## SECTION 230000

## GENERAL REQUIREMENTS FOR MECHANICAL TRADES

### PART 1 - GENERAL

### 1.1 GENERAL

A. Applicable portions of all documents listed in the index apply to work of this section.

B. Provisions stated in this section are applicable to all sections of the Division 23 Mechanical Specifications and to all phases of the Mechanical work shown on the drawings.

C. The "Materials and Equipment" paragraph of this section shall take precedence over all related provisions of Division 1 Section, which may conflict with this section.

### 1.2 SINGULAR NUMBER

A. In all cases where a device or piece of equipment is herein referred to in the singular, such reference shall apply to as many such items as are required to complete the installation. Quantity determinations of all materials and equipment shall be the complete responsibility of the Contractor.

### 1.3 DEFINITIONS

A. The following are definitions of terms and expressions used throughout division 23 specifications:

1. Owner - Rockland Green MRF Facility
2. Architect - RRT
3. Engineer - Martin Rogers Associates, P.C.
4. A/E - Architect or Engineer
5. Provide - Furnish and install.
6. Work - Plant, labor, and material.
7. Directed - Directed by the A/E.
8. Indicated - Indicated by the contract documents
9. Concealed - Hidden from sight; includes items in shafts, pipe and duct spaces, and above ceilings.
10. Exposed - Not concealed; work within equipment rooms and exposed to view by the occupant shall be considered exposed.
11. Ductwork - Includes ducts, fittings, housings, plenums, dampers, hangers, and accessories comprising a system.
12. ATC - Automatic Temperature Control.
13. DDC - Direct Digital Control.
14. HVAC - Heating, Ventilating, and Air-conditioning.

### 1.4 SCOPE OF WORK

A. This Section includes general administrative procedures and requirements for mechanical installations, as well as basic materials and methods of construction for the installation of mechanical systems.

B. The following administrative procedures and requirements are included in this section to expand and supplement the requirements specified in the front end of this specification:

1. Work included
2. Work excluded
3. Intent of drawings
4. Contract drawings

5. Coordination drawings
6. Record drawings
7. Codes, permits, approvals
8. Inspections
9. Materials and equipment
10. Source of supply List
11. Submittals/shop drawings
12. Contractor's responsibilities - submittals
13. Substitution of materials and equipment
14. Service agencies
15. Performance of equipment
16. Guaranty/warranty
17. Operating and maintenance manuals
18. Charts
19. Temporary Heat

C. The following basic materials and methods of construction for the installation of mechanical systems are included in this section:

1. Vibration Control
2. Accessibility
3. Examination of site
4. Dimension of existing structures
5. Lines, grades, and measurements
6. Coordination
7. Delivery, storage, and handling
8. Protection
9. Cutting and patching
10. Equipment installation and connections
11. Mounting mechanical devices in suspended ceilings

**1.5 WORK INCLUDED**

A. Work under Division 23 of the specifications of the contract shall include all plant, labor, and material required to complete the work as shown on the drawings, hereinafter specified, or both. Work of this contract shall include but not be limited to the items outlined in each of the Division 23 sections herein. Work generally includes:

1. Mechanical (HVAC):
    - Miscellaneous general construction as noted.
    - Rooftop HVAC units.
    - Rooftop Exhaust fans.
    - Infrared tube heaters.
    - Gas fired unit heaters.
    - Supply VAV boxes with electric reheat coils, controls, and accessories.
    - Hangers, supports, and equipment pads as specified and required.
    - Thermal insulation as specified and required.

- Ductless split systems for IT closet.
- Ductwork, dampers, and related sheet metal work as noted and required.
- Smoke and fire dampers through rated assemblies per the architectural life safety plan.
- Ceiling and wall diffusers, grilles, and louvers as indicated.
- New Building Management System.
- Coordination of ceiling heights and clearances with General and Electrical Contractors necessary to accomplish effective HVAC in harmony with the architectural design.
- Coordination of sizes, weights, roof openings, roof curb requirements, and floor and wall openings of mechanical equipment with General Contractor.
- Factory start-up for all major HVAC equipment.
- Testing, adjusting, and balancing of all work installed.
- Owner training on operation and maintenance of all systems and equipment.

**1.6 WORK EXCLUDED**

A. All work shown or specified shall be included in the Contract unless specifically mentioned herein.

**1.7 INTENT OF DRAWINGS**

A. The Contractor generally responsible for the trade of a specific drawing shall provide all work indicated on that drawing unless explicitly indicated otherwise. For example:

1. M-# drawings - Mechanical/HVAC Contractor
2. P-# drawings - Plumbing Contractor
3. FP-# drawings - Fire Protection Contractor

B. Work may include items that may relate to other major trades. Specifically, all work indicated on the "M" drawings (Mechanical/HVAC) shall be provided by the Mechanical/HVAC Contractor unless specifically indicated to be provided by others. The same principle shall apply to "P" drawings (Plumbing), and “FP” (Fire Protection) drawings.

**1.8 CONTRACT DRAWINGS**

A. Drawings that constitute a part of this contract indicate the general arrangement of piping, ductwork, accessories, equipment, and other work. It is the intent of these drawings and specifications to describe a complete and integrated system. It is understood that while the drawings may not show every pipe, valve, damper, and detail, all equipment and accessories that are reasonably inferable from the drawings and specifications as being necessary for the completion and proper performance of the work shall be included even though not specifically mentioned. What is called for on either the drawings or in the specifications shall be as binding as if called for on both.

B. It is understood that while the drawings shall be followed as closely as circumstances will permit, the Contractor is held responsible for the proper installation of materials and equipment to the true intent and meaning of plans and specifications. If any equipment, piping, or ductwork cannot be installed as shown, the Contractor shall consult with the A/E before making any changes.

**1.9 COORDINATION DRAWINGS**

A. The contractor shall prepare coordination drawings for the building. Drawings shall be coordinated among all trades and shall be generated in Revit.

B. Coordination drawings shall be prepared to a scale of 1/4”=1’-0” or larger, detailing major elements, components, and systems of mechanical equipment and materials in relationship to other systems, installations and building components.

C. Coordination drawings shall include plans of each area and sections of congested area.

D. Coordination drawings shall:

1. Indicate the proposed locations of any piping, ductwork, equipment and materials relating to the following:
    a. Equipment pads and bases
    b. Clearances for installing, servicing, and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
    c. Equipment service connections and support details.
    d. Ceiling plenums, chases, shafts, trenches, and other tight and congested spaces.
    e. Duct system layout, include elbows, radii, and accessories.
2. Indicate the proposed scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Include floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
4. Include reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, sprinklers, and other ceiling-mounted items.

**1.10 RECORD DRAWINGS**

A. During construction, the Contractor shall maintain a record set of contract drawings and shall record on this set in colored pencil all deviations from the original in pipe, duct, or equipment sizes, locations, and other pertinent details.

B. Upon completion of the work, Contractor shall forward these marked prints to the Architect/Engineer for review.

**1.11 CODES, PERMITS, APPROVALS**

A. All required local, state and utility company permits and approvals shall be applied for and paid for by this Contractor.

B. All persons digging at the site shall notify DIG SAFELY NEW YORK ONE CALL at 1-800-962-7962.

C. All Mechanical/HVAC work shall comply with all applicable provisions of the International Building Codes (IBC), latest edition, including the International Mechanical Code (IMC).

D. All Mechanical/HVAC work shall be subject to all provisions of the National Fire Code, including NFPA-90a and 90b.

E. All work shall meet the requirements and standards of the several Utility Company(s) serving the project. Install and test backflow preventers in accordance with regulations of the serving utility company.

F. All materials furnished shall meet the ASTM Specifications latest revisions.

G. Products furnished under this contract shall comply with the Pennsylvania “Steel Product Procurement Act, of 1978, P.L.6, Number 3” including the 1984 and all subsequent amendments.

H. All electrical work shall be in conformance with the latest edition of the National Electrical Code (NEC).

I. In all cases, the local Authority-Having-Jurisdiction (AHJ) has the right to impose a higher standard of care than the basic codes listed herein. The contractor shall be familiar with the requirements of and, if unsure, consult with the local AHJ, and make due allowance for more stringent stipulations if necessary. The contractor shall be responsible for all additional work and related costs to comply with the requirements of the local AHJ where such requirements differ from those listed in the basic building code(s).

**1.12 MATERIALS AND EQUIPMENT**

A. All materials and equipment shall be new, the best of their respective kinds, and suitable for the conditions and duties imposed on them at the building. The description, characteristics, and requirements of materials to be used shall be in accordance with qualifying conditions established in the following sections.

B. All component parts of each item of equipment or device shall bear the manufacturer's nameplate, giving name of manufacturer, description, size, type, serial or model number, electrical characteristics, and any other imperative information to facilitate their maintenance or replacement. The nameplate of a subcontractor or distributor will not be acceptable.

C. All equipment requiring electrical service shall be UL labeled. If a UL label is not available from the manufacturer, when requested or required by the local authority having jurisdiction, the equipment shall be tested by an approved electrical testing company in accordance with NEC, and at no additional cost to the owner. Submit data indicating compliance with standards prior to installation.

D In specifying materials, four general groups are used and defined as follows:

1. GROUP 1: When the material or equipment is specified:
   a) "make and model as scheduled on the drawings", or
   b) by brand name or other identifying information,

   and <u>one name brand only is used</u>, it is considered that the use of that particular item is essential to the project, and <u>the Contractor shall base their proposal on the cost of that item.</u>

2. GROUP 2: When the material or equipment is specified:
   a) "make and model as scheduled on the drawings", or
   b) by brand name and other identifying information,

and <u>two or more brand names are given</u>, it is considered that the first brand name specified or scheduled is the basis of design but that equivalent models of any one of the brands so named are acceptable - in terms of performance -, and the Contractor shall base their proposal on one of the named brands. Equivalent models shall be like the first brand name specified in all respects, including but not limited to size, appearance, and operation.

3. GROUP 3: When the material or equipment is specified:
   a) "make and model as scheduled on the drawings", or
   b) by brand name and other identifying information,

<u>with the phrase ".... or approved equivalent</u>", it is intended that the brand name used is for establishing a minimum acceptable standard of quality and performance and the Contractor may base his bid proposal on any item which is in all respects equivalent or superior to that specified and presents similar appearance, operation, and performance.

4. GROUP 4: When material is specified as complying with the requirements of published "Standard Specification" of trade associations, American Society for Testing and Materials (ASTM), government specifications, etc., the Contractor's proposal may be based on any item which can be shown to comply in all respects with the referred "Standard Specification".

E. The contractor understands that:

1. The A/E will use their own judgment in determining if any materials, equipment or methods offered for review as an equivalent are equivalent to those specified and will fit the space available;
2. The decision of the A/E on all such questions of equivalency is final;
3. Any acceptable material, equipment, and methods will be provided at no increases in cost to the owner.

