

SECTION 230000 – GENERAL MECHANICAL

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. The work shall include furnishing, installing and testing the equipment and materials specified in other sections of the Mechanical Specifications and shown on the Drawings. It is the intent of these Specifications that the mechanical systems shall be suitable in every way for the intended usage. All material and all work which may be reasonably implied as being incidental to the work of this Division shall be furnished at no extra cost.
- B. Instructions to Bidders, General Conditions of the Contract, Supplementary General Conditions and Division 01 Specifications Sections bound herewith are a component part of Division 23 specifications. Comply with all provisions, details and instructions of these sections in the accomplishment of work covered under Division 23.
- C. Furnish all labor, materials and equipment and incidentals required to make ready for use complete mechanical systems as shown on the Drawings and specified herein.
- D. Where Sub-Contracts are used to perform portions of the work, division of labor between sub trades is the responsibility of the Contractor.
- E. The general scope work includes, but is not limited to, furnishing, coordinating, and installing the following:
  - 1. Heating, air conditioning and ventilation equipment.
  - 2. Ductwork, air distribution.
  - 3. HVAC piping, specialties and equipment.
  - 4. Controls and wiring.
  - 5. Commissioning, testing and balancing.
- F. Visit all areas of the site, buildings and structures (as applicable) in which work under these sections is to be performed. Inspect carefully the existing conditions prior to bidding. Bid submission is evidence that the Contractor has examined the site and existing conditions, understands conditions under which the work will be performed, and takes full responsibility for complete knowledge of all factors governing the work.
- G. Schedule all service interruptions in existing facilities at the Owner's convenience with 24 hours (minimum) notice. Obtain prior approval for each interruption.
- H. Thoroughly test all mechanical systems at the completion of work and make any minor correction changes or adjustments necessary for all the proper functioning of the system and equipment. All workmanship shall be of the highest quality; substandard work will be rejected.

1.2 SUBMITTALS

- A. Procedures for submittals: Submit under provisions of relevant sections of the General and Supplemental General Conditions and Division 1 Specifications Sections.

**Transmit each shop drawing submittal with provided Shop Drawing Submittal Cover Form, attached as Appendix B, for each item of equipment/material or each specification section/paragraph**

- B. Clearly indicate proposed equipment and/or materials substitutions in shop drawings. Summarize all deviations from the specified quality, functionality, appearance or performance of proposed equipment and/or materials in the preface of each submittal. Include documentation to support deviations.
- C. Provide descriptive data on all materials and equipment as required to ascertain compliance with Specifications.
- D. Design layout shown on drawings is based on physical sizes of reputable equipment manufacturers. If equipment other than models indicated is installed, any resulting conflicts with space, maintenance access, clearances or codes are the responsibility of the Contractor to correct at his expense.
- E. Where specific models and manufacturers of materials and equipment are specified, substitutions as allowed by the specifications and State law will be considered. Substitutions must be equivalent in quality, function, suitability and arrangement to specified equipment. Architect/Engineer to have final authority as to equivalency of substitutions.
- F. Equipment model numbers noted in these specifications or on the drawings are intended to establish a minimum standard of quality and do not necessarily relate to specific options or arrangement as shown. Provide equipment with all standard features and optional features as stated and arranged as shown on the drawings.

**1.3 REGULATORY REQUIREMENTS**

- A. Perform Work in accordance with all applicable state and local codes, standards and regulations.
- B. Furnish all materials and labor which is be required for compliance with codes, standards and regulations, whether specifically mentioned in these specifications or shown on the drawings.
- C. Obtain required construction permit from the authority having jurisdiction and arrange, at the proper time, for all inspections required by such authority. Pay all permit and inspection costs required.

**1.4 COORDINATION OF WORK**

- A. Contractor is responsible for coordination of work between trades. Provide fully complete and functional systems.
- B. Compare mechanical drawings and specifications with the drawings and specifications for other trades.
- C. Coordinate mechanical installation with the work of other trades. Report any pertinent discrepancies to the Architect/Engineer and obtain written instructions for any necessary revisions. Before starting any construction, make proper provisions to avoid interferences in a

manner approved by the Architect/Engineer. No extras will be allowed for rework of uncoordinated installations.

- D. Determine exact route and location of each mechanical item prior to fabrication and/or installation. Adjust location of ducts, piping and equipment, etc., to accommodate interferences anticipated and encountered.
- E. Right of Way: General priority for right of way is as follows:
  - 1. Items located per regulatory requirement.
  - 2. Piping with pitch requirement (plumbing drains, etc.).
  - 3. Ductwork.
  - 4. Piping without pitch requirement.
  - 5. Electrical wiring (conduits, etc.).
- F. Arrange all work to permit removal (without damage to other parts) of any equipment requiring periodic replacement.
- G. Provide clearance and easy access to any equipment which requires periodic maintenance. Arrange ducts, piping and equipment to permit ready access to valves, cocks, traps, starters, motors, control components, etc., and to clear the opening of swinging doors and access panels.

#### 1.5 EQUIPMENT AND MATERIALS (GENERAL)

- A. Provide all new materials unless specifically indicated otherwise.
- B. Manufacturers and models listed in drawings and specifications are used for layout and to convey to bidders the general style, type, character and quality of product desired. Listed examples are used only to denote the quality standard of product desired and are not intended to restrict bidders to a specific brand, make, manufacturer or specific name.
- C. Adjust layout, system connections and coordinate with other trades as required to properly install equivalent products.
- D. Where equivalent products are submitted, include all associated costs related to substitution in bid.
- E. Furnish materials bearing the manufacturer's name and trade name. Provide UL label where a UL standard has been established for the particular material.
- F. Furnish standard products of manufacturers regularly engaged in production of equipment types required for the work. Use the manufacturer's latest approved design.
- G. Use the same manufacturer for equipment and materials of the same general type throughout the work to obtain uniform appearance, operation and maintenance.
- H. Protect equipment and materials from dirt, water, chemical or mechanical injury and theft at all times during construction. Provide covers or shelter as required.

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- I. If materials or equipment are damaged at any time prior to final acceptance of the work, repair such damage at no additional cost. If materials or equipment are damaged by water, provide replacement no additional cost.
- J. Follow manufacturer's directions completely in the delivery, storage, protection and installation of all equipment and materials. Notify the Architect/Engineer in writing of any conflicts between any requirements of the contract documents and manufacturer's directions. Obtain written instructions before proceeding with the work. The Contractor is responsible for correction of any work that does not comply with the manufacturer's directions or written instructions from the Architect/Engineer at no additional cost.
- K. Repair any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer. Repaint entire damaged panel or section per the field painting specifications in Division 9 at no additional cost.

### 1.6 PAINTING

- A. Protect sensors, controllers, etc. against painting. Do not install thermostats, devices or trim until painting is complete.

### 1.7 LOCATIONS AND MEASUREMENTS

- A. Location of mechanical work is shown on the drawings as accurately as possible. Field-verify all measurements to ensure that the work suits the surrounding structure, trim, finishes and/or construction. Provide adjustment as necessary.
- B. Make minor relocations of work prior to installation as required or as directed by the Architect/Engineer at no additional cost.

### 1.8 SUPERVISION

- A. Contractor to provide an authorized and competent representative to constantly supervise the work from the beginning to completion and final acceptance. Insofar as possible, keep the same foreman and workmen throughout the project duration.
- B. Representatives of Architect/Engineer, Owner, and local inspection authorities will make inspections during the progress of the work. Contractor to accommodate such inspections and correct deficiencies noted.

### 1.9 QUALITY AND WORKMANSHIP

- A. Contractor to employ skilled tradesmen, laborers and supervisors. Final product to present a neat, well finished, and professional installation.
- B. Remove and replace any work considered substandard quality in the judgment of the Architect/Engineer.

1.10 SEISMIC REQUIREMENTS

- A. Install mechanical work in a manner to be fully compliant with the seismic restraint requirements of the North Carolina State Building Code (NCSBC). The Contractor shall provide any and all seismic restraint details and calculations that may be required by the NCSBC and/or the Authority Having Jurisdiction.
- B. Requirements for restraints are detailed in the NCSBC. All tables and references shall conform to building's location. Restraints shall be per Seismic Performance Category stated on Architectural Drawings.
- C. The Contractor shall retain the services of a Professional Engineer registered in the State of North Carolina to design seismic restraint elements required for this project. The Engineer's calculations, bearing his professional seal, shall accompany shop drawings and shall demonstrate Code compliance including certification that the seismic system components comply with the testing requirements of NCSBC. Calculations and shop drawings shall be submitted for review prior to the purchasing of materials, equipment, systems and assemblies. Internal seismic restraint elements of manufactured equipment shall be certified by a professional engineer retained by the manufacturer. Such certificate applies only to internal elements of the equipment. All equipment anchorage requirements shall be coordinated with the building structure and shall be compatible thereto. All such anchorages shall be subject to the review and approval of the project's structural engineer.
- D. The Professional Engineer retained for seismic restraint calculations shall visit the job site upon completion of the seismic restraint installation to comply with the Special Inspections requirement of the Code. This engineer shall provide written verification of compliance of the installation with the approved seismic submittal. This verification shall be submitted as a Special Inspections Report and shall bear the Engineer's professional seal. Job site inspections by other than this engineer is not acceptable.
- E. Review of the seismic design computations and shop drawings by the Architect/Engineer or his agent shall not relieve the Contractor of his responsibility to comply with the seismic or any other requirements of the North Carolina State Building Code.

1.11 EXCAVATION, TRENCHING AND BACKFILLING

- A. Provide all excavation, trenching and backfilling as required to complete the work under this Division.
- B. Contractor is responsible for investigating conditions prior to excavating and to exercise care during the excavation to avoid any utilities or other objects which may or may not be shown on the drawings.
- C. Excavate so as not to endanger or damage existing utilities and structures. If damage occurs, repair damage to the satisfaction of the Architect/Engineer at no additional cost.
- D. Lay out location of all ditching at grade and obtain approval from the Architect/Engineer prior excavating.
- E. Remove and dispose of all surplus earth from the site.

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- F. Provide suitable backfill materials as required.
- G. Perform excavation, trenching and shoring in accordance with rules and regulations set forth in Article XXI, Bulletin 1 "Trenching" as published in a separate bulletin by the North Carolina Department of Labor, Division of Standards and Inspection Construction Bureau.
- H. Bid excavation work as unclassified with no extra payment for removal of rock, unsuitable soils, etc.

### 1.12 CLOSING IN WORK

- A. Do not cover up or enclose work until it has been inspected, tested and approved by authorities having jurisdiction over the work. Uncover any such work for inspection and/or test at no additional cost. Restore the work to its original condition after inspection and/or test at no additional cost.

### 1.13 CUTTING AND PATCHING

- A. Perform all cutting and patching necessary to install work under this Division.
- B. Perform cutting and patching in professional, workmanlike manner.
- C. Arrange work to minimize cutting and patching.
- D. Do not cut joists, beams, girders, columns or any other structural members without written permission from the Architect/Engineer.
- E. Cut opening only large enough to allow easy installation of piping, wiring or ductwork.
- F. Patching material to match material removed.
- G. Restore patched surface to its original appearance at completion of patching.
- H. Where waterproofed surfaces are patched, maintain integrity of waterproofing.
- I. Remove rubble and excess patching materials from the premises.

### 1.14 INTERPRETATION OF DRAWINGS

- A. Drawings and specifications under this Division are complementary each to the other. Provide any work specified herein and/or indicated on the drawings.
- B. Drawings are diagrammatic and indicate generally the location of fixtures, piping, devices, equipment, etc. Follow drawings as closely as possible, but arrange work to suit the finished surroundings and/or trim.
- C. The words "furnish", "provide", and/or "install" as used in these drawings and specifications are interpreted to include all material and labor necessary to complete the particular item, system, equipment, etc.
- D. Any omissions from either the drawings or specifications are unintentional. Contractor is responsible for notifying the Architect/Engineer of any pertinent omissions before submitting a

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bid. Complete and working systems are required, whether every small item of material is shown and specified or not.

