq. ft. (1.0 sq. m) and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

J. Liquid Temperature Sensor Installation:

1. Assembly shall include sensor, thermowell and connection head.
2. For pipe NPS 4 (DN 100) and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
3. For pipe smaller than NPS 4 (DN 100):

    a. Install reducers to increase pipe size to NPS 4 (DN 100) at point of thermowell installation.

b. For pipe sizes NPS 2-1/2 and NPS 3 (DN 65 and DN 80), thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
c. Minimum insertion depth shall be 2-1/2 inches (65 mm).

4. Install matching thermowell.
5. Fill thermowell with heat-transfer fluid before inserting sensor.
6. Tip of spring-loaded sensors shall contact inside of thermowell.
7. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
8. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
9. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor, service platform, or catwalk.

3.06 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Division 26.

3.07 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.08 CHECK-OUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check temperature instruments for proper location and accessibility.

C. Verify sensing element type and proper material.

D. Verify location and length.

E. Verify that wiring is correct and secure.

3.09 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.10 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform according to manufacturer's written instruction.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Prepare test and inspection reports.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.

END OF SECTION

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