**1.13 SOURCE OF SUPPLY LIST**

A. Within 21 days after award of contract, the contractor shall submit to the A/E for review a list of manufacturer's names of material and equipment he proposes to provide. In the event any item of material or equipment contained in the list fails to comply with the specification requirements, such item will be rejected. If, prior to the expiration of the 21-day period, or any duly authorized extension thereof, the Contractor fails to submit a schedule of acceptable material or equipment, the A/E will select the items; such selection shall be final and binding upon the Contractor as condition of the contract. Rejected items shall be resubmitted within 21 days or the A/E will select such materials and equipment.

**1.14 SUBMITTALS AND SHOP DRAWINGS**

A. After receiving approval of the source of supply list; furnish catalog data, dimensional data, performance specifications, etc., in sufficient detail to properly identify and judge each item. Each item or equipment proposed shall be a standard product of the approved manufacturer.

B. Samples, drawings, specifications, catalogs, etc., submitted for review shall be dated, properly labeled indicating specific service for which material or equipment is to be used, section and article number of specifications governing, Contractor's name, and name of job.

C. Review of shop drawings or samples by the Engineer shall not relieve the Contractor of responsibility for any deviation from the requirements of the contract documents. Deviations from the contract documents will only be allowed if all the following are satisfied:

- The Contractor has informed the Engineer in writing of all deviations at the time of submission,
- The Contractor has noted the deviation on the shop drawings,
- The Engineer has acknowledged, in writing, the specific deviation.

D. In any event, the Engineer's review shall not relieve the Contractor from responsibility for errors or omissions in the shop drawings or samples.

E. No materials or equipment shall be purchased, delivered to the site, or installed until they have been reviewed by the A/E. Review of any submittal shall not relieve the Contractor of responsibility for deviation from the drawings or specifications, nor shall it relieve the Contractor from errors in the submittals. Dimensions and quantities shall, in all cases, be the complete responsibility of the Contractor.

F. After the A/E's review of a submittal, it shall be marked with one or more comments as defined below:

- No Exceptions Taken: The contractor may proceed using the reviewed material,
- Note Markings: The contractor may proceed using the reviewed material provided corrective action is taken on all comments noted on the submittal,
- Comments Attached: Same as "Note Markings", except that, comments have been noted on a supplemental attachment,
- Contractor Confirm: The contractor shall respond in writing to all comments including confirmation that corrective action will be taken on all comments noted prior to proceeding with the work,

- Resubmit: The contractor shall respond to all comments noted, revise shop drawings accordingly, and resubmit for review,
- Rejected: The proposed material or equipment does not comply with the requirements of the contract documents and may not be used for this project.

G. Upon receipt of written notice from the A/E that the material, equipment, or methods have been reviewed and marked “no exceptions taken”, “Note Markings”, or “Comments Attached”, the Contractor may proceed with the reviewed material, equipment, or methods. The Contractor assumes full responsibility for and shall make, at no expense to the owner, all changes or adjustments in construction that may result using such approved materials, equipment or methods, including electrical and other services provided under other divisions of this specification. In the event of any adverse decisions by the A/E, no claim of any sort shall be made or allowed against the A/E or the owner.

H. If material or equipment is installed prior to receipt by the contractor of submittals marked “no exceptions taken”, “note markings”, or “comments attached”, the Contractor shall be liable for its removal and replacement at no extra cost to the Owner.

I. Sufficient sets shall be submitted to allow two (2) copies to be retained by the A/E.

J. Materials and equipment requiring submittals are listed in each section of these specifications.

**1.15 CONTRACTORS RESPONSIBILITY - SUBMITTALS**

A. The Contractor shall submit a letter with each submittal forwarded to the Architect/Engineer's office for review certifying that they have personally reviewed the material submitted and found it to be satisfactory for this project. This certification shall cover dimensional checking as well as cross checking with the Architectural, Mechanical, and/or Electrical documents to ensure that no changes will be required in other contracts.

B. Any material submitted to the Engineer's office without this Contractor's certification will be returned without action.

C. Whenever alternate equipment is submitted, it shall be accompanied by a 1/4" - 1'0" scale drawing of the mechanical equipment room showing the alternate equipment, all clearances, etc. Submittals without this information will be returned without review or comment.

**1.16 SUBSTITUTION OF EQUIPMENT**

A. Substitution of equipment of makes other than those specified, after receipt of the bid, will be approved by the A/E only if:

- The equipment proposed for substitution is equivalent or superior to equipment named in terms of construction, efficiency, and utility, and
- That the equipment named in the specifications cannot be delivered to the job in time to complete the work in proper sequence to work of other Contractors, due to conditions beyond control of the Contractor.

B. To receive consideration, requests for substitutions must be accompanied by documentary proof of equivalence or difference in price and delivery, if any, in form of certified quotations from suppliers of both specified and proposed equipment.

C. In case of a difference in price, the Owner shall receive all benefit of the difference in cost involved in any substitution, and the contract altered by change order to credit Owner with any savings so obtained.

**1.17 SERVICE AGENCIES**

A. All mechanical equipment suppliers shall have an established authorized service agency located within a 50-mile radius of the project area. Within 15 days after award of the contract, submit to the A/E for review along with the list of material and equipment manufacturer’s names, a list of prospective service agencies to be used during the guarantee period. In the event any service agency in the list fails to comply with the specification requirements; such service agency will be rejected.

## 1.18 PERFORMANCE OF EQUIPMENT

A. All materials, equipment, and appurtenances of any kind, shown on the drawings, hereinafter specified or required for the completion of the work in accordance with the intent of these specifications, shall be completely satisfactory and acceptable in operation, performance and capacity. No approval either written or verbal of any drawings, descriptive data or samples of such material, equipment, and/or appurtenances shall relieve the Mechanical Contractor of his responsibility to turn over the same to the Owner in perfect working order at the completion of the work.

B. If the operation, capacity, or performance of any material, equipment, or appurtenance, does not comply with the drawings and/or specification requirements, or is damaged prior to acceptance by the Owner, respective item(s) will be considered defective. All defective items shall be removed and replaced with proper and acceptable materials, equipment, and/or appurtenances, or, put in proper and acceptable working order, satisfactory to the A/E, prior to final payment without additional cost to the Owner.

## 1.19 GUARANTY/WARRANTY

A. Materials, equipment, and systems furnished under these specifications shall be guaranteed against defects in material, design, and workmanship.

B. Contractor shall provide a list of equipment and the warranty periods as a submittal that will be reviewed by the Owner and the design team.

C. The guarantee period shall extend until the later of:

- A period of one (1) year from the date of final acceptance,
- Eighteen (18) months from the date of initial start-up.

D. The Contractor shall replace any material or equipment that comprises a part of any system that develops any defect during the guarantee period, at their expense.

E. All refrigeration equipment, air conditioners, etc. shall be provided with five (5) year extended compressor warranty covering both labor and materials.

F. Contractor shall turn over to the owner all warranties and guarantees upon completion and final acceptance of project.

## 1.20 OPERATING AND MAINTENANCE MANUALS

A. Contractor shall submit operating and maintenance instructions for all equipment furnished by them.

B. Maintenance and operating instructions shall be manuals prepared by the various manufacturers for the specific equipment furnished. Manuals shall cover such items as start-up procedures, trouble-shooting, periodic maintenance, etc. Advertising literature or catalogs will not be acceptable in this connection.

C. Three (3) sets of the above material shall be submitted to the A/E for review and approval.

D. Final job acceptance date shall be the date stamped on the operating and maintenance instructions and the guarantee period shall generally extend from that date.

## 1.21 CHARTS

A. Provide permanent type charts, framed under glass, mounted where directed as follows:

1. Valve charts giving valve use, system, and number on tag attached to valve.
2. Equipment and motor list giving system, equipment designation, and motor horsepower.
3. Automatic temperature control schematics and sequences of operation.
4. Lubrication instructions for all equipment giving type of lubricant and frequency.
5. Service organizations with normal and emergency telephone numbers.
6. Abbreviated operating instructions for all mechanical systems.

## PART 2 - PRODUCTS

### 2.1 VIBRATION CONTROL

A. Vibration isolation devices shall be provided in accordance with Chapter 49, Table 42 (“Selection Guide for Vibration Isolation”) of the American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc.’s (ASHRAE) 2019 Application Handbook.

### 2.2 ACCESSIBILITY

A. Locate all equipment that must be serviced, operated, or maintained, in fully accessible positions. Equipment shall include, but not be limited to, VAV terminal units, coils, valves, motors, controllers, dampers, drain points, traps, strainers, etc. The contractor shall rework, at their expense, any equipment that is deemed inaccessible to the satisfaction of the A/E.

B. Where required or directed by the A/E, provide access panels for access to all equipment where no other means of access is available. All access panels shall be of sufficient size to service and remove the equipment for which they are provided, and in no case, shall they have a clear opening less than 8" x 8". Access panels shall be set flush with finished surface and shall be held securely in place by means of integral anchoring lugs.

C. In finished walls they shall be smooth, polished nickel bronze access covers and full 8" x 8" openings.

D. Those in floors shall be square nickel bronze non-slip scoriated access covers.

E. Access panels in fire rated walls, floors, shafts, and partitions shall be labeled as such

and shall match the rating of the adjacent construction.

F. Access panels larger than 12" x 12" shall be of steel construction, having frames designed to suit the various locations and materials to which they are attached. The frames shall be rabbeted to receive cover and set flush with finished wall or ceiling surface. Covers shall be of rustproof furniture steel of not less than #14 gauge and shall be secured with suitable clips and locking cams or countersunk screws. Covers shall be flush with the frames and finished wall or ceiling surface.

G. Where accessible or removable ceilings are provided, ceiling panels or tiles may be removed to serve as access panels.

H. In general, access panels will <u>not</u> be indicated on the drawings. It shall be the Contractor's responsibility to anticipate these needs and to provide access panels as previously specified.

## PART 3 - EXECUTION

### 3.1 EXAMINATION OF SITE

A. Each bidder shall be required to visit the site, examine the premises, and acquaint themselves with all existing and limiting conditions that may have bearing on the work before submitting proposals for the work. Due allowance shall be made in the bid for difficulties and contingencies that may be encountered.

B. Contractor will be allowed no extras arising out of their failure to make the above examination, or neglect to include all materials and labor required to complete the work.

C. Contractor shall familiarize themselves with all drawings and documents for the entire project.

D. By submitting a proposal, Contractor accepts the fact that tight conditions will likely occur at various locations. No extras will be approved for necessary variations and/or adjustments that may be required to resolve interferences.

E. Details of proposed changes found necessary by field conditions or other causes shall be submitted to the A/E for approval before proceeding with any such change.

F. No extra compensation will be allowed on account of a difference between actual dimensions and measurements at the site and those indicated on the drawings.

### 3.2 DIMENSIONS OF EXISTING STRUCTURES

A. Where the dimensions and locations of existing structures are of critical importance in the installation or connection of new work, verify such dimensions and locations in the field before the fabrication of any material or equipment that is dependent on the correctness of such information.