### 1.15 ACCESSIBILITY

- A. Locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Equipment to include, but not be limited to, valves, traps, cleanouts, motors, controllers, and dampers. If required for accessibility, furnish access doors for this purpose. Minor deviations from drawings may be made to allow for better accessibility. Lack of access doors on drawings does not relieve Contractor of responsibility to provide access doors, if needed to properly service equipment.
- B. Coordinate exact locations and size of access panels for each concealed device requiring service.
- C. Access panels: Steel construction with 16 gauge frames and 18 gauge panels, factory primed with rust inhibiting paint, finish paint by Contractor. Provide suitable UL listed doors where installed in rated construction.
- D. Coordinate access panel locations with architectural construction.
- E. Access panels are not required for access to work located above a lift-out "T" bar type ceiling.

### 1.16 ELECTRICAL WORK IN CONNECTION WITH MECHANICAL CONTRACTS

- A. Comply with Division 26. Any required Division 23 electrical work not specifically specified to be furnished by Division 26 Contractor shall be provided by Division 23 Contractor.
- B. All electrical work performed Division 23 shall comply with Division 26 specification requirements.
- C. Coordinate electrical interface of supplied mechanical equipment with electrical system. Division 26 electrical work for mechanical systems is based on values scheduled on mechanical drawings. Division 23 Contractor is responsible for any costs to modify the contracted electrical work to service equipment with electrical characteristics different than those scheduled.

### 1.17 MECHANICAL WORK IN CONNECTION WITH OTHER CONTRACTS

- A. Provide mechanical services as required for items furnished by other contractors or vendors as shown on the Drawings. Actual requirements may vary from Drawings. Coordinate with equipment installed. Make final connections only after approval of the other contractor or vendor, in the contractor's or vendor's presence.

### 1.18 PROJECT RECORD DRAWINGS

- A. As the work progresses, legibly record all field changes on a set of project contract drawings, herein after called the "record drawings."
- B. Record drawings shall accurately show the installed condition of mechanical work.

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PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 230000



SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 COORDINATION

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

2.2 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.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor. .
- B. Efficiency: Energy efficient, complying with NEMA Standard Publication General Specification for Consultants, Industrial and Municipal: NEMA Premium Efficiency Electric Motors (600 Volts or Less).
- C. Service Factor: 1.15.
- D. Multispeed Motors: Separate winding for each speed.

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- 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 324T and larger; rolled steel for motor frame sizes smaller than 324T.

### 2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

### 2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
  - 1. Permanent-split capacitor.
  - 2. Split phase.
  - 3. Capacitor start, inductor run.
  - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.

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

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Equipment supports.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

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

B. Copper Pipe Hangers:

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

## 2.3 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

## 2.4 THERMAL-HANGER SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength.
- C. For Trapeze Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

## 2.5 EQUIPMENT SUPPORTS

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

## 2.6 MISCELLANEOUS MATERIALS

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

# PART 3 - EXECUTION

## 3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
  - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
  - 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

- D. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- E. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- F. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors.
- G. Install lateral bracing with pipe hangers and supports to prevent swaying.
- H. Install building attachments to structural steel. Install additional attachments at concentrated loads and at changes in direction of piping.
- I. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- J. 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.
- K. Insulated Piping:
  - 1. Attach clamps and spacers to piping.
    - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
  - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
  - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

### 3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. 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.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

### 3.3 METAL FABRICATIONS

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

- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
  - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
  - 2. Obtain fusion without undercut or overlap.
  - 3. Remove welding flux immediately.
  - 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

### 3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

### 3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

### 3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.

- H. Use thermal-hanger shield inserts for insulated piping and tubing.
- 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 noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
- J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
  - 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
- K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
  - 2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  - 3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  - 4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
  - 5. C-Clamps (MSS Type 23): For structural shapes.
- L. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - 1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
  - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
  - 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- M. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

END OF SECTION 230529



SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Pipe labels.

1.2 ACTION SUBMITTAL

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 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-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 PIPE LABELS

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

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

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- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings.
  - 1. Lettering Size: At least 1-1/2 inches high.

### PART 3 - EXECUTION

#### 3.1 PREPARATION

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

#### 3.2 EQUIPMENT LABEL INSTALLATION

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

#### 3.3 PIPE LABEL INSTALLATION

- A. Piping Color-Coding: ANSI/ASME A13.1.
- B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
  - 1. Near each valve and control device.
  - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
  - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
  - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
  - 5. Near major equipment items and other points of origination and termination.
  - 6. Spaced at maximum intervals of 50 feet 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.
- C. Pipe Label Color Schedule:
  - 1. Refrigerant Piping: ANSI/ASME A13.1.
  - 2. Condensate Piping: ANSI/ASME A13.1.
  - 3. Steam Piping: ANSI/ASME A13.1.

END OF SECTION 230553

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## SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

### PART 1 - GENERAL

#### 1.1 SUMMARY

##### A. Section Includes:

##### 1. Balancing Air Systems:

##### a. Constant-volume air systems.

#### 1.2 DEFINITIONS

##### A. AABC: Associated Air Balance Council.

##### B. TAB: Testing, adjusting, and balancing.

##### C. TABB: Testing, Adjusting, and Balancing Bureau.

##### D. TAB Specialist: An entity engaged to perform TAB Work.

#### 1.3 INFORMATIONAL SUBMITTALS

##### A. Certified TAB reports.

#### 1.4 QUALITY ASSURANCE

##### A. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

##### B. TAB Report Forms: Use standard TAB contractor's forms approved by Construction Manager.

##### C. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

### PART 2 - PRODUCTS (Not Applicable)

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

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

- B. Examine systems for installed balancing devices. Verify that locations of these balancing devices are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- F. Examine test reports specified in individual system and equipment Sections.
- G. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- H. Examine terminal units and verify that they are accessible and their controls are connected and functioning.
- I. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- J. Examine operating safety interlocks and controls on HVAC equipment.
- K. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

### 3.2 PREPARATION

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

### 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
  2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation."
- C. Mark equipment and balancing devices with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

### 3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- D. 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.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- F. Verify that motor starters are equipped with properly sized thermal protection.
- G. Check dampers for proper position to achieve desired airflow path.
- H. Check for airflow blockages.
- I. Check condensate drains for proper connections and functioning.
- J. Check for proper sealing of air-handling-unit components.
- K. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

### 3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
1. Measure total airflow.
    - a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
  2. Measure fan static pressures as follows to determine actual static pressure:
    - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.

- b. Measure static pressure directly at the fan outlet or through the flexible connection.
    - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
    - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
  3. Measure static pressure across each component that makes up an air-handling unit.
    - a. Report the cleanliness status of filters and the time static pressures are measured.
  4. Measure static pressures entering and leaving other devices under final balanced conditions.
  5. Obtain approval from Construction Manager for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
  6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
  1. Measure airflow of submain and branch ducts.
    - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
  2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
  3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure air outlets and inlets without making adjustments.
  1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
  1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
  2. Adjust patterns of adjustable outlets for proper distribution without drafts.

### 3.6 PROCEDURES FOR MOTORS

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

### 3.7 PROCEDURES FOR CONDENSING UNITS

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

### 3.8 TOLERANCES

- A. Set HVAC system's air flow 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.

### 3.9 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.

### 3.10 FINAL REPORT

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

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1. Field test reports prepared by system and equipment installers.
2. 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. Project name.
3. Project location.
4. Architect's name and address.
5. Engineer's name and address.
6. Contractor's name and address.
7. Report date.
8. Signature of TAB supervisor who certifies the report.
9. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
10. 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.
11. Nomenclature sheets for each item of equipment.
12. Data for terminal units, including manufacturer's name, type, size, and fittings.
13. Notes to explain why certain final data in the body of reports vary from indicated values.
14. Test conditions for fans and pump performance forms including the following:
  - a. Settings for outdoor-, return-, and exhaust-air dampers.
  - b. Conditions of filters.
  - c. Cooling coil, wet- and dry-bulb conditions.
  - d. Fan drive settings including settings and percentage of maximum pitch diameter.
  - e. Other system operating conditions that affect performance.

### 3.11 ADDITIONAL TESTS

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

END OF SECTION 230593



SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating the following duct services:
  - 1. Indoor, concealed supply, return, exhaust and outdoor air.
  - 2. Indoor, exposed supply, return, exhaust and outdoor air.
- B. Related Sections:
  - 1. Section 230719 "HVAC Piping Insulation."

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

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

1.7 SCHEDULING

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor 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. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- D. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 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.
- C. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

## 2.3 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
  - 1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
  - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
  - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
  - 4. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
  - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
  - 2. Service Temperature Range: 0 to 180 deg F.
  - 3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
  - 4. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
  - 1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
  - 2. Service Temperature Range: Minus 50 to plus 220 deg F.
  - 3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
  - 4. Color: White.

## 2.4 SEALANTS

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

## 2.5 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 C 1136, Type II.

## 2.6 TAPES

- A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
  - 1. Width: 3 inches.
  - 2. Thickness: 6.5 mils.
  - 3. Adhesion: 90 ounces force/inch in width.

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

## 2.7 SECUREMENTS

### A. Insulation Pins and Hangers:

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

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
  1. Verify that systems to be insulated have been tested and are free of defects.
  2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

### 3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, 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.
  - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
  - 1. Draw jacket tight and smooth.
  - 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. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

### 3.4 PENETRATIONS

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

### 3.5 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
  - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
  - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
  - 3. Install pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

- b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    - d. Do not overcompress insulation during installation.
    - e. Impale insulation over pins and attach speed washers.
    - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
  - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
  - 5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
  - 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
  - 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- 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 100 percent coverage of duct and plenum surfaces.
  - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
  - 3. Install pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    - d. Do not overcompress insulation during installation.

- e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
- 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
  - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
  - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
- 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
- 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

### 3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
  - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

### 3.7 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
  - 1. Indoor, concealed supply, return, exhaust and outdoor air.
  - 2. Indoor, exposed supply, return, exhaust and outdoor air.
  - 3. Outdoor, exposed supply and return.



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### B. Items Not Insulated:

1. Fibrous-glass ducts.
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.

### 3.8 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

#### A. Concealed supply, return, exhaust and outdoor air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 2 inches thick and 0.75-lb/cu. ft. nominal density.

#### B. Exposed supply, return, exhaust and outdoor air duct insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density.

END OF SECTION 230713

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## SECTION 230719 - HVAC PIPING INSULATION

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Refrigerant suction and hot-gas piping.
2. Condensate piping.

B. Related Sections:

1. Section 230713 "Duct Insulation."

#### 1.2 ACTION SUBMITTALS

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

#### 1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

#### 1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing 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.

### PART 2 - PRODUCTS

#### 2.1 INSULATION MATERIALS

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

B. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials. Must be plenum-rated.

#### 2.2 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.

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- B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- C. PVC Jacket Adhesive: Compatible with PVC jacket.

### 2.3 SEALANTS

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

#### B. PVC Jacket Flashing Sealants:

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

### 2.4 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
  - 1. Adhesive: As recommended by jacket material manufacturer.
  - 2. Color: White.
  - 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
    - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

### 2.5 TAPES

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

## PART 3 - EXECUTION

### 3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

### 3.2 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
  - 1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- D. 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."

### 3.3 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturers 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 manufacturers 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.

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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.

### 3.4 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturers 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.

### 3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

### 3.6 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.

### 3.7 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate Piping: Insulation shall be the following:
  1. Flexible Elastomeric: 1/2 inch thick.
- B. Refrigerant Suction and Hot-Gas Tubing/Piping: Flexible elastomeric, 1-1/2 inch thick.

### 3.8 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Refrigerant Suction and Hot-Gas Piping: Flexible Elastomeric: 2 inches thick.

### 3.9 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. Refrigerant Piping, Exposed:
  1. PVC: 30 mils thick.

END OF SECTION 230719

SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
  - 1. DDC system for monitoring and controlling of HVAC systems.
  - 2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

1.3 PRE-INSTALLATION MEETINGS

- A. Pre-installation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product include the following:
  - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
  - 3. Product description with complete technical data, performance curves, and product specification sheets.
  - 4. Installation, operation and maintenance instructions including factors effecting performance.
  - 5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
    - a. Routers.
    - b. DDC controllers.
    - c. Enclosures.
    - d. Electrical power devices.
    - e. Accessories.
    - f. Instruments.
    - g. Control dampers and actuators.
    - h. Control valves and actuators.
  - 6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.

7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. Shop Drawings:

1. General Requirements:
  - a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
  - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
2. Include plans, elevations, sections, and mounting details where applicable.
3. Include details of product assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
4. Plan Drawings indicating the following:
  - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
  - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
  - c. Each 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.
5. Schematic drawings for each controlled HVAC system indicating the following:
  - a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
  - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
  - c. A graphic showing location of control I/O in proper relationship to HVAC system.
  - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
  - e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
  - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
  - g. Narrative sequence of operation.
  - h. Graphic sequence of operation, showing all inputs and output logical blocks.
6. Control panel drawings indicating the following:
  - a. Panel dimensions, materials, size.

- b. Front elevation.
7. 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. Indicate raceway type and size for each.
  - d. Each network port for connection of an operator interface with unique identification for each.
8. 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, and DC power supplies 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.
9. 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.
10. Color graphics indicating the following:
- a. Itemized list of color graphic displays to be provided.
  - b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
  - c. Intended operator access between related hierarchical display screens.
- C. System Description:
- 1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, controller types and applications, routers and other network devices, and power supplies.
  - 2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
  - 3. System and product operation under each potential failure condition including, but not limited to, the following:
    - a. Loss of power.
    - b. Loss of network communication signal.
    - c. Loss of controller signals to inputs and outputs.
    - d. Network failure
    - e. Controller failure.
    - f. Instrument failure.



- g. Control damper and valve actuator failure.
  - 4. Complete bibliography of documentation and media to be delivered to Owner.
  - 5. Description of testing plans and procedures.
  - 6. Description of Owner training.
- D. 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 and design calculations for control dampers and actuators.
    - a. Flow at Project design and minimum flow conditions.
    - b. Face velocity at Project design and minimum airflow conditions.
    - c. Pressure drop across damper at Project design and minimum airflow conditions.
    - d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
    - e. Maximum close-off pressure.
    - f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
    - g. Torque required at worst case condition for sizing actuator.
    - h. Actuator selection indicating torque provided.
    - i. Actuator signal to control damper (on, close or modulate).
    - j. Actuator position on loss of power.
    - k. 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. Leakage flow at maximum system pressure differential.
    - g. Torque required at worst case condition for sizing actuator.
    - h. Actuator selection indicating torque provided.
    - i. Actuator signal to control damper (on, close or modulate).
    - j. Actuator position on loss of power.
    - k. 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.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Field quality-control reports.
- C. Sample Warranty: For manufacturer's warranty.

#### 1.6 CLOSEOUT SUBMITTALS

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

##### 1. 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, 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.

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- o. Owner training materials.

### 1.7 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.
- B. Include product manufacturers' recommended parts lists for proper product operation over four-year period following warranty period. Parts list shall be indicated for each year.

### 1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

## PART 2 - PRODUCTS

### 2.1 TRANE TRACER SC BUILDING AUTOMATION SYSTEM

- A. The controls contractor shall provide a complete building DDC control system to comply with the following specification. Basis of design is Trane tracer SC system. Provide a global control system that can communicate with all HVAC equipment. The system shall be viewable and editable from a computer using internet web browser communicating either directly or remotely with the bas main control panel. The control system shall be provided by the HVAC equipment manufacturer
- B. General System Requirements:
  - 1. Direct digital control (DDC) technology shall be used to provide the functions necessary for control of all mechanical systems.
  - 2. The control system shall be designed such that in the event of a network communication failure, or the loss of any other controller, the control system shall continue to independently operate under control.
  - 3. Owner shall provide wan/LAN connection to the building automation system for remote access.
  - 4. Unit level controllers shall use BACnet MS/TP protocol. Controllers shall be BACnet BTL certified.
  - 5. The system must be provided, installed, wired, and programed by the equipment manufacturer's local factory office. Bids by wholesalers, contractors, franchised dealers, or any other firm whose principle business is not that of manufacturing and installing HVAC equipment and building automation systems is not acceptable.
  - 6. Provide one year parts and labor warranty of the bas.
  - 7. Provide 8 hours of owner's training at jobsite on the building automation system operation.
- C. The system shall have the following functions:
  - 1. Time of day scheduling including optimal start/stop, holiday, and exception schedules.
  - 2. Timed override based on duration limit or fixed until released.
  - 3. Data logging and trending.

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4. User security level assignment.
  5. System and alarms reports.
  6. Floor plans, system, equipment graphics with dynamic data display.
  7. Alarm e-mail routing.
  8. Global navigation icons to manage alarms, user credentials, help functions.
  9. Support a minimum of 5 concurrent users.
  10. BACnet unit level controllers shall be BTL certified.
- D. The system shall have the following programming standard applications:
1. Static pressure setpoint optimization as defined by ASHRAE 90.1-2010.
  2. Demand control ventilation optimization as defined by ASHRAE 62.1-2004.
  3. Free downloadable mobile device apps.
- E. Installation requirements:
1. Install all exposed wiring or in mechanical room in conduit.
  2. Where class 2 wires are in concealed and accessible locations, including above lay-in ceiling space, approved plenum rated cables not in raceway may be used.
- F. Graphics:
1. The following graphics shall be provided thru the DDC control system.
    - a. Building floor plans with pressure sensors indicated.
    - b. Packaged units.
    - c. Electric duct heaters.
    - d. Exhaust fans.
    - e. Humidifier.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
1. Verify compatibility with and suitability of substrates.
- B. Examine roughing-in for products to verify actual locations of connections before installation.
1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
  2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

### 3.2 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:
  - a. Self-contained steam humidifiers specified in Section 238413.29 "Self-Contained Steam Humidifiers."
  - b. Packaged units specified in Section 237416.13 "Packaged, Large-Capacity, Rooftop Air-Conditioning Units."

### 3.3 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, wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a force.
- 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. 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.
- I. 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.

### 3.4 ROUTER INSTALLATION

- A. Install routers if required for DDC system communication interface requirements indicated.

1. Install router(s) required to suit requirements.
- B. Test router to verify that communication interface functions properly.

### 3.5 CONTROLLER INSTALLATION

- A. Install controllers in enclosures to comply with indicated requirements.
- B. Connect controllers to field power supply.
- 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.

### 3.6 ENCLOSURES INSTALLATION

- A. Install the following items in enclosures, to comply with indicated requirements:
  1. Routers.
  2. Controllers.
  3. Electrical power devices.
  4. Relays.
  5. Accessories.
  6. Instruments.
- B. Attach wall-mounted enclosures to wall using the following types of steel struts:
  1. For NEMA 250, Type 1 Enclosures: Use galvanized-steel strut and hardware.

2. For NEMA 250, Type 4X Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
  3. Install plastic caps on exposed cut edges of strut.
- C. Align top or bottom of adjacent enclosures.
- D. Install floor-mounted enclosures located on concrete housekeeping pads. Attach enclosure legs using galvanized- or stainless-steel anchors.
- E. 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.

### 3.7 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.

### 3.8 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.
- B. Install self-adhesive labels, laminated acrylic or melamine plastic signs with unique identification on face for each of the following:
1. Router.
  2. DDC controller.
  3. Enclosure.
  4. Electrical power device.
  5. Accessory.
- C. Install unique instrument identification on face of each instrument connected to a DDC controller.
- D. Install 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.

### 3.9 NETWORK INSTALLATION

- A. Install balanced twisted pair cable when connecting between the following network devices located in same building:
  - 1. Network controllers.
- B. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:
  - 1. Network controllers or programmable application controllers.
  - 2. Routers.
  - 3. Routers and network controllers or programmable application controllers.
  - 4. Network controllers and programmable application controllers.
  - 5. Programmable application controllers.
  - 6. Programmable application controllers and application-specific controllers.
  - 7. Application-specific controllers.
- C. Install cable in continuous raceway.
  - 1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit. Low voltage wire without conduit can be installed in areas that are concealed and accessible.

### 3.10 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 or tables 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.

### 3.11 PIPING AND TUBING INSTALLATION

#### A. Above-Grade Pneumatic and 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 and concealed in walls and connecting wall-mounted instruments with recessed connections.
  - b. Install copper tubing for sizes up through NPS 1 and install galvanized-steel pipe for larger sizes, except as follows:
    - 1) Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing where exposed to view.
    - 2) Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when concealed behind accessible ceilings and concealed in walls and connecting wall-mounted instruments with recessed connections.
  - c. Install copper tubing, unless other accessible materials are indicated, for pneumatic main and control signals to instruments including, but not limited to, the following:
    - 1) Pneumatic actuators.
    - 2) I/P transducers.
    - 3) Sensors.
    - 4) Switches.
    - 5) Transmitters.
  - d. 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.
  - e. Install drawn-temper copper tubing, except within 36 inches of device terminations tubing shall be annealed-tempered copper tubing.
  - f. Install compression fittings to connect copper tubing to instruments, control devices, and accessories.
  - g. Install barbed or compression 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 76 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. Install a dirt leg with an isolation valve and threaded plug at each main air, connection to a panel, pneumatic pilot positioner and PRV station.
  - c. Make threaded joints for connecting to instrument equipment with connectors with a compression tubing connector on one end and threaded connection on other end.
  - d. Make tubing bends with a tube-bending tool. Hard bends, wrinkled or flattened bends are unacceptable.
  - e. Install tube fittings according to manufacturer's written instructions.
  - f. Do not make tubing connections to a fitting before completing makeup of the connection.
  - g. 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.
  - h. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
  - i. Check tubing for correct diameter and wall thickness.
  - j. Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.
  - k. Thread pipe on a threading machine. Ream inner edges of pipe ends, file and grind to remove burrs.

- l. Wrap pipe threads of fittings on pneumatic lines with a single wrap of PTFE tape.
  - m. 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. Every 50 feet of straight run.
  2. At least once for each branch within 36 inches of main tee.
  3. At each change in direction.
  4. Within 36 inches of each ceiling, floor, roof and wall penetration.
  5. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.
  6. At each valve.
  7. 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.
- C. Isolation Valves Installation:
1. Install valves full size of piping and tubing.
  2. Install at the following locations:
    - a. At each branch.
    - b. Before and after each PRV.
    - c. Before and after each air dryer.
    - d. At each control device.
  3. Valves shall be located to be readily accessible from floor.
- D. Process Tubing Installation:
1. Install process tubing for signal to instruments in liquid and steam systems. Instruments include, but are not limited to, the following:
    - a. Meters.
    - b. Sensors.
    - c. Switches.
    - d. Transmitters.
  2. Support tubing according to MSS SP-69, Table 3, but at intervals no less than 60 inches.
  3. Install NPS 1/2 process tubing for industrial-grade sensors, transmitters, and switches. Install stainless-steel bushings where required.
  4. Make tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.
  5. Support tubing independent of other trades.
  6. Route tubing parallel to and at right angles to building construction.
  7. Install tubing concealed in areas with ceilings.
  8. Install a dirt leg with an isolation valve and threaded plug in drain valve at each connection to a transmitter and switch.

9. Insulate process piping connected to hot water and steam systems for personnel protection if the surface temperature exceeds 120 deg F. Only insulate piping within maintenance personnel reach from floor, platform, or catwalk.
10. Wrap pipe threads of fitting in process tubing with service temperatures below 350 deg F with a single wrap of PTFE tape.
11. Coat pipe threads of fittings on process tubing in services with temperatures exceeding 350 deg F with pipe compound before being made up to reduce the possibility of galling.
12. Do not make tubing connections to a fitting before completing makeup of the connection.
13. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.
14. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
15. Align tubing with fitting when installed. Avoid springing tube into position.
16. Install tubing with extreme care exercised to keep foreign matter out of system. Open tubing ends shall be kept plugged to keep out dust, dirt and moisture.
17. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.
18. Protect exposed tubing in mechanical equipment rooms from inadvertent mechanical damage within 76 inches above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.

E. Isolation Valves Installation:

1. Install valves full size of piping and tubing.
2. Install isolation valves at the following locations:
  - a. Process connection.
  - b. Inlet to each instrument including, sensors, transmitters, switches, gages, and other control devices.
3. Locate valves to be readily accessible from floor.

3.12 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. 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.
2. 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.

3. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
4. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
5. Use shielded cable to transmitters.
6. Use shielded cable to temperature sensors.
7. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section "260533 "Conduit" for control-voltage conductors.
2. Comply with Section 270510 "Telecommunications Pathways" for balanced twisted pair cabling installation.
3. Plenum cable without conduit is acceptable if concealed and accessible.