B. This stipulation applies specifically to existing sewer lines, manholes, etc. Establish exact invert of existing lines before beginning installation of any new work.

### 3.3 LINES, GRADES, AND MEASUREMENTS

A. Make all measurements and check all dimensions necessary for the proper construction of the work called for by the drawings and specifications. During the prosecution of the work, make all necessary measurements to prevent misfitting in said work, and for the accurate construction of the entire work.

### 3.4 COORDINATION

A. HVAC Contractor shall plan all phases of their portion of the project so that the work proceeds with a minimum of interference with other trades. They shall cooperate with all other Contractors in coordinating the locations of piping, ducts, etc., with lighting fixtures, structural members, sprinkler heads, etc.

B. HVAC Contractor shall check all project drawings prior to installing any equipment, pipes, ducts, etc. Any conflicts that become apparent because of cross checking drawings shall be resolved with the A/E prior to any work being done. Minor adjustments in location, size, and type of materials necessary to work out any interference shall be made at no extra cost. Being installed "first" in any situation will not be considered a factor in the proper resolution of a conflict.

### 3.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification; adequately packaged and protected to prevent damage during shipment, storage, and handing.

B. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.

C. If any materials or equipment are found to be damaged or in poor condition at the time installation, the A/E may, at their discretion, order the Contractor to furnish and install new materials or equipment at no additional expense to the owner.

## 3.6 PROTECTION

A. Protect all work, equipment, and materials at all times. All pipe openings shall be capped and plugged during installation.

B. All necessary precautions shall be taken to prevent damage to any work, materials, or equipment furnished by the Contractor. The Contractor shall be held responsible for all damage incurred to his work, materials, and equipment until his portion of the project is fully and finally accepted.

C. Drainage lines shall be kept free of dirt, concrete, or debris during construction. The contractor shall correct any blockages resulting from the above.

D. Protect make-up piping or accessories having polished, plated, or finished surfaces to avoid scarring. Protect fixtures or equipment having finished surfaces before, during, and after installation with special protective coatings for this purpose.

E. Do not install exposed polished metal fittings, parts, and devices, until adjoining tile or masonry has been finally acid cleaned.

F. All equipment, devices, controls, and motors shall be tightly covered and protected during construction up to the time of operation. Protection shall be arranged and of such design to prevent damage by infiltration of dust, dirt, debris, moisture, chemicals, or water. Minimum protection shall be by covering with transparent plastic sheeting to the satisfaction of the A/E.

G. The HVAC Contractor shall likewise protect from damage all materials, new and existing, turned over to them by others (including the Owner) for installation. The Contractor shall replace any material that becomes damaged at their expense.

## 3.7 CUTTING AND PATCHING

A. HVAC Contractor shall do all cutting necessary to properly install their materials, except as noted hereafter. This shall include cutting of existing concrete floors and walls. Cutting and patching of every nature required regarding this Contract shall be done with mechanics experienced in their respective lines of work. All patching shall match adjacent finishes.

B. All cutting in the building shall be done with great care so as not to leave an unsightly surface that may not be concealed by plates, escutcheons, or other normal concealing construction. If such unsightly conditions occur through fault of the Contractor, they shall be required to correct such deficiencies to the satisfaction of the Architect/Engineer.

C. All holes for piping shall be core drilled through existing concrete floors and walls.

D. No cutting of structural members shall be done until approval has been received from the A/E.

E. HVAC Contractor(s) shall do all patching required to restore the substrate to a condition that will readily receive new finishes. The General Contractor will provide all new finishes; tile, plaster, paint, etc.

F. HVAC Contractor shall provide the General Contractor or any other Contractors, which may be affected by his work, locations, and sizes of chases, sleeves, and openings required for installation of pipes, ducts, and other equipment. This information shall be presented to the General Contractor before pouring concrete or erecting walls to avoid unnecessary cutting and patching.

G. If openings are omitted or are incorrect through failure of the contractors to follow these instructions, the respective Contractors shall, at their own expense, engage the trade which originally installed the work, to cut and patch to the satisfaction of the A/E.

## 3.8 EQUIPMENT INSTALLATION AND CONNECTIONS

A. All equipment shall be installed and connected in accordance with the best engineering practice and in accordance with manufacturer's instructions and recommendations. Auxiliary piping, valves, and electric connections recommended by the manufacturer or required for proper operation shall be provided.

B. Any conflicts between the installation instructions indicated on the contract documents and the manufacturer's instructions and recommendations shall be brought to the attention of the A/E for resolution. The A/E's decision as to the final equipment installation and connections is final and any modifications necessary to obtain such an installation shall be made at no expense to the owner.

**3.9 MOUNTING MECHANICAL DEVICES IN SUSPENDED CEILINGS**

A. Support light troffers, air diffusers, grilles, etc. by supplementary hangers located within 6" of each corner. If the weight of the components causes the total dead load to exceed deflection capability of the main runners or cross runners, the components shall be supported independently of the suspension system by the installer of the components placed in ceiling.

B. Contractor shall carefully check existing suspension system for adequacy and completeness. He shall also test its supporting strength where additional weights are to be added due to changes of the existing HVAC or Electric systems.

**END OF SECTION**

## SECTION 230500
## COMMON WORK RESULTS FOR HVAC

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Equipment installation requirements common to equipment sections.
4. Supports and anchorages.

#### 1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

C. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

#### 1.3 SUBMITTALS

A. Welding certificates.

#### 1.4 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

#### 1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

#### 1.6 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

### PART 2 - PRODUCTS

#### 2.1 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

#### 2.2 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12.

**2.3 DIELECTRIC FITTINGS**

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

**PART 3 - EXECUTION**

**3.1 PIPING SYSTEMS - COMMON REQUIREMENTS**

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. 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, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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 to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors.

M. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

N. Verify final equipment locations for roughing-in.

O. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

P. Provide drain pans under piping installed within electrical rooms or above electrical equipment.

## 3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. 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.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

## 3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

## 3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

## 3.5 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

## 3.6 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

**END OF SECTION**

## SECTION 230513

## COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

### PART 1 - GENERAL

### 1.1 SUMMARY

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

### 1.2 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.

### 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: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 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 SINGLE-PHASE MOTORS

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

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

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

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

**PART 3 - EXECUTION (Not Applicable)**

**END OF SECTION**

## 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. Fastener systems.
5. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
3. Section 233113 "Metal Ducts" for duct hangers and supports.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

### 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."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

### PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

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

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

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

2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

## 2.2 METAL PIPE HANGERS AND SUPPORTS

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

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

## 2.3 TRAPEZE PIPE HANGERS

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

## 2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Buckaroos, Inc.
2. Carpenter & Paterson, Inc.
3. National Pipe Hanger Corporation.
4. Piping Technology & Products, Inc.
5. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psi minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate with 100-psi minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

## 2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hilti, Inc.
b. ITW Ramset/Red Head; Illinois Tool Works, Inc.

c. MKT Fastening, LLC.

d. Simpson Strong-Tie Co., Inc.

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

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

a. Hilti, Inc.

b. ITW Ramset/Red Head; Illinois Tool Works, Inc.

c. MKT Fastening, LLC.

## 2.6 EQUIPMENT SUPPORTS

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

## 2.7 MATERIALS

A. Aluminum: ASTM B 221.

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

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

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

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

1. Properties: Nonstaining, noncorrosive, and nongaseous.

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

# PART 3 - EXECUTION

## 3.1 APPLICATION

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

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

## 3.2 HANGER AND SUPPORT INSTALLATION

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

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

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

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

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

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

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

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

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

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

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

K. Install building attachments within concrete slabs or attach to structural steel. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

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

N. Insulated Piping:

1. Attach clamps and spacers to piping.
    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
    a. Option: Thermal-hanger shield inserts may be used.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
    a. Option: Thermal-hanger shield inserts may be used.
4. Shield Dimensions for Pipe: Not less than the following:
    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

## 3.3 EQUIPMENT SUPPORTS

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

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

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

## 3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for 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.

## 3.5 ADJUSTING

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

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

## 3.6 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. Touchup: Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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

## 3.7 HANGER AND SUPPORT SCHEDULE

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

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

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

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

E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems 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.
2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
3. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
4. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
5. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
6. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
7. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
8. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

K. 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. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

L. 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.
6. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
7. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
8. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

9. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
10. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
11. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
12. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

M. 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.

N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

**END OF SECTION**

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## SECTION 230553
## IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### PART 2 - PRODUCTS

### 2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Brimar Industries, Inc.
    b. Carlton Industries, LP.
    c. Craftmark Pipe Markers.
    d. LEM Products Inc.
    e. Marking Services, Inc.
2. Material and Thickness: Brass, 0.032-inch stainless steel, 0.025-inch aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
3. Letter Color: Black.
4. Background Color: White.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Brady Corporation.
    b. Brimar Industries, Inc.
    c. Carlton Industries, LP.
    d. LEM Products Inc.
    e. Marking Services, Inc.

2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
3. Letter Color: Black.
4. Background Color: White.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.
4. LEM Products Inc.
5. Marking Sevices Inc.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

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

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

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

## 2.3 DUCT LABELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
2. Brimar Industries, Inc.
3. Carlton Industries, LP.

4. LEM Products Inc.
5. Marking Sevices Inc.

B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

C. Letter Color: Black.

D. Background Color: White.

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

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

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

H. Fasteners: Stainless-steel rivets or self-tapping screws.

I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

## 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. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces:

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 major equipment items and other points of origination and termination.
4. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
5. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Pipe Label Color Schedule:

1. Refrigerant Piping: Black letters on a safety-orange background.

### 3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.

3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

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

**END OF SECTION**

## SECTION 230593

## TESTING, ADJUSTING, AND BALANCING FOR HVAC

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

a. Constant-volume air systems.

b. Variable-air-volume systems.

### 1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

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

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

F. TDH: Total dynamic head.

### 1.3 ACTION SUBMITTALS

A. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

### 1.4 INFORMATIONAL SUBMITTALS

A. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

B. Certified TAB reports.

### 1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.

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

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

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

### PART 2 - PRODUCTS (Not Applicable)

### PART 3 - EXECUTION

### 3.1 EXAMINATION

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

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

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

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

E. Examine equipment performance data including fan curves.

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

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

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

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

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

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

J. Examine 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 for balancing the systems.

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

1. Airside:

a. Duct systems are complete with terminals installed.

b. Volume and fire dampers are open and functional.

c. Clean filters are installed.

d. Fans are operating, free of vibration, and rotating in correct direction.

e. Variable-frequency controllers' startup is complete and safeties are verified.

f. Automatic temperature-control systems are operational.

g. Ceilings are installed.

h. Windows and doors are installed.

i. Suitable access to balancing devices and equipment is provided.

## 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in 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, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."

2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation.”