3.13 FIELD QUALITY CONTROL

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

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

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 Pneumatic and 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 Results: Record test results and submit copy of test results for Project record.

### 3.14 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. For pneumatic products, verify that air supply for each product is properly installed.
- F. Control Damper Checkout:
  1. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
  2. Verify that control dampers are installed correctly for flow direction.
  3. Verify that proper blade alignment, either parallel or opposed, has been provided.
  4. Verify that damper frame attachment is properly secured and sealed.
  5. Verify that damper actuator and linkage attachment is secure.
  6. Verify that actuator wiring is complete, enclosed and connected to correct power source.
  7. Verify that damper blade travel is unobstructed.
- G. Control Valve Checkout:
  1. For pneumatic valves, verify that pressure gages are provided in each air line to valve actuator and positioner.
  2. Verify that control valves are installed correctly for flow direction.
  3. Verify that valve body attachment is properly secured and sealed.
  4. Verify that valve actuator and linkage attachment is secure.
  5. Verify that actuator wiring is complete, enclosed and connected to correct power source.

6. Verify that valve ball, disc or plug travel is unobstructed.
7. 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.

H. 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.

3.15 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.

3.16 FINAL REVIEW

A. Submit written request to Architect 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 Architect 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 more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.
- E. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article 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.

3.17 EXTENDED OPERATION TEST

- A. Prepare test and inspection reports.

3.18 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 eight hours of training total.
- C. Training Schedule:
  - 1. Schedule training with Owner 20 business days before expected Substantial Completion.
  - 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.

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 hard copy of all training materials and visual presentations.

F. Instructor Requirements:

1. One or multiple qualified instructors, as required, to provide training.
2. Instructors shall have not less than five years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

G. Organization of Training Sessions:

1. Organize training into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
  - a. Daily operators.
  - b. Advanced operators.
  - c. System managers and administrators.
2. Plan and organize training 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.

H. Training Outline:

1. Submit training outline for Owner review at least 10 business day before scheduling training.
2. Outline shall include a detailed agenda and synopses for each lesson planned.

I. On-Site Training:

1. Instructor shall provide training materials, projector and other audiovisual equipment used in training.

2. 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.

J. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
5. Logging on and off system.
6. Accessing graphics, reports and alarms.
7. Adjusting and changing set points and time schedules.
8. Recognizing DDC system malfunctions.
9. Understanding content of operation and maintenance manuals including control drawings.
10. Understanding physical location and placement of DDC controllers and I/O hardware.
11. Accessing data from DDC controllers.
12. Operating portable operator workstations.
13. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
14. Running each specified report and log.
15. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
16. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
17. Executing digital and analog commands in graphic mode.
18. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
19. Demonstrating DDC system performance through trend logs and command tracing.
20. Demonstrating scan, update, and alarm responsiveness.
21. Demonstrating spreadsheet and curve plot software, and its integration with database.
22. Demonstrating on-line user guide, and help function and mail facility.
23. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
24. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
  - a. Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.
  - b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers.
  - c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.

- d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
- e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
- f. Each control loop responds to set point adjustment and stabilizes within time period indicated.
- g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

K. Training Content for System Managers and Administrators:

- 1. DDC system software maintenance and backups.
- 2. Uploading, downloading and off-line archiving of all DDC system software and databases.
- 3. Interface with Project-specific, third-party operator software.
- 4. Understanding password and security procedures.
- 5. Adding new operators and making modifications to existing operators.
- 6. Operator password assignments and modification.
- 7. Operator authority assignment and modification.

END OF SECTION 230923

# WILMINGTON EYE SURGERY CENTER

## SECTION 232213 - STEAM AND CONDENSATE HEATING PIPING

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes pipe and fittings for LP steam and condensate piping:
  - 1. Steel pipe and fittings.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
  - 1. Steel pipe and fitting.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the minimum working pressures as defined by humidifier manufacturer.

#### 2.2 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.
- C. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

### PART 3 - EXECUTION

#### 3.1 LP STEAM PIPING APPLICATIONS

- A. LP Steam Piping: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

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- B. Condensate piping above grade: Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

### 3.2 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.

### 3.3 PIPING INSTALLATION

- 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.

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- O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.
- P. Install unions in piping adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- Q. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

### 3.4 HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers and supports. Comply with requirements below for maximum spacing.

### 3.5 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.

### 3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

### 3.7 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. Testing Agency: Engage a qualified testing agency to perform tests and inspections.



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- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
  - 2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
  - 3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
- E. Prepare test and inspection reports.

END OF SECTION 232213

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## SECTION 232300 - REFRIGERANT PIPING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

#### 1.2 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A:

- 1. Suction Lines: 535 psig.
- 2. Hot-Gas and Liquid Lines: 535 psig.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.
- B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
  - 1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual 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.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

#### 1.6 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

#### 1.7 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

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### PART 2 - PRODUCTS

#### 2.1 COPPER TUBE AND FITTINGS

- A. Provide as recommended by equipment by manufacturer.

#### 2.2 VALVES AND SPECIALTIES

- A. Provide as recommended by equipment by manufacturer.

#### 2.3 REFRIGERANTS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

### PART 3 - EXECUTION

#### 3.1 PIPING APPLICATIONS

- A. Provide as recommended by equipment by manufacturer.

#### 3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Provide as recommended by equipment by manufacturer.

#### 3.3 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.

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- 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 rigid or flexible conduit in locations where exposed to mechanical injury.
  - L. 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. Install traps and double risers to entrain oil in vertical runs.
    - 4. Liquid lines may be installed level.
  - M. 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.
  - N. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
  - O. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."
  - P. Install sleeves for piping penetrations of walls, ceilings, and floors.
  - Q. Install sleeve seals for piping penetrations of concrete walls and slabs.
  - R. Install escutcheons for piping penetrations of walls, ceilings, and floors.
- 3.4 PIPE JOINT CONSTRUCTION

- A. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- B. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
  - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

### 3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
  - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.

2. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

### 3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections as recommended by equipment manufacturer and prepare test reports.
- B. Tests and Inspections:
  1. Comply with ASME B31.5, Chapter VI.
  2. Test refrigerant piping and specialties. 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 Part 1 "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. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    - c. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

### 3.7 SYSTEM CHARGING

- A. Charge system as recommended by equipment manufacturer.

END OF SECTION 232300

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## SECTION 233113 - METAL DUCTS

### PART 1 - GENERAL

#### 1.1 SUMMARY

##### A. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

##### B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, duct-mounting access doors, turning vanes, and flexible ducts.

#### 1.2 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 performance requirements and design criteria indicated in "Duct Schedule" Article.

#### 1.3 ACTION SUBMITTALS

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

##### B. Shop Drawings:

1. Hangers and supports, including methods for duct and building attachment and vibration isolation.

##### C. 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.

#### 1.4 QUALITY ASSURANCE

- ##### A. Welding Qualifications:
- Qualify procedures and personnel according to AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

- ##### B. Welding Qualifications:
- Qualify procedures and personnel according to the following:

1. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

## PART 2 - PRODUCTS

### 2.1 RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

### 2.2 ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Fabricate round ducts larger Than 90 inches in diameter with butt-welded longitudinal seams.

- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

## 2.3 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - 1. Galvanized Coating Designation: G90.
  - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; galvanized.

## 2.4 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
  - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
  - 2. Tape Width: 4 inches.
  - 3. Sealant: Modified styrene acrylic.
  - 4. Water resistant.
  - 5. Mold and mildew resistant.
  - 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  - 7. Service: Indoor and outdoor.
  - 8. Service Temperature: Minus 40 to plus 200 deg F.
  - 9. Substrate: Compatible with galvanized sheet steel .
- C. Flanged Joint Sealant: Comply with ASTM C 920.
  - 1. General: Single-component, acid-curing, silicone, elastomeric.



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2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

### D. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-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.

## 2.5 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. 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."
- C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- F. Trapeze and Riser Supports:
  1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

## PART 3 - EXECUTION

### 3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.

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- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. 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.
- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

### 3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

### 3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

- B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 12 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.

### 3.4 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
  - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  - 2. Unconditioned Space, Supply-Air Ducts: Seal Class B.
  - 3. Unconditioned Space, Exhaust Ducts: Seal Class C.
  - 4. Unconditioned Space, Return-Air Ducts: Seal Class B.
  - 5. Conditioned Space, Supply-Air Ducts: Seal Class C.
  - 6. Conditioned Space, Exhaust Ducts: Seal Class B.
  - 7. Conditioned Space, Return-Air Ducts: Seal Class C.

### 3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - 1. Where practical, install concrete inserts before placing concrete.
  - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
  - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- 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.

3.6 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.

3.7 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.

3.8 START UP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel unless indicated otherwise.
- B. Supply Ducts:
  - 1. Ducts Connected to Constant-Volume Air-Handling Units:
    - a. Pressure Class: Positive 2-inch wg.
    - b. Minimum SMACNA Seal Class: B.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- C. Return Ducts:
  - 1. Ducts Connected to Air-Handling Units:
    - a. Pressure Class: Positive or negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: B.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- D. Exhaust Ducts:
  - 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
    - a. Pressure Class: Negative 1-inch wg.
    - b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
    - c. SMACNA Leakage Class for Rectangular: 24.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
  - 2. Ducts Connected to Air-Handling Units:
    - a. Pressure Class: Negative 1-inch wg.

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- b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
  - c. SMACNA Leakage Class for Rectangular: 24.
  - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- E. Outdoor-Air Ducts:
  - 1. Ducts Connected to Air-Handling Units:
    - a. Pressure Class: Positive or negative 2-inch wg.
    - b. Minimum SMACNA Seal Class: B.
    - c. SMACNA Leakage Class for Rectangular: 12.
    - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- F. Intermediate Reinforcement:
  - 1. Galvanized-Steel Ducts: Galvanized steel.
  - 2. Stainless-Steel Ducts:
    - a. Exposed to Airstream: Match duct material.
    - b. Not Exposed to Airstream: Match duct material.
- G. Elbow Configuration:
  - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
    - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
    - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
    - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
  - 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
    - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      - 4) Radius-to Diameter Ratio: 1.5.
    - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

- c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
  - a. Rectangular Main to Rectangular Branch: 45-degree entry.
  - b. Rectangular Main to Round Branch: Spin in.
2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
  - a. Velocity 1000 fpm or Lower: 90-degree tap.
  - b. Velocity 1000 to 1500 fpm: Conical tap.
  - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

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## SECTION 233300 - AIR DUCT ACCESSORIES

### PART 1 - GENERAL

#### 1.1 SUMMARY

##### A. Section Includes:

1. Manual volume dampers.
2. Fire dampers.
3. Combination fire and smoke dampers.
4. Flange connectors.
5. Turning vanes.
6. Duct-mounted access doors.
7. Flexible connectors.
8. Flexible ducts.
9. Duct accessory hardware.

##### B. Related Requirements:

1. Section 28 Fire Alarm specification.

#### 1.2 ACTION SUBMITTALS

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

#### 1.3 CLOSEOUT SUBMITTALS

- ##### A. Operation and maintenance data.

### PART 2 - PRODUCTS

#### 2.1 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.

#### 2.2 MATERIALS

- ##### A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation: G90.
  2. Exposed-Surface Finish: Mill phosphatized.

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- B. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

### 2.3 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
  - 1. Standard leakage rating, with linkage outside airstream.
  - 2. Suitable for horizontal or vertical applications.
  - 3. Frames:
    - a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel.
    - b. Mitered and welded corners.
    - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
  - 4. Blades:
    - a. Multiple or single blade.
    - b. Parallel- or opposed-blade design.
    - c. Stiffen damper blades for stability.
    - d. Galvanized-steel, 0.064 inch thick.
  - 5. Blade Axles: Galvanized steel.
  - 6. Bearings:
    - a. Molded synthetic.
    - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
  - 7. Tie Bars and Brackets: Galvanized steel.
- B. Damper Hardware:
  - 1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
  - 2. Include center hole to suit damper operating-rod size.
  - 3. Include elevated platform for insulated duct mounting.

### 2.4 COMBINATION FIRE AND SMOKE DAMPERS

- A. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
- B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- C. Fire Rating: 1-1/2 hours.
- D. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel, with interlocking, gusseted or mechanically attached corners and mounting flange.
- E. Heat-Responsive Device: Electric resettable device and switch package, factory installed, rated.
- F. Smoke Detector: Integral, factory wired for single-point connection.



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- G. Blades: Roll-formed, horizontal, interlocking, galvanized sheet steel.
- H. Leakage: Class I.
- I. Rated pressure and velocity to exceed design airflow conditions.
- J. Mounting Sleeve: Factory-installed, 0.039-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.
- K. Damper Motors: Two-position action.
- L. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections.
  - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
  - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
  - 5. Electrical Connection: 115 V, single phase, 60 Hz.

### 2.5 FIRE DAMPERS

- A. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- C. Fire Rating: 1-1/2 hours.
- D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
  - 1. Minimum Thickness: 0.138 inch thick and of length to suit application.
  - 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- F. Mounting Orientation: Vertical or horizontal as indicated.
- G. Blades: Roll-formed, interlocking, 0.024-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

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- I. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

### 2.6 FLANGE CONNECTORS

- A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- B. Material: Galvanized steel.
- C. Gage and Shape: Match connecting ductwork.

### 2.7 TURNING VANES

- A. Manufactured Turning Vanes for Metal Ducts: 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. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- D. Vane Construction: Single wall.

### 2.8 DUCT-MOUNTED ACCESS DOORS

- A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
  1. Door:
    - a. Double wall, rectangular.
    - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
    - c. Vision panel.
    - d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
    - e. Fabricate doors airtight and suitable for duct pressure class.
  2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
  3. Number of Hinges and Locks:
    - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
    - b. Access Doors up to 18 Inches Square: Continuous and two sash locks.

### 2.9 FLEXIBLE CONNECTORS

- A. Materials: Flame-retardant or noncombustible fabrics.

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- B. Coatings and Adhesives: Comply with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.
- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
  - 1. Minimum Weight: 26 oz./sq. yd.
  - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
  - 3. Service Temperature: Minus 40 to plus 200 deg F.

### 2.10 FLEXIBLE DUCTS

- A. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or 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 20 to plus 210 deg F.
  - 4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

### 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.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," 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 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.
- D. Set dampers to fully open position before testing, adjusting, and balancing.

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- E. Install test holes at fan inlets and outlets and elsewhere as indicated.
- F. Install fire and smoke dampers according to UL listing.
- G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
  - 1. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
  - 2. Control devices requiring inspection.
  - 3. Elsewhere as indicated.
- H. Install access doors with swing against duct static pressure.
- I. Access Door Sizes:
  - 1. One-Hand or Inspection Access: 8 by 5 inches.
  - 2. Two-Hand Access: 12 by 6 inches.
  - 3. Head and Hand Access: 18 by 10 inches.
- J. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- K. Install flexible connectors to connect ducts to equipment.
- L. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- M. Connect diffusers to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- N. Install duct test holes where required for testing and balancing purposes.

### 3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
  - 1. Operate dampers to verify full range of movement.
  - 2. Inspect locations of access doors and verify that purpose of access door can be performed.
  - 3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
  - 4. Inspect turning vanes for proper and secure installation.

END OF SECTION 233300

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Centrifugal roof ventilators.
2. In-line centrifugal fans.

1.2 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on sea level.
- B. Operating Limits: Classify according to AMCA 99.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
1. Certified fan performance curves with system operating conditions indicated.
  2. Certified fan sound-power ratings.
  3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
  4. Material thickness and finishes, including color charts.
  5. Dampers, including housings, linkages, and operators.
  6. Roof curbs.
  7. Fan speed controllers.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

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

### 1.8 COORDINATION

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

## PART 2 - PRODUCTS

### 2.1 CENTRIFUGAL ROOF VENTILATORS

- A. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
  - 1. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- B. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- C. 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.
  - 4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
  - 5. Fan and motor isolated from exhaust airstream.
- D. Accessories:
  - 1. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
  - 2. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
- E. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
  - 1. Configuration: Built-in cant and mounting flange.
  - 2. Overall Height: 12 inches above finished roof level.
  - 3. Metal Liner: Galvanized steel.
- F. Capacities and Characteristics:
  - 1. Refer to schedule on design drawings.

2.2 IN-LINE CENTRIFUGAL FANS

- A. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- B. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- C. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- E. Accessories:
  - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
  - 2. Companion Flanges: For inlet and outlet duct connections.
  - 3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
  - 4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
- F. Capacities and Characteristics:
  - 1. Refer to schedule on design drawings.

2.3 MOTORS

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

2.4 SOURCE QUALITY CONTROL

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

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### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:
  - 1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Secure roof-mounted fans to roof curbs with stainless steel hardware.
- D. Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 1 inch. Vibration-control devices are specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Install units with clearances for service and maintenance.
- F. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

#### 3.2 CONNECTIONS

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

#### 3.3 FIELD QUALITY CONTROL

- A. 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.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Prepare test and inspection reports.

#### 3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation. Adjust belt tension.



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- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- C. Replace fan and motor pulleys as required to achieve design airflow. Lubricate bearings.

END OF SECTION 233423

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## SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

### PART 1 - GENERAL

#### 1.1 SUMMARY

##### A. Section Includes:

1. Diffusers, registers, and grilles.

##### B. Related Sections:

1. Section 089000 "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

#### 1.2 ACTION SUBMITTALS

##### A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

### PART 2 - PRODUCTS

#### 2.1 DIFFUSERS, REGISTERS, AND GRILLES

- ##### A. Refer to schedule on design drawings for further information.

#### 2.2 SOURCE QUALITY CONTROL

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

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- ##### A. Install diffusers, registers, and grilles level and plumb.
- ##### B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as 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.

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- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

### 3.2 ADJUSTING

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

END OF SECTION 233713

SECTION 233723 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hooded ventilators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For gravity ventilators.

1. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
2. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

1.3 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

1. Wind Loads: Basic Wind Speed (3-Second Gust): 130 MPH.

- a. Basic Wind Speed (3-Second Gust): 130 MPH.
- b. Winward Pressure Coefficient: +0.80.
- c. Leeward Pressure Coefficient: -0.50.
- d. Wind Base Shear: 29.7 kips.

B. Capacities and Characteristics:

1. Refer to schedule on design drawings.

2.2 FABRICATION

A. Factory fabricate gravity ventilators.

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- B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
- D. Fabricate supports, anchorages, and accessories required for complete assembly.
- E. Perform shop welding by AWS-certified procedures and personnel.

### 2.3 HOODED VENTILATORS

- A. Description: Hooded rectangular penthouse for intake air.
- B. Construction:
  - 1. Material, Galvanized Steel: Thickness required to comply with structural performance requirements, but not less than 0.064-inch- thick base and 0.040-inch- thick hood; suitably reinforced.
  - 2. Bird Screening: Galvanized-steel, 1/2-inch-square mesh wire.
- C. Galvanized-Steel Finish:
  - 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A780/A780M. Apply a conversion coating suited to the organic coating to be applied over it.
  - 2. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.
    - a. Color and Gloss: As selected by Owner from manufacturer's full range.
- D. Roof Curbs: Galvanized-steel sheet; with 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 fit roof opening and ventilator base.
  - 1. Configuration: Self-flashing without a cant strip, with mounting flange.
  - 2. Overall Height: 12 inches or height required for proper roof flashing (contractor to confirm before submitting).

### 2.4 SOURCE QUALITY CONTROL

- A. AMCA Certification for Hooded Ventilators: Test, rate, and label gravity ventilators in accordance with AMCA 511.

## 2.5 MATERIALS

- A. Galvanized-Steel Sheet: ASTM A653/A653M, G90 zinc coating, mill phosphatized.
- B. Fasteners: 300 Series stainless steel. Do not use metals that are incompatible with joined materials.
  - 1. Use types and sizes to suit unit installation conditions.
  - 2. Use hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.

## PART 3 - EXECUTION

### 3.1 INSTALLATION, GENERAL

- A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Secure gravity ventilators to roof curbs with stainless steel hardware, that comply with the wind fastening requirements. Use concealed anchorages where possible.
- C. Install gravity ventilators with clearances for service and maintenance.
- D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses.
- F. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Equipment."
- G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes, so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

### 3.2 DUCT CONNECTIONS

- A. Duct installation and connection requirements are specified in Section 233113 "Metal Ducts." Drawings indicate general arrangement of ducts and duct accessories.

END OF SECTION 233723

SECTION 237416.11 - PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components and accessories:
  - 1. Casings.
  - 2. Fans.
  - 3. Motors.
  - 4. Coils.
  - 5. Refrigerant circuit components.
  - 6. Air filtration.
  - 7. Gas furnaces.
  - 8. Dampers.
  - 9. Electrical power connections.
  - 10. Controls.
  - 11. Accessories.
  - 12. Roof curbs.

1.2 DEFINITIONS

- A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, small-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.3 ACTION SUBMITTALS

- A. Product Data: For each RTU.
  - 1. Include manufacturer's technical data.
  - 2. Include rated capacities, dimensions, required clearances, characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
  - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

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1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Wind-Restraint Details: Detail fabrication and attachment of wind restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

### 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For special warranty.

### 1.5 CLOSEOUT SUBMITTALS

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

### 1.6 MAINTENANCE MATERIAL SUBMITTALS

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

### 1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of RTUs that fail in materials or workmanship within specified warranty period.
  1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
  2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than ten years from date of Substantial Completion.
  3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
  4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 DESCRIPTION

- A. AHRI Compliance:



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1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 270 for testing and rating sound performance for RTUs.

### B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested according to AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

### C. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

### D. ASHRAE/IES Compliance: Comply with applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

### E. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.

### F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.2 PERFORMANCE REQUIREMENTS

### A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.

1. Design RTU supports to comply with wind performance requirements.

### B. Wind-Restraint Performance:

1. Basic Wind Speed: 145 mph.
2. Building Classification Category: III.
3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

## 2.3 CAPACITIES AND CHARACTERISTICS

### A. Refer to schedule on design drawings.

## 2.4 MOTORS

### A. Comply with Section 230513 "Common Motor Requirements for HVAC Equipment" and the requirements of this Article.

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- B. 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.

### 2.5 ROOF CURBS

- A. Roof curbs shall be provided by the unit's supplier. Curbs shall be vibration isolation type custom made from 12 gauge or heavier as required galvanized steel with welded one-piece construction and insulated with 1-1/2" thick rigid insulation. Curb height shall be minimum of 14" high above the finished roof height. Secure curb to roof structure and unit to curb per manufacturer's recommendations for site's wind zone loading. Curbs shall have structural cross members.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Roof Curb: Install on roof structure or existing curb, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction. Secure RTUs to upper curb rail, and secure curb base to roof framing with anchor bolts.
- B. Install drain pipes from unit drain pans to roof drains. Provide manufactured roof pipe supports for condensate piping. Piping supports shall be designed specifically for support of condensate piping systems. Supports shall be UV resistant and suitable for installation on roofing material. Supports must comply with NCPC 301.10 for wind speeds up to 145 MPH.
  - 1. Drain Piping: Schedule 40 PVC pipe complying with ASTM D 1785, with solvent-welded fittings.
  - 2. Pipe Size: Same size as condensate drain pan connection.

### 3.3 CONNECTIONS

- A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
  2. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
  3. Install return-air duct continuously through roof structure.
- B. Where installing piping adjacent to RTUs, allow space for service and maintenance.
- C. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. 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 as layers of black with engraved white letters at least 1/2 inch high.
  3. Locate nameplate where easily visible.

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. RTU will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

### 3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
1. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

### 3.6 CLEANING AND 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.
- B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.7 DEMONSTRATION

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

END OF SECTION 237416.11

SECTION 237416.13 - PACKAGED, LARGE-CAPACITY, AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes packaged, large-capacity, air conditioning units (RTUs).

1.3 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

- 1. Factory selection calculations for each antimicrobial ultraviolet lamp installation.

- B. Shop Drawings:

- 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Filters: One set of filters for each unit.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of RTUs that fail in materials or workmanship within specified warranty period.