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

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

## 3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

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

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

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

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

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

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

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

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

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

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

## 3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

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

1. Measure total airflow.
    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
2. Measure fan static pressures as follows:
    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.
3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

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

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

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

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

## 3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

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

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
    f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
    g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.

b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.

c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.

d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.

b. Measure static pressure directly at the fan inlet or through the flexible connection.

c. Measure static pressure across each component that makes up the air-handling system.

d. Report any artificial loading of filters at the time static pressures are measured.

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

a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.

b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.

9. Verify final system conditions as follows:

a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.

b. Re-measure and confirm that total airflow is within design.

c. Re-measure final fan operating data, rpms, volts, amps, and static profile.

d. Mark final settings.

e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.

f. Verify tracking between supply and return fans.

## 3.7 TOLERANCES

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

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.

2. Air Outlets and Inlets: Plus or minus 10 percent.

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

## 3.8 FINAL REPORT

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

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.

2. Include a list of instruments used for procedures, along with proof of calibration.

3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Fan curves.
   2. Manufacturers' test data.
   3. Field test reports prepared by system and equipment installers.
   4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

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

D. System Diagrams: Include schematic layouts of air distribution systems. Present each system with single-line diagram and include the following:
   1. Quantities of outdoor, supply, return, and exhaust airflows.
   2. Duct, outlet, and inlet sizes.
   3. Terminal units.
   4. Balancing stations.
   5. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
    1. Unit Data:
        a. Unit identification.
        b. Location.
        c. Make and type.
        d. Model number and unit size.
        e. Manufacturer's serial number.
        f. Unit arrangement and class.
        g. Discharge arrangement.
        h. Sheave make, size in inches, and bore.
        i. Center-to-center dimensions of sheave and amount of adjustments in inches.
        j. Number, make, and size of belts.
        k. Number, type, and size of filters.
    2. Motor Data:
        a. Motor make, and frame type and size.
        b. Horsepower and rpm.
        c. Volts, phase, and hertz.
        d. Full-load amperage and service factor.
        e. Sheave make, size in inches, and bore.
        f. Center-to-center dimensions of sheave and amount of adjustments in inches.
    3. Test Data (Indicated and Actual Values):
        a. Total airflow rate in cfm.
        b. Total system static pressure in inches wg.
        c. Fan rpm.
        d. Discharge static pressure in inches wg.
        e. Filter static-pressure differential in inches wg.
        f. Cooling-coil static-pressure differential in inches wg.
        g. Outdoor airflow in cfm.
        h. Return airflow in cfm.
        i. Outdoor-air damper position.
        j. Return-air damper position.
F. Apparatus-Coil Test Reports:
    1. Coil Data:
        a. System identification.
        b. Location.
        c. Coil type.
        d. Number of rows.
        e. Fin spacing in fins per inch o.c.
        f. Make and model number.
        g. Face area in sq. ft..
        h. Tube size in NPS.

i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Refrigerant expansion valve and refrigerant types.
   i. Refrigerant suction pressure in psig.
   j. Refrigerant suction temperature in deg F.

G. Gas-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Fuel type in input data.
   g. Output capacity in Btu/h.
   h. Ignition type.
   i. Burner-control types.
   j. Motor horsepower and rpm.
   k. Motor volts, phase, and hertz.
   l. Motor full-load amperage and service factor.
   m. Sheave make, size in inches, and bore.
   n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Entering-air temperature in deg F.
   c. Leaving-air temperature in deg F.
   d. Air temperature differential in deg F.
   e. Entering-air static pressure in inches wg.
   f. Leaving-air static pressure in inches wg.
   g. Air static-pressure differential in inches wg.
   h. Low-fire fuel input in Btu/h.
   i. High-fire fuel input in Btu/h.
   j. Manifold pressure in psig.

k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
1. Unit Data:
a. System identification.
b. Location.
c. Coil identification.
d. Capacity in Btu/h.
e. Number of stages.
f. Connected volts, phase, and hertz.
g. Rated amperage.
h. Airflow rate in cfm.
i. Face area in sq. ft..
j. Minimum face velocity in fpm.
2. Test Data (Indicated and Actual Values):
a. Heat output in Btu/h.
b. Airflow rate in cfm.
c. Air velocity in fpm.
d. Entering-air temperature in deg F.
e. Leaving-air temperature in deg F.
f. Voltage at each connection.
g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.
2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.

e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

J. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

K. Air-Terminal-Device Reports:

1. Unit Data:
a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.

2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

L. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.

b. Serial number.

c. Application.

d. Dates of use.

e. Dates of calibration.

## 3.9 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

**END OF SECTION**

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# SECTION 230713
# DUCT INSULATION

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, concealed return located in unconditioned space.
3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
4. Exposed, Outdoor-Air Duct and Plenum Insulation.

B. Related Sections:

1. Section 230719 "HVAC Piping Insulation."
2. Section 233113 "Metal Ducts" for duct liners.

### 1.2 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

### 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 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. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

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

F. Rigid fiberglass Insulation System: Insulation shall be rigid fiberglass insulation system for hot and cold temperature service consisting of a rigid board of glass fibers with a non-combustible vapor barrier facing. Board shall be UL labeled, "K" of 0.25 at 75°F mean temperature, 3 lb. density. Facing shall be type FRK consisting of a foil reinforced Kraft vapor barrier laminate.

G. 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.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. CertainTeed Corporation.
    b. Johns Manville; a Berkshire Hathaway company.
    c. Knauf Insulation.
    d. Manson Insulation Inc.
    e. Owens Corning.

## 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.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Childers Brand; H. B. Fuller Construction Products.
    b. Eagle Bridges - Marathon Industries.
    c. Foster Brand; H. B. Fuller Construction Products.
    d. Mon-Eco Industries, Inc.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Childers Brand; H. B. Fuller Construction Products.
    b. Eagle Bridges - Marathon Industries.
    c. Foster Brand; H. B. Fuller Construction Products.
    d. Mon-Eco Industries, Inc.

## 2.3 MASTICS

A. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Childers Brand; H. B. Fuller Construction Products.
    b. Foster Brand; H. B. Fuller Construction Products.
    c. Knauf Insulation.
    d. Vimasco Corporation.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

5. Color: White.

B. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Foster Brand; H. B. Fuller Construction Products.
   c. Knauf Insulation.
   d. Vimasco Corporation.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

## 2.4 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Childers Brand; H. B. Fuller Construction Products.
   b. Eagle Bridges - Marathon Industries.
   c. Foster Brand; H. B. Fuller Construction Products.
   d. Mon-Eco Industries, Inc.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.

## 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 FIELD-APPLIED JACKETS

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

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

## 2.7 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Avery Dennison Corporation, Specialty Tapes Division.
   b. Ideal Tape Co., Inc., an American Biltrite Company.
   c. Knauf Insulation.
   d. Venture Tape.
2. Width: 3 inches.

3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

## 2.8 SECUREMENTS

A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ITW Insulation Systems; Illinois Tool Works, Inc.
      b. RPR Products, Inc.

B. Insulation Pins and Hangers:
   1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) AGM Industries, Inc.
         2) Gemco.
         3) Hardcast, Inc.
         4) Midwest Fasteners, Inc.
         5) Nelson Stud Welding.
      b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
      c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
      d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. C & F Wire.

# 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 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 2 inches o.c.

a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints 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.

### 3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at 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" for firestopping and fire-resistive joint sealers.

### 3.4 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 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts (except for top surface of horizontal rectangular ducts) and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    a. On duct sides with dimensions 18 inches 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.

## 3.5 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

## 3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. 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.

C. 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 and outdoor air.
2. Indoor, concealed return located in unconditioned space.
3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:
1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

## 3.8 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick (R-5) and 0.75-lb/cu. ft. nominal density.

B. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick (R-5) and 0.75-lb/cu. ft. nominal density.

C. Concealed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick (R-5) and 0.75-lb/cu. ft. nominal density.

D. Exposed, Duct and Plenum Insulation (ductwork in Process Areas to be considered Exposed): Rigid fiberglass insulation system, 2 inches (R-5) and 0.75-lb/cu. ft. nominal density.

**END OF SECTION**

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

## PART 1 – GENERAL

### 1.1 GENERAL

A. Scope of Work

B. Approved Control System Contractors/Manufacturers

C. Quality Assurances

D. Submittals

E. Warranty

F. System Maintenance

### 1.2 SCOPE OF WORK

A. The control system shall be as described in the specifications, and shall consist of a peer-to-peer network of digital building control panels and an operator workstation. The user interface shall also be through any personal computer available on the network. The PC shall provide users an interface with the system through dynamic color graphics of building areas and systems.

B. Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of systems defined for control on this project.

C. The control system shall accommodate simultaneous multiple user operation. Access to the control system data should be limited by operator ID and password. An operator shall be able to log onto any PC on the designated network and have access to all designated data.

D. The control system shall be designed such that each mechanical system will operate under stand-alone control. As such, in the event of a network communication failure, or the loss of other controllers, the control system shall continue to independently operate the unaffected equipment.

E. Communication between the control panels and all workstations shall be over a high-speed network. All nodes on this network shall be peers. Internet connectivity shall be provided for remote access to the system.

### 1.3 APPROVED CONTROL SYSTEM CONTRACTORS AND MANUFACTURERS

A. Trane Tracer, SC or approved equivalent by:

B. Johnson Controls, Metasys

C. NRG Controls, Schneider Electric

### 1.4 QUALITY ASSURANCES

A. System Installer Qualifications

1. The installer shall have an established working relationship with the control system manufacturer of not less than three years.

2. The installer shall have successfully completed control system manufacturer's classes on the control system. The installer shall present for review the certification of completed training, including the hours of instruction and course outlines upon request.

3. The installer shall have an office within 50 miles of the project site and provide 24-hour response in the event of a customer call.

## 1.5 SUBMITTALS

A. Contractor shall provide shop drawings and manufacturers' standard specification data sheets on all hardware and software to be provided. No work may begin on any segment of this project until the Engineer and Owner have reviewed submittals for conformity with the plan and specifications. Six (6) copies are required unless specifically noted that electronic copies are acceptable. All shop drawings shall be provided to the Owner electronically as .dwg or .dxf file formats.

1. Quantities of items submitted shall be reviewed by the Engineer and Owner. Such review shall not relieve the contractor from furnishing quantities required for completion.
2. Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with these specifications or which is deemed valuable in documenting the system to be installed.
3. Submit the following within 30 days of contract award:
    a. A complete bill of materials of equipment to be used indicating quantity, manufacturer and model number.
    b. A schedule of all control dampers. This shall include the damper size, pressure drop, manufacturer and model number.
    c. Provide manufacturers cut sheets for major system components. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is being submitted to cover. Include:
        1) Building Controllers
        2) Custom Application Controllers
        3) Application Specific Controllers
        4) Operator Interface Computer
        5) Auxiliary Control Devices
        6) Proposed control system riser diagram showing system configuration, device locations, addresses, and cabling.
        7) Detailed termination drawings showing all required field and factory terminations. Terminal numbers shall be clearly labeled.
        8) Points list showing all system objects, and the proposed English language object names.
        9) Sequence of operations for each system under control. This sequence shall be specific for the use of the control system being provided for this project.
        10) Provide a BACnet Product Implementation Conformance Statement (PICS) for each BACnet device type in the submittal.
        11) Color prints of proposed graphics with a list of points for display.