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1. Provide parts warranty extending either 12-months from date of unit start-up or a maximum of 18-months from unit ship date.
2. Compressor warranty: 5 years.
3. Warranty Period for Antimicrobial Ultraviolet Lamp System: Lifetime with exception of lamps.

## PART 2 - PRODUCTS

### 2.1 SYSTEM DESCRIPTION

- A. The contractor shall furnish and install packaged unit(s) as shown and scheduled on the contract documents. The unit(s) shall be installed in accordance with this specification and perform at the specified conditions as scheduled.
- B. AHRI Compliance:
  1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
- C. ASHRAE Compliance:
  1. Comply with ASHRAE 15 for refrigeration system safety.
- D. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

### 2.2 CAPACITIES AND CHARACTERISTICS

- A. Refer to schedule on design drawings.

### 2.3 GENERAL DESCRIPTION

- A. Unit(s) furnished and installed shall be packaged unit(s) as scheduled on contract documents and described in these specifications. Unit(s) shall be designed for cooling only. For cooling modes the evaporator temperature shall be monitored, reported at unit controller. Compressor controls shall modulate capacity to maintain evaporator leaving set point. Hot Gas Bypass shall not be used to control compressor capacity.
- B. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.
  1. Unit discharge airflow configuration shall be horizontal discharge thru side of pad-mount curb.

### 2.4 CABINET

- A. Cabinet panels: 2" double-wall foamed panel construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed.

- B. Insulation: 2" polyisocyanurate foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.
- C. Cabinet base shall be double wall construction designed to prevent trapping or ponding of water within the unit base. Cabinet base pan shall be insulated with 2" thick polyisocyanurate foam. Foam insulation shall be fully enclosed with galvanized steel insulation cover. Insulation shall not be applied to underside of unit base.
- D. Cabinet Base Rails: Side and end base rails shall include openings for forklift and tie-down access. To protect unit base from fork damage side rails shall include removable heavy gauge fork pockets.
- E. Shipping anchors attach to and/or through unit base rails. Straps over unit shall not be used to secure unit for shipping.
- F. Cabinet material interior and base rails: shall be G-90 zinc-coated galvanized steel. Material gauge shall be a minimum of 14-gauge for base rails, 16-gauge for structural members and 20-gauge for access doors and cabinet panels.
- G. Exterior Corrosion Protection: Exterior cabinet panels shall be a base coat of G-90 galvanized steel with both exterior and interior surfaces cleaned, phosphatized and finished with a weather-resistant baked enamel finish. Unit's surface shall be in compliance with ASTM B45 salt spray testing at a minimum of 672 hour duration.
- H. Cabinet construction shall provide hinged panels providing easy access for all parts requiring routine service.
- I. Cabinet top cover shall be one piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.
- J. Hinged Access Panels: Water- and air-tight hinged access panels shall provide access to all areas requiring routine service including air filters, heating section, electrical and control cabinet sections, optional ERV and power exhaust fan section, supply air fan section, evaporator and reheat coil sections. Insulated doors shall be constructed to allow the hinges to be reversed in the field.
  - 1. Hold-open devices shall be factory installed on all hinged access doors. Chains shall not be used as hold-open devices.
  - 2. Latches with locking hasp or tool operated closure devices shall be factory installed on all hinged access panels.
- K. Drain Pan material shall be Type 430 Stainless steel drain and constructed to sloped in two directions to ensure positive drainage with corners exposed to standing water and drain fittings welded liquid tight to prevent leaks. Pan shall have a minimum depth of 2". Base of drain pan shall be insulated with 1" thick foam insulation.
- L. Provide openings either on side of unit or thru the base for power and control connections.
- M. Air inlet hood shall be factory installed and shall not require field assembly. Hood shall include 2" thick removable aluminum mesh mist eliminators sized for a velocity not to exceed 500 FPM

at maximum unit rated airflow. Service access shall be hinged and held in place with thumb latches that shall not require tools for service access.

- N. Unit shall be equipped with a 6" filter rack upstream of the evaporator. Frame shall be field-adjustable to match any filter combination specified in the following section.

## 2.5 AIR FILTERS

- A. Unit inlet hood shall include 2" thick aluminum mesh removable mist eliminators with hinged access cover. Inlet velocity shall not exceed 500 FPM.
- B. Evaporator Inlet shall include a full complement of pleated media air filters. Filters shall be 2" deep MERV 8.

## 2.6 DAMPERS

- A. Unit shall include a motor operated outdoor air damper constructed of galvanized steel:
- B. Damper blades shall be air foil design with rubber edge seals designed not to exceed a 4 CFM/SQ FT leakage rate exceeding ASHRAE 90.1 damper leakage requirements.
- C. Damper actuator shall be factory mounted and wired sealed spring return and two-position.
- D. Dampers air velocity shall not exceed 2000 fpm.
- E. Return Air damper shall be of same material, construction and leakage rate as outdoor air damper. Return air damper actuator shall be factory mounted and wired sealed spring fully modulating and operate based on outdoor air damper feedback signal to properly regulate RA airflow.

## 2.7 COOLING

- A. Compressors:
  - 1. Units shall have direct-drive, digital scroll type compressors, all circuits.
  - 2. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
  - 3. Internal overloads shall be provided with the scroll compressors.
  - 4. Each compressor shall have a crankcase heater to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
  - 5. Each compressor shall be mounted on rubber vibration isolators, to reduce the transmission of noise.
  - 6. Provide each unit with two (2) hermetically sealed refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, liquid line charging port, suction and liquid line pressure ports, sight glass, and thermal expansion valve.
  - 7. Provide each circuit with automatic reset high and low pressure and high temperature switches for safety control.
- B. Coils:



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1. Evaporator and Condenser coils shall be constructed with copper tubes mechanically bonded to configured aluminum plate fins.
2. Coils shall be factory leak tested in accordance ANSI/ASHRAE 15-1992 at a minimum pressure of 500 PSIG.
3. The condenser coil shall have a fin designed for ease of cleaning.
4. Evaporator coil shall include (six / four) rows of cooling interlaced for superior sensible and latent cooling with a maximum of 12 FPI for ease of cleaning.
5. Condenser coil hail guards shall be factory installed.
6. UVC Emitters/Lamps: Ultraviolet light (C band) emitters/lamps shall be incorporated downstream of evaporator coils, upstream of hot gas reheat coils, and above all drain pans to control airborne and surface microbial growth and transfer. Applied fixtures must be specifically manufactured for this purpose. Safety interlocks/features shall be provided to limit hazard to operating staff.

### C. Condenser Section:

1. Outdoor Fans: Shall be direct drive vertical discharge design with low-noise corrosion resistant glass reinforced polypropylene props, powder coated wire discharge guards and electro-plated motor mounting brackets.
2. Fans shall be statically and dynamically balanced.

## 2.8 FANS AND MOTORS

- A. Indoor fan shall be direct drive plenum fan, factory installed and wired to on-board Variable Frequency Drive and shall be equipped with slide out service access.
- B. All fan motors shall be premium efficiency ODP and meet the U.S. Energy Policy Act of 2005/10 (EPACT).
- C. All fan motors shall either be permanently lubricated and/ or have internal thermal overload protection.
- D. Outdoor fans shall be direct drive with premium efficiency motors, statically and dynamically balanced, draw through in the vertical discharge position.
- E. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

## 2.9 ELECTRICAL RATINGS AND CONNECTIONS

- A. All high voltage power components such as fuses, switches and contactors shall include a service personnel protection barrier or shall be a listed as touch-safe design.
- B. Field wiring access to be provided thru unit base into isolated enclosure with removable cover.
- C. Power wiring to be single point connection.
- D. Wiring internal to the unit shall be colored and numbered for identification.
- E. Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.

- F. Factory wired main power disconnect and overcurrent device shall be rated for total unit connected power.
- G. Unit SCCR rating shall be a minimum of 5Ka.
- H. Factory wired Voltage/Phase monitor shall be included as standard. In the event of any of the following, the units will be shut down and a fault code will be stored in the monitor for the most recent 25 faults. Upon correction of the fault condition the unit will reset and restart automatically.
  - 1. Phase Unbalance Protection: Factory set 2%.
  - 2. Over/Under/Brown Out Voltage Protection: +/-10% of nameplate voltage.
  - 3. Phase Loss/Reversal.
- I. All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.

#### 2.10 UNIT CONTROLS

- A. Main Unit Controller (MCM) shall be a microprocessor based controller with resident control logic. Controller program logic shall include Discharge Air control with unit conditioning modes enabled based on outdoor air conditions and controlled to maintain discharge air setpoints.
- B. MCM shall:
  - 1. Prevent simultaneous operation of any conditioning modes.
  - 2. Accept separate setpoints for Occupied and Unoccupied states.
  - 3. Include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
  - 4. Unit shall include minimum discharge air control.
- C. MCM Touch Screen shall include full color display and shall be (factory installed in unit control compartment / field mounted remote from unit and field wired up to a maximum of 300 ft.) and provide a full list of points included in the MCM. The display shall provide a list and history of all unit alarms.
- D. System Sensors shall include: Factory installed and wired Outdoor Air Temperature, Outdoor Air Humidity and Evaporator Leaving Air Temperature and factory furnished, field installed Discharge Air Temperature.
- E. System controls shall include:
  - 1. Anti-cycle timing.
  - 2. Minimum compressor run/off-times.

#### 2.11 CURBS

- A. Contractor shall provide factory fabricated roof-mount curb.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A. Curb: Install on roof, level and secure, according to AHRI Guideline B. Secure RTUs to upper curb rail.

#### 3.3 CONNECTIONS

- A. Install condensate drain, minimum connection size, with trap and indirect connection and spill to grade.
- B. Install piping adjacent to RTUs to allow service and maintenance.
- C. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts.
- D. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. 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 layers of black with engraved white letters at least 1/2 inch high.
  - 2. Locate nameplate where easily visible.

#### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
  - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
  - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - 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. RTU will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

### 3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup check according to manufacturer's written instructions.

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.
10. Verify lubrication on fan and motor bearings.
11. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
12. Start unit according to manufacturer's written instructions.
  - a. Start refrigeration system.
  - b. Do not operate below recommended low-ambient temperature.
  - c. Complete startup sheets and attach copy with Contractor's startup report.
13. Inspect and record performance of interlocks and protective devices; verify sequences.
14. Operate unit for an initial period as recommended or required by manufacturer.
15. Calibrate thermostats.
16. Adjust and inspect high-temperature limits.
17. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
18. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:
  - a. Coil leaving-air, dry- and wet-bulb temperatures.
  - b. Coil entering-air, dry- and wet-bulb temperatures.
  - c. Outdoor-air, dry-bulb temperature.
  - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
19. Inspect controls for correct sequencing of dampers, refrigeration, and normal and emergency shutdown.
20. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
  - a. Supply-air volume.
  - b. Return-air volume.

- c. Outdoor-air intake volume.
- 21. Simulate maximum cooling demand and inspect the following:
  - a. Compressor refrigerant suction and hot-gas pressures.
  - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
- 22. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
  - a. Low-temperature safety operation.
  - b. Filter high-pressure differential alarm.
  - c. Smoke and firestat alarms.
- 23. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

### 3.6 CLEANING AND 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.
- B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

### 3.7 DEMONSTRATION

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

END OF SECTION 237416.13

SECTION 238126 - VARIABLE CAPACITY, HEAT PUMP HEAT RECOVERY AIR  
CONDITIONING SYSTEM

PART 1 – GENERAL

1.1 SYSTEM DESCRIPTION

- A. The variable capacity, heat pump heat recovery air conditioning system shall be a Mitsubishi Electric CITY MULTI VRF (Variable Refrigerant Flow) zoning system.
- B. The R2-Series system shall consist of a PURY outdoor unit, BC (Branch Circuit) Controller, multiple indoor units, and M-NET DDC (Direct Digital Controls). Each indoor unit or group of indoor units shall be capable of operating in any mode independently of other indoor units or groups. System shall be capable of changing mode (cooling to heating, heating to cooling) with no interruption to system operation. To ensure owner comfort, each indoor unit or group of indoor units shall be independently controlled and capable of changing mode automatically when zone temperature strays 1.8 degrees F from set point for ten minutes. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of outdoor rated capacity.