B. Project Record Documents. Upon completion of installation submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:

1. Project Record Drawings. These shall be as-built versions of the submittal shop drawings. One set of electronic media including CAD .DWG or .DXF drawing files shall also be provided.
2. Testing and Commissioning Reports and Checklists.

3. Operating and Maintenance (O & M) Manual. These shall be as-built versions of the submittal product data. In addition to that required for the submittals, the O & M manual shall include:
    a. Names, address and 24-hour telephone numbers of Contractors installing equipment, and the control systems and service representative of each.
    b. Operators Manual with procedures of operating the control systems including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
    c. Programming Manual with a description of the programming language including syntax, statement descriptions including algorithms and calculations used, point database creation and modification, program creation and modification, and use of the editor.
    d. Engineering, Installation and Maintenance Manual(s) that explains how to design and install new points, panels, and other hardware; preventative maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware. A listing and documentation of all custom software created using the programming language including the point database. One set of magnetic media containing files of the software and database shall also be provided.
    e. One set of electronic media containing files of all color-graphic screens created for the project.
    f. Complete original issue documentation, installation, and maintenance information for all third-party hardware provided including computer equipment and sensors.
    g. Complete original issue media for all software provided including operating systems, programming language, operator workstation software, and graphics software.
    h. Licenses and warranty documents for all equipment and systems.
    i. Recommended preventive maintenance procedures for all system components including a schedule of tasks, time between tasks, and task descriptions.

C. Training Materials: The Contractor shall provide a course outline and training material for all training classes at least six weeks prior to the first class. The Owner reserves the right to modify any or all of the training course outline and training materials. Review and approval by Owner and Engineer shall be completed at least 3 weeks prior to first class.

## 1.6 WARRANTY

A. Warrant all work as follows:
1. Labor and materials for control system specified shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. Control System failures during the warranty period shall be adjusted, repaired, or replaced at no charge or reduction in service to the Owner. The Contractor shall respond to the Owner's request for warranty service within 24 hours during customary business hours.
2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of warranty.
3. Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the Owner at no charge during the warranty period. Written authorization by Owner must, however, be granted prior to the installation of such changes.
4. The system provider shall provide a web-accessible system and support on-line resource that provides the Owner access to a question/answer forum, graphics library, user tips, upgrades, and manufacturer training schedules.

## 1.7 SYSTEM MAINTENANCE

A. Perform Building Automation System preventative maintenance and support for a period of one year (beginning the date of substantial completion).

1. Make a minimum of 2 complete Building Automation System inspections (onsite or remote), in addition to normal warranty requirements. Inspections to include.

a. System Review – Review the BAS to correct, failed points, points in alarm, and points that have been overridden manually.

b. Seasonal Control Loop Tuning – Control loops are reviewed to reflect changing seasonal conditions and / or facility heating and cooling loads

c. Sequence of operation verification – Systems all verified to be operating as designed and in automatic operation. Scheduling and setpoints are reviewed and modified.

d. Setback adjustment tuning

e. Database back-up

f. Operator coaching

g. Technician shall review critical alarm log and advise owner of additional services that may be required.

2. Provide local remote monitoring services within 50 miles of the project site to access and diagnose system capabilities and troubleshooting of the Building Automation System to assist with inspections and any service calls needed. Owner to provide VPN access to building network if firewall exists.

# PART 2 - PRODUCTS

## 2.1 PART INCLUDES

A. General Description

B. Architecture/Communication

C. Operator Interface

D. Application and Control Software

E. System Controllers

F. Input/Output Modules

G. Unit Level Controllers

H. Auxiliary Control Devices

I. Local Control Panels.

## 2.2 GENERAL DESCRIPTION

A. The Trane Tracer SC system is an open protocol web-based building automation system (BAS) which utilizes a tier network of system level and unit level direct digital controllers to control and manage the building HVAC. The use of wired and secure wireless communication protocols adds to the flexibility of the system. The BAS system has the ability to integrate multiple other building systems through the open communication BACnet/IP to provide a single multiple user access point to the facilities automated systems, all through a common internet browser.

## 2.3 ARCHITECTURE/COMMUNICATION

A. This project shall be comprised of a high-speed Ethernet network utilizing BACnet/IP communications between System Controllers and Workstations. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall utilize BACnet MSTP (RS485) communications.

1. Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using BACnet/MSTP (RS485) as defined by the BACnet standard.

a. Each System Controller shall function as a BACnet Router to each unit controller providing a unique BACnet Device ID for all BACnet/MSTP controllers within the system.

2. The Owner will provide all communication media, connectors, repeaters, network switches, and routers necessary for the high-speed Ethernet network. An active Ethernet port will be provided adjacent to each System Controller and operator interface (PC) for connection to this high-speed Ethernet network.

3. All values within the system (i.e. schedules, data logs, points, software variables, custom program variables) shall be readable and controllable (where appropriate) by any System Controller or BACnet Workstation on the communications network via BACnet.

B. Wireless equipment controllers and auxiliary control devices shall conform to:

1. IEEE 802.15.4 radios to minimize risk of interference and maximize battery life, reliability, and range.

2. Operating range shall be a minimum of 200 feet; open range shall be 2,500 ft. (762 m) with less than 2% packet error rate.

3. To check for proper operation, wireless zone temperature sensors shall include a signal strength and battery condition indicators on the zone sensor display or using LED’s on non-display models.

4. To maintain robust communication, two-way communications shall be used between the wireless zone sensor and receiver to allow channel switching based on varying channel traffic and signal strength.

5. The wireless zone sensor and receiver addresses shall be held in non-volatile memory to ensure operation through system voltage disturbances and to minimize the risk of incorrect association.

6. The wireless zone sensor and receiver shall be addressed using rotary switches with numerical indication to simplify and reduce installation time and minimize risk of incorrect addressing. Two position DIP switches are not acceptable.

7. Installation and replacement of failed sensors shall be accomplished automatically after power up.

8. To allow local troubleshooting without specialized tools, error codes shall be displayed on the digital display through a blinking pattern on the non-display models. Error codes shall include: not associated, address to 000, improper software configuration, input voltage too high, or general sensor failure. Codes shall be indicated on inside of sensor back cover.

9. Certifications shall include FCC CFR47 - RADIO FREQUENCY DEVICES - Section 15.247 & Subpart E.

## 2.4 OPERATOR INTERFACE

A. The building owner shall furnish all PC based operator interfaces as shown on the system drawings. Each operator interface shall be able to access all information in the system. The operator interface shall reside on the Enterprise-wide network, which is same high-speed communications network as the System Controllers. The Enterprise-wide network will be provided by the owner and supports the Internet Protocol (IP).

1. Each PC based operator interface shall include the following:
    a. Hardware type
    b. PC
2. Operating Systems
    a. Windows XP
    b. Windows 7
3. Minimum Hardware
    a. Pentium Core 2 DUO or better
    b. 4 GB RAM
    c. 100 GB hard drive space
    d. Internet Browser compatible with operator interface requirements outlined in the operator interface section.
    e. Java Runtime Environment (JRE) V6.0 or higher
4. Operator Interface
    a. The operator interface shall be accessible via a web browser.
    b. The operator interface shall support the following Internet web browsers:
        1) Internet Explorer 8.0+
        2) Firefox 4.0+
        3) Chrome 10.0+
    c. The operator interface shall support the following mobile web browsers:
        1) iOS (iPad/iPhone) V4.0+
        2) Android (Tablet) V4.0+
        3) Android (Phone) V2.3+
    d. System Security
        1) Each operator shall be required to login to the system with a user name and password in order to view, edit, add, or delete data.
        2) User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.
        3) Each operator shall be allowed to change their user password
        4) The System Administrator shall be able to manage the security for all other users
        5) The system shall include pre-defined “roles” that allow a system administrator to quickly assign permissions to a user.
        6) User logon/logoff attempts shall be recorded.
        7) The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
        8) All system security data shall be stored in an encrypted format.

e. Database

1) Save. A system operator with the proper password clearance shall be able to archive the Database data-base on the designated operator interface PC.

2) Database Restore. The system operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.

f. On-Line Help and Training

1) Provide a context sensitive, on line help system to assist the operator in operation and configuration of the system.

2) On-line help shall be available for all system functions and shall provide the relevant data for each screen.

g. System Diagnostics

1) The system shall automatically monitor the operation of all network connections, building management panels, and controllers.

2) The failure of any device shall be annunciated to the operator.

h. Equipment & Application Pages

1) The operator interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application, including:

a) Animated Equipment Graphics for each major piece of equipment and floor plan in the System. This includes:

- Each Rooftop Unit, Rooftop Unit, Variable Air Volume Box, Exhaust Fan, etc. These graphics shall show all points dynamically as specified in the points list.
- Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog outputs, such as damper positions. Graphics shall be capable of launching other web pages.

2) Alarms relevant to the equipment or application without requiring a user to navigate to an alarm page and perform a filter.

3) Historical Data (As defined in Automatic Trend Log section below) for the equipment or application without requiring a user to navigate to a data log page and perform a filter.

i. System Graphics

1) Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point.

2) Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point and-click navigation between zones or equipment, and to edit set points and other specified parameters.

3) Graphic imagery. Graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.

4) Animation. Graphics shall be able to animate by displaying different Image lies for changed object status.

5) Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.

6) Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).

j. Custom Graphics

1) The operator interface shall be capable of displaying custom graphics in order to convey the status of the facility to its operator.

2) Graphical Navigation. The operator interface shall provide dynamic color graphics of building areas, systems and equipment.

3) Graphical Data Visualization. The operator interface shall support dynamic points including analog and binary values, dynamic text, static text, and animation files.

4) Custom background images. Custom background images shall be created with the use of commonly available graphics packages such as Adobe Photoshop. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as GIF and JPEG.

k. Graphics Library

1) Furnish a library of standard HVAC equipment such as chillers, air handlers, terminals, fan coils, unit ventilators, rooftop units, and VAV boxes, in 3-dimensional graphic depictions. The library shall be furnished in a file format compatible with the graphics generation package program.

l. Manual Control and Override

1) Point Control. Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs.

2) Temporary Overrides. The user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.

3) Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.

4) Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually.

m. Engineering Units

1) Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system.

2) Unit selection shall be able to be customized by locality to select the desired units for each measurement.

3) Engineering units on this project shall be IP.

B. Scheduling. A user shall be able to perform the following tasks utilizing the operator interface:

1. Create a new schedule, defining the default values, events and membership.
2. Create exceptions to a schedule for any given day.
3. Apply an exception that spans a single day or multiple days.
4. View a schedule by day, week and month.
5. Exception schedules and holidays shall be shown clearly on the calendar.