1.2 QUALITY ASSURANCE

- A. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.
- B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).
- C. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
- D. All units must meet or exceed the 2010 Federal minimum efficiency requirements and the ASHRAE 90.1 efficiency requirements for VRF systems. Efficiency shall be published in accordance with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1230.
- E. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.

1.3 DELIVERY, STORAGE AND HANDLING

- A. Unit shall be stored and handled according to the manufacturer's recommendation.

1.4 CONTROLS

- B. The control system shall consist of a low voltage communication network of unitary built-in controllers with on-board communications and a web-based operator interface. A web controller with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.

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- C. System controls and control components shall be installed in accordance with the manufacturer's written installation instructions.
- D. Furnish energy conservation features such as optimal start, night setback, request-based logic, and demand level adjustment of overall system capacity as specified in the sequence.
- E. System shall provide direct and reverse-acting on and off algorithms based on an input condition or group conditions to cycle a binary output or multiple binary outputs.
- F. Provide capability for future system expansion to include monitoring and use of occupant card access, lighting control and general equipment control.
- G. System shall be capable of email generation for remote alarm annunciation.
- H. Control system start-up shall be a required service to be completed by the manufacturer or a duly authorized, competent representative that has been factory trained in Mitsubishi Electric controls system configuration and operation. The representative shall provide proof of certification for Mitsubishi Electric Controls Applications Training indicating successful completion of no more than two (2) years prior to system installation. This certification shall be included as part of the equipment and/or controls submittals. This service shall be equipment and system count dependent and shall be a minimum of one (1) eight (8) hour period to be completed during normal working hours.

### 1.5 WARRANTY

- A. The CITY MULTI units shall be covered by the manufacturer's limited warranty for a period of one (1) year parts and seven (7) year compressor to the original owner from date of installation.
- B. The S-Series units shall be covered by the manufacturer's limited warranty for a period of one (1) year parts and six (6) year compressor to the original owner from date of installation. If the systems are:
  - 1. Designed by a certified CITY MULTI Diamond Designer using Diamond System Builder,
  - 2. Installed by a contractor that has successfully completed the Mitsubishi Electric three day service course, AND
  - 3. Verified with required materials submitted to and approved by the Mitsubishi Electric Service Department, which include:
    - As built Diamond System Builder file,
    - A one (1) hour Maintenance Tool record with system information, in Ordinary Control Mode (not initial),
    - Outdoor and Indoor unit dip switch settings
    - Outdoor unit(s) function settings,then the units shall be covered by an extended manufacturer's limited warranty for a period of ten (10) years to the original owner from date of installation.

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In addition the compressor shall have a manufacturer's limited warranty for a period of ten (10) years to the original owner from date of installation.

If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer.

This warranty shall not include labor.

- C. The CITY MULTI VRFZ system shall be installed by a contractor with extensive CITY MULTI install and service training. The mandatory contractor service and install training should be performed by the manufacturer.

## PART 2 - PRODUCTS

### 2.1 R2-SERIES OUTDOOR UNIT

- A. General: The R2-Series PURY outdoor unit shall be used specifically with CITY MULTI VRFZ components. The PURY outdoor units shall be equipped with multiple circuit boards that interface to the M-NET controls system and shall perform all functions necessary for operation. Each outdoor unit module shall be completely factory assembled, piped and wired and run tested at the factory.
  - 1. All units requiring a factory supplied twinning kits shall be piped together in the field, without the need for equalizing line(s). If an alternate manufacturer is selected, any additional material, cost, and labor to install additional lines shall be incurred by the contractor.
  - 2. Outdoor unit shall have a sound rating no higher than 61 dB(A) individually or 64 dB(A) twinned. Units shall have a sound rating no higher than 51 dB(A) individually or 54 dB(A) twinned while in night mode operation. If an alternate manufacturer is selected, any additional material, cost, and labor to meet published sound levels shall be incurred by the contractor.
  - 3. Both refrigerant lines from the outdoor unit to the BC (Branch Circuit) Controller (Single or Main) shall be insulated.
  - 4. There shall be no more than 3 branch circuit controllers connected to any one outdoor unit.
  - 5. Outdoor unit shall be able to connect to up to 50 indoor units depending upon model.
  - 6. The outdoor unit shall have an accumulator with refrigerant level sensors and controls.
  - 7. The outdoor unit shall have a high pressure safety switch, over-current protection, crankcase heater and DC bus protection.
  - 8. The outdoor unit shall have the ability to operate with a maximum height difference of 164 feet and have total refrigerant tubing length of 1804-2625 feet. The greatest length is not to exceed 541 feet between outdoor unit and the indoor units without the need for line size changes or traps.
  - 9. The outdoor unit shall be capable of operating in heating mode down to -4°F ambient temperature or cooling mode down to 23°F ambient temperature, without additional low ambient controls. If an alternate manufacturer is selected, any additional material, cost, and labor to meet low ambient operating condition and performance shall be incurred by the contractor.



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10. The outdoor unit shall be capable of operating in cooling mode down to -10°F with optional manufacturer supplied low ambient kit.
  11. Manufacturer supplied low ambient kit shall be provided with predesigned control box rated for outdoor installation and capable of controlling kit operation automatically in all outdoor unit operation modes.
  12. Manufacturer supplied low ambient kit shall be listed by Electrical Laboratories (ETL) and bear the ETL label.
  13. Manufacturer supplied low ambient kit shall be factory tested in low ambient temperature chamber to ensure operation. Factory performance testing data shall be available when requested.
  14. The outdoor unit shall not cease operation in any mode based solely on outdoor ambient temperature.
  15. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
  16. Unit must defrost all circuits simultaneously in order to resume full heating more quickly. Partial defrost which may extend “no or reduced heating” periods shall not be allowed.
- B. Unit Cabinet: The casing(s) shall be fabricated of galvanized steel, bonderized and finished. Units cabinets shall be able to withstand 960 hours per ASTM B117 criteria for seacoast protected models (–BS models).
- C. Fan:
1. Each outdoor unit module shall be furnished with one direct drive, variable speed propeller type fan. The fan shall be factory set for operation under 0 in. WG external static pressure, but capable of normal operation under a maximum of 0.24 in. WG external static pressure via dipswitch.
  2. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
  3. All fan motors shall be mounted for quiet operation.
  4. All fans shall be provided with a raised guard to prevent contact with moving parts.
  5. The outdoor unit shall have vertical discharge airflow.
- D. Refrigerant: R410A refrigerant shall be required for PURY-P-T/Y(S) JMU-A outdoor unit systems. Polyolester (POE) oil shall be required. Prior to bidding, manufacturers using alternate oil types shall submit material safety data sheets (MSDS) and comparison of hygroscopic properties for alternate oil with list of local suppliers stocking alternate oil for approval at least two weeks prior to bidding.
- E. Coil:
1. The outdoor coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.
  2. The coil fins shall have a factory applied corrosion resistant blue-fin finish.
  3. A stainless steel pipe connects the aluminum coil to copper piping.
  4. The coil shall be protected with an integral metal guard.
  5. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.
  6. The outdoor coil shall include 4 circuits with two position valves for each circuit, except for the last stage.

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### F. Compressor:

1. Each outdoor unit module shall be equipped with one inverter driven scroll hermetic compressor. Non inverter-driven compressors shall not be allowed.
2. A crankcase heater(s) shall be factory mounted on the compressor(s).
3. The outdoor unit compressor shall have an inverter to modulate capacity. The capacity shall be completely variable with a turndown of 19%-5% of rated capacity, depending upon unit size.
4. The compressor will be equipped with an internal thermal overload.
5. The compressor shall be mounted to avoid the transmission of vibration.
6. Field-installed oil equalization lines between modules are not allowed. Prior to bidding, manufacturers requiring equalization must submit oil line sizing calculations specific to each system and module placement for this project.

### G. Controls:

1. The outdoor unit shall have the capability of up to 8 levels of demand control for each refrigerant system

### H. Electrical:

1. The outdoor unit shall be controlled by integral microprocessors.
2. The control circuit between the indoor units, BC Controller and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

## 2.2 BRANCH CIRCUIT (BC) CONTROLLERS FOR R2-SERIES SYSTEMS

- A. General: The BC (Branch Circuit) Controllers shall be specifically used with R410A R2-Series systems. These units shall be equipped with a circuit board that interfaces to the M-NET controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish. The BC Controller shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors, with access and service clearance provided for each controller. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of rated capacity.

### B. BC Unit Cabinet:

1. The casing shall be fabricated of galvanized steel.
2. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
3. The unit shall house two tube-in-tube heat exchangers.

- C. Refrigerant: R410A refrigerant shall be required.

### D. Refrigerant Valves:

1. The unit shall be furnished with multiple branch circuits which can individually accommodate up to 54,000 BTUH and up to three indoor units. Branches may be twinned to allow more than 54,000 BTUH.
2. Each branch shall have multiple two-position valves to control refrigerant flow.

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3. Service shut-off valves shall be field-provided/installed for each branch to allow service to any indoor unit without field interruption to overall system operation.
  4. Linear electronic expansion valves shall be used to control the variable refrigerant flow.
- E. Integral Drain Pan: An integral condensate pan and drain shall be provided.
- F. Electrical:
1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
  2. The unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253V (230V/60Hz).
  3. The BC Controller shall be controlled by integral microprocessors.
  4. The control circuit between the indoor units and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

### 2.3 PKFY (WALL MOUNTED) INDOOR UNIT

- A. General:
1. The PKFY shall be a wall-mounted indoor unit section and shall have a modulating linear expansion device and a flat front. The PKFY shall be used with the R2-Series outdoor unit and BC Controller, Y-Series outdoor unit, or S-Series outdoor unit. The PKFY shall support individual control using M-NET DDC controllers.
- B. Indoor Unit
1. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.
- C. Unit Cabinet:
1. All casings, regardless of model size, shall have the same white finish
  2. Multi directional drain and refrigerant piping offering four (4) directions for refrigerant piping and two (2) directions for draining shall be standard.
  3. There shall be a separate back plate which secures the unit firmly to the wall.
- D. Fan:
1. The indoor fan shall be an assembly with one or two line-flow fan(s) direct driven by a single motor.
  2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
  3. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
  4. A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution.

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### E. Filter:

1. Return air shall be filtered by means of an easily removable, washable filter.

### F. Coil:

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. Both refrigerant lines to the PKFY indoor units shall be insulated in accordance with the installation manual.

### G. Electrical:

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz)

### H. Controls:

1. This unit shall use controls provided by Mitsubishi Electric Cooling & Heating to perform functions necessary to operate the system.
2. The unit shall be able to control external backup heat.
3. The unit shall have a factory built in receiver for wireless remote control
4. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
5. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
6. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
7. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

## 2.4 PEFY-NMAU (CEILING-CONCEALED DUCTED) INDOOR UNIT

### A. General:

1. The PEFY shall be a ceiling-concealed ducted indoor fan coil design that mounts above the ceiling with a 2-position, field adjustable return and a fixed horizontal discharge supply and shall have a modulating linear expansion device. The PEFY shall be used with the R2-Series outdoor unit and BC Controller, Y-Series outdoor unit, or S-Series outdoor unit. The PEFY shall support individual control using M-NET DDC controllers. The unit shall be suitable for use in plenums in accordance with UL1995 ed 4.

### B. Indoor Unit.

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1. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.
- C. Unit Cabinet:
1. The unit shall be, ceiling-concealed, ducted.
  2. The cabinet panel shall have provisions for a field installed filtered outside air intake.
- D. Fan:
1. PEFY-NMAU models shall feature external static pressure settings from 0.14 to 0.60 in. WG.
  2. The indoor unit fan shall be an assembly with one or two Sirocco fan(s) direct driven by a single motor.
  3. The indoor fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.
  4. The indoor fan shall consist of three (3) speeds, High, Mid, and Low plus the Auto-Fan function
  5. The indoor unit shall have a ducted air outlet system and ducted return air system.
- E. Filter:
1. Return air shall be filtered by means of a return air filter grille(s).
- F. Coil:
1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
  2. The tubing shall have inner grooves for high efficiency heat exchange.
  3. All tube joints shall be brazed with phos-copper or silver alloy.
  4. The coils shall be pressure tested at the factory.
  5. A condensate pan and drain shall be provided under the coil.
  6. The condensate shall be gravity drained from the fan coil.
  7. Both refrigerant lines to the PEFY indoor units shall be insulated in accordance with the installation manual.
- G. Electrical:
1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
  2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).
- H. Controls:
1. This unit shall use controls provided by Mitsubishi Electric Cooling & Heating to perform functions necessary to operate the system.
  2. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of

compensation shall be possible for individual units to accommodate instances when compensation is not required.

3. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
4. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
5. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

## 2.5 CONTROLS OVERVIEW

### A. Wiring:

1. Control wiring shall be installed in a system daisy chain configuration from indoor unit to ME remote controller to indoor unit, to the BC controller (main and subs, if applicable) and to the outdoor unit. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.
2. Control wiring for schedule timers, system controllers, and centralized controllers shall be installed in a daisy chain configuration from outdoor unit to outdoor unit, to system controllers, to the power supply.
3. Control wiring for the Deluxe MA, Simple MA, and Wireless MA remote controllers shall be from the remote controller to the first associated indoor unit (TB-15) then to the remaining associated indoor units (TB-15) in a daisy chain configuration.
4. The AE-200A system controller shall be capable of being networked with other AE-200A system controllers for web based control.

### B. Wiring Type:

1. Wiring shall be 2-conductor (16 AWG), twisted shielded pair, stranded wire, as defined by the Design Tool AutoCAD output.
2. Network wiring shall be CAT-5e with RJ-45 connection.

### C. Remote Controllers Backlit Simple MA Remote Controller (PAC-YT53CRAU) – **ALL AREAS**

1. The Backlit Simple MA Remote Controller (PAC-YT53CRAU) shall be capable of controlling up to 16 indoor units (defined as 1 group). The Backlit Simple MA Remote Controller shall be compact in size, approximately 3" x 5" and have limited user functionality. The Backlit Simple MA supports temperature display selection of Fahrenheit or Celsius. The Backlit Simple MA Remote Controller shall allow the user to change on/off, mode (cool, heat, auto (R2/WR2-Series only), dry, setback (R2/WR2-Series only) and fan), temperature setting, and fan speed setting and airflow direction. The Backlit Simple MA Remote Controller shall be able to limit the set temperature range from the Backlit Simple MA. The Backlit Simple MA Remote controller shall be capable of night setback control with upper and lower set temperature settings. The room temperature shall be sensed at either the Backlit Simple MA Remote Controller or the Indoor Unit dependent on the indoor unit dipswitch setting. The Backlit Simple MA Remote Controller shall display a four-digit error code in the event of system abnormality/error.
2. The Backlit Simple MA Remote Controller shall only be used in same group with Wireless MA Remote Controllers (PAR-FL32MA-E / PAR-FA32MA-E) or with other

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Backlit Simple MA Remote Controllers (PAC-YT53CRAU), with up to two remote controllers per group.

3. The Backlit Simple MA Remote Controller shall require no addressing. The Backlit Simple MA Remote Controller shall connect using two-wire, stranded, non-polar control wire to TB15 connection terminal on the indoor unit. The Simple MA Remote Controller shall require cross-over wiring for grouping across indoor units.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install unit's level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

#### 3.2 CONNECTIONS

- A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.
- B. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.
- D. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

#### 3.3 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.

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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.

### 3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

### 3.5 DEMONSTRATION

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

B. The VRF manufacturer shall provide the owner's representative a minimum 4-hour VRF Operation and Maintenance training class covering systems installed under this scope of work.

C. Training program is to be provided at the time of owner occupancy. Owner shall provide a suitable location, onsite, to conduct the VRF Operation and Maintenance class.

D. Training material shall be provided to participants in electronic format.

END OF SECTION 238126



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## SECTION 238216.14 - ELECTRIC-RESISTANCE AIR COILS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes electric resistance air coils.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
  - 2. Include rated capacities, operating characteristics, and pressure drops for each air coil.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

#### 1.5 CLOSEOUT SUBMITTALS

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

### PART 2 - PRODUCTS

#### 2.1 DESCRIPTION

- A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

#### 2.2 COILS

- A. Testing Agency Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Coil Assembly: Comply with UL 1995.
- C. Heating Elements, provide one of the following:

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1. Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
  2. Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, and fastened to supporting brackets.
- D. High-Temperature Coil Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or casing.
1. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
- E. Frames: Galvanized-steel channel frame, minimum **0.064 inch** thick for slip-in mounting.
- F. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:
1. Magnetic contactor.
  2. Mercury contactor.
  3. Toggle switches; one per step.
  4. Step controller.
  5. Time-delay relay.
  6. Pilot lights; one per step.
  7. Airflow proving switch.
- G. Capacities and Characteristics:
1. Refer to schedule on design drawings.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine ducts to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

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### 3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### 3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Prepare test and inspection reports.

END OF SECTION 238216.14

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## SECTION 238239.19 - WALL UNIT HEATERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section includes wall heaters with propeller fans and electric-resistance heating coils.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

### PART 2 - PRODUCTS

#### 2.1 DESCRIPTION

- A. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.
- 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.

#### 2.2 CABINET

- A. Front Panel: Stamped-steel louver, with removable panels fastened with tamperproof fasteners.
- B. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

#### 2.3 COIL

- A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic

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sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection.

### 2.4 FAN AND MOTOR

- A. Fan: Aluminum propeller directly connected to motor.
- B. Motor: Permanently lubricated. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

### 2.5 CONTROLS

- A. Controls: Unit-mounted thermostat.
- B. Electrical Connection: Factory wire motors and controls for a single field connection.

### 2.6 CAPACITIES AND CHARACTERISTICS

- A. Refer to schedule on design drawings.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas to receive wall and ceiling unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install wall unit heaters to comply with NFPA 90A. Install wall unit heaters level and plumb.
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 238239.19

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## SECTION 238413 - HUMIDIFIERS

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. This Section includes the following humidifiers:
  - 1. Outdoor electrode type.

#### 1.3 DEFINITION

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

#### 1.4 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, and sections, details of components, manifolds, and attachments to other work.
  - 1. Wiring Diagrams: Power, signal, and control wiring.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

#### 1.6 CLOSEOUT SUBMITTALS

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

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Supply one replacement electrode cylinder with each self-contained humidifier.

#### 1.8 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- B. Comply with ARI 640, "Commercial and Industrial Humidifiers."

#### 1.9 COORDINATION

- A. Coordinate location and installation of humidifiers with manifolds in ducts and air-handling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

### PART 2 - PRODUCTS

#### 2.1 SELF-CONTAINED ELECTRODE STEAM HUMIDIFIERS

- A. Provide outdoor electrode humidifier generating mineral-free, sterile steam from a potable water supply packaged unit, stand-mounted, atmospheric steam generation using an electrode steam cylinders.
- B. Unit to be complete with: Factory assembled and tested.
  - 1. Touchscreen controller with standard building automation:
    - a. Intuitive touchscreen control with color graphic user interface.
    - b. Standard building automation communication protocols BACnet IP, BACnet MSTP (Slave) and Modbus. Additional hardware required for building automation communication not acceptable.
    - c. Embedded web interface for easy configuration and remote monitoring from any computer with a web browser over a local area network (LAN) connection.
    - d. USB interface for new software/feature upload and download of operational information.
    - e. Single or dual channel analog signal acceptance, supporting both demand and transducer control. Ability to control setpoint from humidifier control when using transducer controls.
  - 2. Packaged system suitable for outdoor installation with Nortec electrode cylinder technology:
    - a. Cylinder optimized for humidifier capacity and supply voltage. Cylinder must have welded seam to ensure watertight and have high water sensor to prevent overfilling.
    - b. Weatherproof, durable, powder coated steel cabinet integrated to the unit.
    - c. Insulating air gap between plumbing and electrical compartment for increased electronic reliability.
    - d. Standard internal drain water tempering to ensure maximum 140° F drain water. External drain water cooler not acceptable.
    - e. Integral fill cup with minimum 1-inch air gap to prevent back siphoning.
    - f. Full cylinder indication and pre-notification of automatic shutdown at end of cylinder life.
    - g. Automatic pulse feature to clean any obstruction from the drain solenoid valve if required.

- h. Automatic off-season shut-down will completely drain the cylinders and automatically restart on call for humidity. Adjustable on/off and time sequence. Provides extended cylinder life, while ensuring stagnant water does not remain in the system.
  - i. Internal transformers to power all components from a single electrical connection to the unit. Multiple power supplies to humidifier are unacceptable.
- 3. Auto-Adaptive Control water management:
  - a. Advanced water management utilizing the patented Proportional plus Integral Auto-Adaptive Control system for optimal energy efficiency, water usage and cylinder life.
  - b. 98% thermal efficiency from startup until end of cylinder life.
  - c. Drains automatically optimized to water conditions to maximize cylinder and reduce water usage.
  - d. Modulating output between 20% and 100% of rated capacity.

C. Headers:

- 1. The header shall distribute clean steam, precisely controlled, uniformly into the entire air stream, and void of any condensate spray. Steam distribution takes place via steam tubes with integrated nozzles. The steam shall be kept dry as condensate is drained through the main header.
- 2. The stainless steel headers shall be installed horizontally (10 deg. incline from horizontal) for vertical airflow applications.
- 3. Manufactured from 304 stainless steel, the header features welded inlet and condensate connections to ensure leak-free operation. Stainless steel inlet adapter is factory supplied for connection to steam supply line, allowing maximum flexibility, and simplification of installation. Specialized synthetic grommets form an air and water-tight seal around the base of the steam tubes, simplifying installation and ensuring reliable leak-free operation.
- 4. Headers shall be provided with 304 stainless steel insulation. This metal shielding creates an insulating air-gap around the header which minimizes heat transfer by conduction and convection, while the reflective surface minimizes heat transfer by radiation. Insulating the header in this manner increases energy efficiency by up to 70%, and results in significantly reduced airstream heat gain and steam condensate loss.
- 5. Features:
  - a. Steam tubes with end support bracket for easy installation.
  - b. All stainless steel distributors and nozzles ensure permanent bond.
  - c. Stainless steel header with rubber grommet seals for easy installation of steam tubes.
  - d. Includes hose cuffs and clamps for steam line connections.
  - e. Adjustable mounting frame available for quick and easy installation.
  - f. Available with 3", 6", 9" or 12" center to center steam tube spacing.
  - g. Available insulated for increased energy efficiency and reduced airstream heat gain.
  - h. High capacities.



- i. Ten year limited warranty.
- D. Distributors:
  - 1. Compatible with headers. Construct from high quality 304 stainless steel, this shielding provides an insulating air gap around the header. The insulating air-gap shall significantly reduce energy losses from hot distributor headers. Insulation factory installed.
  - 2. Provide inlet adapter enabling pipe steam line from a humidifier directly to short absorption manifold. Steam outlet shall come with a 1 ft long flexible steam hose and 2 clamps for a connection to the hard pipe between the humidifier and manifold.
  - 3. Features:
    - a. Aerodynamic design.
    - b. Fiberglass free and non-hygroscopic for hygienic operation.
- E. Controls: Single Channel Demand Signal by Others accepts a varying 2-wire output signal from a modulating humidity controller supplied by others. Controller shall have built-in adjustable %rH set point circuitry. Signal from the controller must increase with a drop in sensed %rH below set point. Humidifier will respond by controlling unit output between 0% - 100% of capacity to match load requirements. Percentage of control signal (demand) will be shown on the humidifier display.
- F. Capacities and Characteristics:
  - 1. Refer to schedule on design drawings.

### PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION

- A. Install humidifiers with required clearance for service and maintenance.
- B. Seal humidifier manifold duct or plenum penetrations with flange.
- C. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- D. Install manifold supply piping pitched to drain condensate back to humidifier.
- E. Equipment Mounting: Install steam generator on stand anchored to cast-in-place concrete equipment base.

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct concrete bases 6-inch high and extend base not less than 6 inches in all directions beyond the maximum dimensions of steam generator.
3. Minimum Compressive Strength: 4000 psi at 28 days.
4. 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.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.

### 3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
  1. Install piping adjacent to humidifiers to allow service and maintenance.
  2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.
- B. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.
- C. Install piping from safety relief valves to nearest floor drain.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections and prepare test reports.
  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.

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- D. Remove and replace malfunctioning units and retest as specified above.

### 3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 238413