6. Modify the schedule events, members and exceptions.

C. Trend Logs

1. Trend Logs Definition

   a. The operator interface shall allow a user with the appropriate security permissions to define a trend log for any data in the system.

   b. The operator interface shall allow a user to define any trend log options as described in the Application and Control Software section.

2. Trend Log Viewer

   a. The operator interface shall allow Trend Log data to be viewed and printed.

   b. The operator interface shall allow a user to view trend log data in text-based (time – stamp/value).

   c. The operator shall be able to view the data collected by a trend log in a graphical chart in the operator interface.

   d. Trend log viewing capabilities shall include the ability to show a minimum of 5 points on a chart.

   e. Each data point trend line shall be displayed as a unique color.

   f. The operator shall be able to specify the duration of historical data to view by scrolling and zooming.

   g. The system shall provide a graphical trace display of the associated time stamp and value for any selected point along the x-axis.

3. Export Trend Logs

   a. The operator interface shall allow a user to export trend log data in CSV or PDF format for use by other industry standard word processing and spreadsheet packages.

4. Alarm/Event Notification

   a. An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.

   b. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any operator interface.

      1) The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity.

      2) Alarm/event messages shall use full language, easily recognized descriptors.

      3) An operator with the proper security level may acknowledge and clear alarms/events.

      4) All alarms/events that have not been cleared by the operator shall be stored by the building controller.

      5) The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.

   c. Alarm Processing

      1) The operator shall be able to configure any object in the system to generate an alarm when transitioning in and out of a normal state.

      2) The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system.

5. Reports and Logs

   a. The operator interface shall provide a reporting package that allows the operator to select reports.

b. The operator interface shall provide the ability to schedule reports to run at specified intervals of time.

c. The operator interface shall allow a user to export reports and logs from the building controller in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Acceptable formats include:

1) CSV, HTML, XML, PDF

d. Reports and logs shall be readily printed to the system printer.

e. Provide a means to list and access the last 10 reports viewed by the user.

f. The following standard reports shall be available without requiring a user to manually configure the report:

1) All Points in Alarm Report: Provide an on-demand report showing all current alarms.

2) All Points in Override Report: Provide an on-demand report showing all overrides in effect.

3) Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.

4) Points report: Provide a report that lists the current value of all points.

6. Custom Application Programming. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs while all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded.

7. Custom Graphic Editor. Provide the tools to create, modify, and debug custom graphics. The operator shall be able to create, edit, and download custom graphics at the same time that all other system applications are operating. The system shall be fully operable while custom graphics are edited, compiled, and downloaded.

## 2.5 APPLICATION AND CONTROL SOFTWARE

A. Furnish the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the operator interface.

1. Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to [10] events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:

a. Weekly Schedule. Provide separate schedules for each day of the week.

b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard schedule for that day of the week.

c. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

d. Optimal Start. The scheduling application outlined above shall support an optimal start algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less then and greater than 24 hours. Provide the ability to modify the start algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit.

2. Trend Log Application

a. Trend log data shall be sampled and stored on the System Controller panel and shall capable of being archived to a BACnet Workstation for longer term storage.

1) Trend logs shall include interval, start-time, and stop-time.

2) Trend log intervals shall be configurable as frequently as 1 minute and as infrequently as 1 year.

b. Automated Trend Logs

1) The system controller shall automatically create trend logs for defined key measurements for each controlled HVAC device and HVAC application.

2) The automatic trend logs shall monitor these parameters for a minimum of 7 days at 15-minute intervals. The automatic trend logs shall be user adjustable.

c. Alarm/Event Log

1) Any object in the system shall be configurable to generate an alarm when transitioning in and out of a normal or fault state.

2) Any object in the system shall allow the alarm limits, warning limits, states, and reactions to be configured for each object in the system.

3) An alarm/event shall be capable of triggering any of the following actions:

a) Route the alarm/event to one or more alarm log

4) The alarm message shall include the name of the alarm location, the device that generated the alarm, and the alarm message itself.

a) Route an e-mail message to an operator(s)

b) Log a data point(s) for a period of time

c) Run a custom control program

3. Point Control. User shall have the option to set the update interval, minimum on/off time, event notification, custom programming on change of events.

4. Timed Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, operator interface, or the local operator display. The amount of time that the override takes precedence will be selectable from the operator interface.

5. Anti-Short Cycling. All binary output points shall be protected from short cycling

## 2.6 SYSTEM CONTROLLERS

A. There shall be one or more independent, standalone microprocessor-based system controllers to manage the global strategies described in application and control software section.

1. The System Controller shall have sufficient memory to support its operating system, database, and programming requirements.

2. The controller shall provide a USB communications port for connection to a PC

3. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.

4. All System Controllers shall have a real-time clock.
5. Data shall be shared between networked System Controllers.
6. The System Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
    a. Assume a predetermined failure mode.
    b. Generate an alarm notification.
    c. Create a retrievable file of the state of all applicable memory locations at the time of the failure.
    d. Automatically reset the System Controller to return to a normal operating mode.
7. Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at -40 F to 122 F.
8. Clock Synchronization
    a. All System Controllers shall be able to synchronize with a NTP server for automatic time synchronization.
    b. All System Controllers shall be able to accept a BACnet time synchronization command for automatic time synchronization.
    c. All System Controllers shall automatically adjust for daylight savings time if applicable.
9. Serviceability
    a. Provide diagnostic LEDs for power, communications, and processor.
    b. The System Controller shall have a display on the main board that indicates the current operating mode of the controller.
    c. All wiring connections shall be made to field removable, modular terminal connectors.
    d. The System controller shall utilize standard DIN mounting methods for installation and replacement.
10. Memory. The System Controller shall maintain all BIOS and programming information indefinitely without power to the System controller.
11. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shut-down below 80% nominal voltage
12. BACnet Test Labs (BTL) Listing. Each System Controller shall be listed as a Building Controller (B-BC) by the BACnet Test Labs

## 2.7 INPUT/OUTPUT INTERFACE

A. Hard-wired inputs and outputs may tie into the system through Custom, or Application Specific Controllers.

B. All input points and output points shall be protected such that shorting of the point to itself, another point, or ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to the controller.

C. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices.

D. Pulse accumulation input points. This type of point shall conform to all the requirements of Binary Input points, and accept up to 3 pulses per second for pulse accumulation, and shall be protected against effects of contact bounce and noise.

E. Analog inputs shall allow the monitoring of low voltage (0-10 Vdc), current (4-20 ma), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.

F. Binary outputs shall provide for on/off operation. Terminal unit and zone control applications may use 2 outputs for drive-open, drive-close (tri-state) modulating control.

G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0-10 Vdc or a 4-20 ma signal as required to provide proper control of the output device.

## 2.8 UNIT LEVEL CONTROLLERS

A. Programmable Controllers

1. Environment. Controller hardware shall be suitable for the anticipated ambient conditions.

a. Controller used in conditioned ambient shall be mounted in NEMA 1 type enclosures, and shall be rated for operation at 0 C to 50 C [32 F to 120 F].

b. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40 F to 158 F.

2. Serviceability. Custom Application Controller shall possess diagnostic LED's indicating power, communications, and processor functions. All wiring connections shall be terminated at field removable, modular terminal strips, or at communication board.

3. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for minimum of (72) continuous hours.

B. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

C. Application Specific Controllers (ASC) shall be microprocessor-based DDC controllers which through hardware or firmware design control specified equipment. They are not user programmable, but are customized for operation within the confines of the equipment they are designed to serve.

1. Application Specific Controller are only allowed when both the following:

a. The equipment is compressor based or boiler based and

b. The controller is provided by the equipment manufacturer and warrantied as part of the equipment.

D. Zone Controllers are controllers that operate equipment that control the space temperature of single zone. Examples are controllers for VAV, Fan coil, Blower Coils, Unit Ventilators, Heat Pumps, and Water Source Heat Pumps.

1. Software

a. To meet the sequence of operation for each zone control, the controller shall use programs developed and tested by the controller manufacturer that are either factory loaded or downloaded with service tool to the controller.

b. Stand-Alone Operation: Each piece of equipment specified in section A shall be controlled by a single controller and provide stand-alone control in the event of communication failure. In case of communications failure stand-alone operation shall use default values or last values for remote sensors read over the network such as outdoor air temperature.

c. For controlling ancillary devices and for flexibility to change to sequence of operation in the future, the controller shall be capable running custom programs written in a graphical programming language.

2. Environment Controller hardware shall be suitable for the anticipated ambient conditions:

a. Storage: -55 to 203 ºF (-48 to 95ºC) and 5 to 95% Rh, non-condensing.

b. Operating: -40 to 158 ºF (-40 to 70 ºC) and 5 to 95% Rh, non-condensing.

c. Controllers used indoors shall be mounted in a NEMA 1 enclosure at a minimum

d. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40 F to 158 F [-40 C to 70 C].

3. Input/Output

   a. For flexibility in selection and replacement of valves, the controllers shall be capable of supporting all of the following valve control types 0-10VDC, 0-5VDC, 4-20mA, 24VAC floating point, 24VAC - 2 position (Normally Open or Normally Closed).

   b. For flexibility in selection and replacement of sensors, the controllers shall be capable of reading sensor input ranges of 0 to10V, 0 to 20mA, pulse counts, and 200 to 20Kohm.

   c. For flexibility in selection and replacement of binary sensors, the controller shall support dry and wetted (24VAC) binary inputs.

   d. For flexibility in selection and replacement devices, the controllers shall have binary output which are able to drive at least 12VA each.

   e. For flexibility in selection and replacement of motors, the controller shall be capable of outputting 24VAC (binary output), DC voltage (0 to 10VDC minimum range) and PWM (in the 80 to 100 Hz range).

   f. For future needs, any I/O that is unused by functionality of equipment control shall be available to be used by custom program on the controller and by another controller on the network.

   g. For future expansion and flexibility, the controller shall have either on board or through expansion, 50 hardware input/output points. Expansion points must communicate with the controller via an internal communications bus. Expansion points must be capable of being mounted up to 200 meters from the controller. Expansion points that require the BACnet network for communication with the controller are not allowed.

4. Serviceability. The controller shall provide the following in order to improve serviceability of the controller:

   a. Diagnostic LEDs shall indicate correct operation or failures/faults for all the following: power, sensors, BACnet communications, and I/O communications bus.

   b. All binary output shall have LED's indicating the output state.

   c. All wiring connections shall removable without the use of a tool.

   d. Software service tool connection through all of the following methods: direct cable connection to the controller, connection through another controller on BACnet link and through the controller's zone sensor.

   e. For safety purposes, the controller shall be capable of being powered by a portable computer for the purposes of configuration, programming, and testing programs so that this work can be accomplished with the power off to the equipment.

   f. Capabilities to temporarily override of BACnet point values with built-in time expiration in the controller.

   g. BACnet Mack Address shall be set using decimal (0-9) based rotary switches.

   h. Configuration change shall not be made in a programming environment, but rather by a configuration page utilizing dropdown list, check boxes, and numeric boxes.

   i. BACnet trending objects resident on controller

      1) Minimum of 20,000 trending points total on controller

      2) Shall be capable of trending all BACnet points used by controller

      3) Shall be capable of 1 second sample rates on all points

j. Software Retention. All Zone Controller operating parameters, setpoints, BIOS, and sequence of operation code must be stored in non-volatile memory in order to maintain such information for months without power.

k. Transformer for the controller must be rated at minimum of 115% of ASC power consumption, and shall be fused or current limiting type. 24 VAC, +/- 15% nominal, 50-60 Hz, 24 VA plus binary output loads, for a maximum of 12 VA for each binary output.

l. Agency Approval. The controller shall have Agency Compliance:

1) UL916 PAZX, Open Energy Management Equipment

2) UL94-5V, Flammability

3) FCC Part 15, Subpart B, Class B Limit

## 2.9 AUXILIARY CONTROL DEVICES

A. Motorized dampers and actuators shall be provided by ATC Contractor.

B. Provide all automatic dampers not specified elsewhere in the Specifications. These dampers shall be of heavy gauge steel construction, tight shutoff type, with replaceable elastomer seals along the blade edges and damper frames. These dampers are standard size dampers, to be installed by the Mechanical Contractor. Dampers maximum leakage rate shall be 3 CFM/ft$^2$ at 1-inch water gauge.

C. Electric Damper Actuators

1. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.

2. Where shown, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.

3. All rotary spring return actuators shall be capable of both clockwise or counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.

4. Proportional actuators shall accept a 0-10 VDC or 0-20 ma control signal and provide a 2-10 VDC or 4-20 ma operating range.

5. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.

6. Actuators shall be provided with a conduit fitting and a minimum 1m electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

7. Actuators shall be Underwriters Laboratories Standard 873 listed.

8. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.

D. Binary Temperature Devices

1. Low-Voltage Space Thermostats shall be 24 V, bimetal-operated, mercury-switch type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 55°F-85°F setpoint range, 2°F maximum differential, and vented cover.

2. Line-Voltage Space Thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 55°F-85°F setpoint range, 2°F maximum differential, and vented cover.

3. Low-Limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 20 ft long. Element shall sense temperature in each 1 ft section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

E. Temperature Sensors

1. Temperature sensors shall be Resistance Temperature Device (RTD) or Thermistor.
2. Duct sensors shall be rigid or averaging as shown. Averaging sensors shall be a minimum of 5 feet in length.
3. Space sensors shall be equipped with set-point adjustment wheel, override switch, and/or communication port as shown on the drawings.
4. Wireless Zone Sensors
    a. Space sensors shall be equipped with set-point adjustment, override switch, and/or communication port as shown on the drawings.
    b. To check for proper operation, wireless zone temperature sensors shall include a signal strength and battery condition indicators using LED's under cover on non-display models
    c. The wireless zone sensor shall include a readily visual indication of battery condition. The battery indication lights shall flash periodically for a minimum of 5 days to indicate the need for battery replacement prior to failure.
    d. Zone sensor shall utilize AA batteries and have published battery life of a minimum 5 years. If OEM zone sensor batteries are only available from vendor, then vendor must supply spare set of batteries. In addition, if minimum published battery life is less than 5 years then vendor must supply replacement batteries to achieve 5 years of battery replacement cost avoidance.
    e. Provide matched temperature sensors for differential temperature measurement. Differential accuracy shall be within 0.2 F.

F. Low Limit Thermostats

1. Safety low limit thermostats shall be vapor pressure type with an element 6m [20 ft] minimum length. Element shall respond to the lowest temperature sensed by any one-foot section.
2. Low limit shall be manual reset only.

G. Carbon Dioxide (CO2) Sensors

1. Carbon Dioxide sensors shall measure CO2 in PPM in a range of 0-2000 ppm. Accuracy shall be +/- 3% of reading with stability within 5% over 5 years. Sensors shall be duct or space mounted as indicated in the sequence of operation.

H. Relays

1. Control relays shall be UL listed plug-in type with dust cover. Contact rating, configuration, and coil voltage suitable for application.
2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus or minus 200% (minimum) from set-point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 Type enclosure when not installed in local control panel.

I. Transformers and Power Supplies

1. Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.
2. Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 mV maximum Peak-to-Peak. Regulation shall be 0.10% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection.
3. Unit shall operate between 0 C and 50 C.
4. Unit shall be UL recognized.

5. Provide UPS back-up power supply for Building Automation System.

J. Current Switches

1. Current-operated switches shall be self-powered, solid state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

## 2.10 LOCAL CONTROL PANELS

A. All indoor control cabinets shall be fully enclosed NEMA 1 Type construction with hinged door, and removable sub-panels or electrical sub-assemblies.

B. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

C. Provide on/off power switch with over-current protection for control power sources to each local panel.

# PART 3 – EXECUTION

## 3.1 PART INCLUDES

A. Examination

B. General Workmanship

C. Wiring

D. Installation of Sensors

E. Damper Actuator Installation

F. Identification of Hardware and Wiring

G. BAS DDC Controllers

H. Programming

I. Cleaning

J. Protection

K. Training

L. Field Quality Control

M. Acceptance

## 3.2 EXAMINATION

A. The Contract Documents shall be thoroughly examined for coordination of control devices their installation, wiring, and commissioning. Coordinate and review mechanical equipment specifications, locations, and identify any discrepancies, conflicts, or omissions that shall be reported to the Architect/Engineer for resolution before rough-in work is started.

B. The BAS manufacturer shall inspect the jobsite in order to verify that control equipment can be installed as required, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

## 3.3 GENERAL WORKMANSHIP

A. Install equipment, piping, wiring/conduit, parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install all equipment in readily accessible location as defined by National Electric Code (NEC). Control panels shall be attached to structural walls or properly supported in a free-standing configuration, unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service.

D. Verify integrity of all control wiring to ensure continuity and freedom from shorts and grounds prior to commencing the startup and commissioning procedures.

E. All control device installation, and wiring shall comply with Contract Documents, acceptable industry specifications, and industry standards for performance, reliability, and compatibility. Installation and wiring shall be executed in strict adherence to local codes and standard practices referenced in Contract Documents.

**3.4 WIRING**

A. All control and interlock wiring shall comply with the National, Local Electrical Codes, and Section 260500 of these Contract Document specifications. Where the requirements of this section differ with those in Section 260500, the requirements of this section shall take precedence.

B. Where Class 2 wires are in concealed and accessible locations; including ceiling return air plenums, approved cables outside of electrical raceway can be used provided that the following conditions are met:

1. Circuits meet NEC Class 2 (current limited) requirements. (Low voltage power circuits shall be sub fused when required to meet Class 2 current limit.
2. All cables shall be UL listed for application (i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose).

C. Do not install Class 2 wiring in conduits containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two via control relays and transformers.

D. Where Class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 10 ft intervals. Such bundled cable shall be fastened to the structure, using industry approved fasteners, at 5 ft intervals or more often to achieve a neat and workmanlike result.

E. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

F. Maximum allowable voltage for control wiring shall be 120Vac. If only higher voltages are available for use, the BAS manufacturer shall provide step-down transformers to achieve the desired control voltages.

G. All control wiring shall be installed as continuous lengths, where possible. Any required splices shall be made only within an approved junction box or other approved protective device.

H. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with Contract Documents and National and/or Local Codes.

I. Conduit and wire sizing shall be determined by the BAS manufacturer in order to maintain manufacturer’s recommendation and must meet National and Local Codes.

J. Control and status relays are to be located in pre-fabricated enclosures that meet the application. These relays may also be located within packaged equipment control panel enclosures as coordinated. These relays shall not be located within Class 1 starter enclosures.

K. Follow manufacturer's installation recommendations for all communication and network bus cabling. Network or communication cabling shall be run separately from all control power wiring.

L. Adhere to Electrical Specification Requirements for installation of electrical raceways.

M. BAS manufacturer shall terminate all control and/or interlock wiring and shall maintain updated (as built) wiring diagrams with terminations identified at the job site.

N. Flexible metal conduits and liquid tight flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid tight, flexible metal conduits shall be used.

### 3.5 INSTALLATION OF SENSORS

A. All thermostats, humidistats, temperature sensors, etc., shall be mounted 5’-0” above finished floor.

B. Sensors required for mechanical equipment operation shall be factory installed and wired as specified in mechanical equipment specifications. BAS manufacturer shall be responsible for coordinating these control devices and ensuring the sequence of operations will be met. Installation and wiring shall be in accordance with the BAS manufacturer's recommendations.

C. Sensors that require field mounting shall meet the BAS manufacturer’s recommendations and be coordinated with the mechanical equipment they will be associated.

D. Mount sensors rigidly and adequately for the environment the sensor will operate.

E. Room temperature sensors shall be installed on concealed junction boxes properly supported by the block wall framing. For installation in dry wall ceilings, the low voltage sensor wiring can be installed exposed in the wall and must meet applicable National and Local Electrical Codes.

F. All wires attached to wall mounted sensors shall be sealed off to prevent air from transmitting in the associated conduit and affecting the room sensor readings.

G. Install duct static pressure tap with tube end facing directly down-stream of air flow.

H. Install space static pressure sensor with static sensing probe applicable for space installation where applicable.

I. Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.

J. All pipe mounted temperature sensors shall be installed in matched thermowells. Install all liquid temperature sensors with heat conducting fluid in thermal wells for adequate thermal conductance.

K. Wiring for space sensors shall be concealed in building drywall. EMT conduit is acceptable within mechanical equipment and service rooms.

L. Install outdoor air temperature sensors on north wall complete with sun shield at manufacturer’s recommended location and coordinated with Engineer.

### 3.6 DAMPER ACTUATOR INSTALLATION

A. Mount and link multiple control damper actuators where required, per manufacturer's instructions.

B. To compress seals when spring-return actuators are used on normally closed dampers, power the actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.

C. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions. Coordinate any installation problems with Sheet Metal Contractor.

### 3.7 IDENTIFICATION OF HARDWARE AND WIRING

A. All field wiring and cabling, including that within factory mounted, and wired control panels and devices for mechanical equipment, shall be labeled at each end within 2" of termination with a cable identifier and other descriptive information for troubleshooting, maintenance, and service purposes. BAS manufacturer to coordinate this labeling requirement with mechanical equipment manufacturer as it relates to controls.

B. Permanently label or code each point of field terminal strips to show the instrument or item served and correlate them to the BAS design drawings.

C. Identify control panels with minimum 1-cm letters on laminated plastic nameplates.

D. Identifiers shall match record documents. All plug-in components shall be labeled such that removal of the component does not remove the label.

## 3.8 BAS DDC CONTROLLERS

A. Provide a separate DDC Controller for individual HVAC mechanical equipment. DDC Controllers shall be factory mounted, installed, and wired by mechanical equipment manufacturer as specified. BAS manufacturer to furnish and coordinate DDC controllers and control devices and ensure that installation and wiring adhere to BAS manufacturer's design recommendations. For those mechanical equipment units that do not have factory installed controls specified, the BAS manufacturer shall field mount controls and coordinate all installation and termination information to ensure the specified sequence of operations are met.

B. Building Controllers and Custom Application Controllers shall be selected to provide a minimum of 15% spare I/O point capacity for each point type (analog or digital) found at each location. If input points are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point used in each controller.

C. Future use of spare I/O point capacity shall require providing the field instrument and control device, field wiring, engineering, programming, and commissioning. No additional Controller boards or point modules shall be required to implement use of these spare points.

## 3.9 PROGRAMMING

A. Provide sufficient internal memory for all controllers to ensure specified sequence of operations, alarming, trending, and reporting requirements are achieved. BAS manufacturer shall provide a minimum of 25% spare memory capacity for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index.

C. Software Programming:

1. Provide programming for individual mechanical systems to achieve all aspects of the sequence of operation specified. It is the BAS manufacturer's responsibility to ensure all mechanical equipment functions and operates as specified in sequence of operations. Provide sufficient programming comments in controller application software to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations.

D. BAS Operator's Interface:

1. When Operator Workstation is specified, provide color graphics for each piece of mechanical equipment depicting sufficient I/O to monitor and troubleshoot operation. Additionally, provide individual floor plans of the building allowing an operator to quickly view the overall floor plan area for any out of tolerance conditions that may need addressing. Operator color graphics shall include Rooftop Units, Exhaust Fans, etc. These standard graphics shall depict all points dynamically as specified in the points list and/or indicated in sequence of operation.

2. The BAS manufacturer shall provide all the labor necessary to install, initialize, start up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface data base, and any third-party software installation and integration required for successful operation of the operator interface.

## 3.10 CLEANING

A. The BAS manufacturer's installing contractor(s) shall clean up all debris resulting from their installation activities on a daily basis. The installation contractors shall remove all cartons, containers, crates, etc. under his control as soon as their contents have been removed. Waste shall be collected and placed in a location designated by the Owner, Construction Manager, General Contractor, and/or Mechanical Contractor.

B. At the completion of work in any area, the installation contractor shall clean all of their work, equipment, etc., making it free from dust, dirt and debris.

C. At the completion of work, all equipment furnished under this Section shall be checked for paint damage. Any factory finished paint that has been damaged shall be repaired to match the adjacent areas. Any metal cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

## 3.11 PROTECTION

A. The BAS installation contractor shall protect all work and material from damage by their work or personnel, and shall be liable for all damage.

B. The BAS manufacturer shall be responsible for their work and equipment until final inspection, testing, and acceptance. The BAS installing contractor shall protect their work against theft or damage, and shall carefully store material and equipment received on site that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

## 3.12 TRAINING

A. Provide minimum of (2) on-site training sessions, and (4) hours for each session, throughout the contract period. The training will be provided for personnel designated by the Owner.

B. The Owner training shall enable personnel to proficiently operate the BAS by being able to create, modify and delete programming; add, remove and modify physical points for individual controllers; and add additional controllers when required.

C. These objectives will be divided into three logical groupings; participants may attend one or more of these, depending on level of knowledge required:

1. Day-to-day BAS Operators
2. BAS Troubleshooting & Maintenance
3. Maintenance Manager: Parts Inventory

D. Provide course outline and materials prior to schedule training session. The instructor(s) shall provide one copy of training material per student.

E. The instructor(s) shall be factory-trained and experienced in teaching this technical material.

## 3.13 FIELD QUALITY CONTROL

A. All work, materials and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Contract Documents.

B. BAS manufacturer shall continually monitor the field installation for building code compliance and quality of workmanship. All visible piping and or wiring runs shall be installed parallel to building lines and properly supported.

C. BAS installing Contractor(s) shall arrange for field inspections by local and/or state authorities having jurisdiction over the work.

## 3.14 ACCEPTANCE

A. The BAS will not be accepted as meeting the requirements of Completion until all tests described in this specification have been performed to the satisfaction of both the Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor may be exempt from the Completion requirements if stated as such in writing by the Owner's representative. Such tests shall then be performed as part of the warranty.

**END OF SECTION**

## SECTION 230993.11
## SEQUENCE OF OPERATIONS FOR HVAC DDC

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment.

B. Related Requirements:

1. Section 230923 "DDC Systems for HVAC" for control equipment.

### PART 2 - SEQUENCE OF OPERATIONS

### 2.1 VARIABLE AIR VOLUME ROOFTOP UNITS:

A. Building Automation System Interface:

1. The Building Automation System (BAS) shall send the controller Occupied Bypass, Morning Warm-up / Pre-Cool, Occupied / Unoccupied and Heat / Cool modes. If a BAS is not present, or communication is lost with the BAS the controller shall operate using default modes and setpoints.

B. Occupied Mode:

1. During occupied periods, the supply fan shall run continuously and the outside air damper shall open to maintain minimum ventilation requirements. The unit controller shall control the supply fan speed to maintain the current duct static pressure setpoint (adj.). DX cooling and gas heat shall stage to maintain the current discharge air temperature setpoint. If economizing is enabled the outside air damper shall modulate to maintain the current discharge air temperature setpoint.

C. Unoccupied Mode:

1. When the space temperature is below the unoccupied heating setpoint of 60.0 deg. F (adj.) the supply fan shall start, the outside air damper shall remain closed and the gas heat shall be enabled. When the space temperature rises above the unoccupied heating setpoint of 60.0 deg. F (adj.) plus the unoccupied differential of 4.0 deg. F (adj.) the supply fan shall stop and the gas heat shall be disabled.

2. When the space temperature is above the unoccupied cooling setpoint of 85.0 deg. F (adj.) the supply fan shall start, the outside air damper shall open if economizing is enabled and remain closed if economizing is disabled and the DX cooling shall be enabled. When the space temperature falls below the unoccupied cooling setpoint of 85.0 deg. F (adj.) minus the unoccupied differential of 4.0 deg. F (adj.) the supply fan shall stop, the DX cooling shall be disabled and the outside air damper shall close.

D. Optimal Start:

1. The BAS shall monitor the scheduled occupied time, occupied space setpoints and space temperature to calculate when the optimal start occurs.

E. Morning Warm-Up Mode:

1. During optimal start, if the average space temperature is below the occupied heating setpoint a morning warm-up mode shall be activated. When morning warm-up is initiated, the unit shall enable the heating and supply fan. The outside air damper shall remain closed. When the average space temperature reaches the occupied heating setpoint (adj.), the unit shall transition to the occupied mode.

F. Pre-Cool Mode:

1. During optimal start, if the average space temperature is above the occupied cooling setpoint, pre-cool mode shall be activated. When pre-cool is initiated, the unit shall enable the fan and cooling or economizer. The outside air damper shall remain closed, unless economizing. When the average space temperature reaches occupied cooling setpoint (adj.), the unit shall transition to the occupied mode.

G. Occupied Bypass**:**

1. The BAS shall monitor the status of the “on” and “cancel” buttons of the space temperature sensors. When an occupied bypass request is received from a space sensor, the unit shall transition from its current occupancy mode to occupied bypass mode and the unit shall maintain the space temperature to the occupied setpoints (adj.).

H. Economizer:

1. The supply air sensor shall measure the dry bulb temperature of the air leaving the evaporator coil while economizing. When economizing is enabled and the unit is operating in the cooling mode, the economizer damper shall be modulated between its minimum position and 100% to maintain the discharge air temperature setpoint. The economizer damper shall modulate toward minimum position in the event the discharge air temperature falls below the discharge low limit temperature setpoint. Compressors shall be delayed from operating until the economizer has opened to 100%.

I. Comparative Enthalpy:

1. Outside air (OA) enthalpy shall be compared with Return air (RA) enthalpy point. The economizer shall enable when OA enthalpy is less than RA enthalpy - 3.0 BTU/LB. The economizer shall disable when OA enthalpy is greater than RA enthalpy.

J. Smoke Detector Shutdown: The unit shall shut down in response to a signal from either smoke detector indicating the presence of smoke. The smoke detectors shall be interlocked to the unit through the dry contacts of the smoke detectors. A manual reset of the smoke detectors shall be required to restart the unit.

K. Filter Status:

1. A differential pressure switch shall monitor the differential pressure across the filter when the fan is running. If the switch closes for 2 minutes after a request for fan operation a dirty filter alarm shall be annunciated at the BAS.

## 2.2 VAV BOXES WITH ELECTRIC REHEAT

A. Building Automation System Interface:

1. The Building Automation System (BAS) shall send the controller Occupied and Unoccupied commands. The BAS may also send a Heat/Cool mode, priority shutdown commands, space temperature and/or space temperature setpoint. If communication is lost with the BAS, the VAV controller shall operate using its local setpoints.

B. Occupancy Mode:

1. The occupancy mode shall be communicated or hardwired to the controller via a binary input. Valid occupancy modes for the unit shall be:

C. Occupied:

1. Normal operating mode for occupied spaces or daytime operation. When the unit is in the occupied mode the VAV shall maintain the space temperature at the active occupied heating or cooling setpoint. Applicable ventilation and airflow setpoints shall be enforced. The occupied mode shall be the default mode of the VAV.

D. Unoccupied:

1. Normal operating mode for unoccupied spaces or nighttime operation. When the unit is in unoccupied mode the VAV controller shall maintain the space temperature at the stored unoccupied heating or cooling setpoint regardless of the presence of a hardwired or communicated setpoint. When the space temperature exceeds the active unoccupied setpoint the VAV shall modulate fully closed.

E. Occupied Bypass:

1. Mode used to temporarily place the unit into the occupied operation. Tenants shall be able to override the unoccupied mode from the space sensor. The override shall last for a maximum of 4 hours (adj.). The tenants shall be able to cancel the override from the space sensor at any time. During the override the unit shall operate in occupied mode.

F. Heat/Cool Mode:

1. The Heat/Cool mode shall be set by a communicated value or automatically by the VAV. In standalone or auto mode the VAV shall compare the primary air temperature with the configured auto changeover setpoint to determine if the air is "hot" or "cold". Heating mode it implies the primary air temperature is hot. Cooling mode it implies the primary air temperature is cold.

G. Heat/Cool Setpoint:

1. The space temperature setpoint shall be determined either by a local (e.g., thumbwheel) setpoint, the VAV default setpoint or a communicated value. The VAV shall use the locally stored default setpoints when neither a local setpoint nor communicated setpoint is present. If both a local setpoint and communicated setpoint exist, the VAV shall use the communicated value.

H. Heating Mode:

1. When the unit is in heating mode, the VAV controller shall maintain the space temperature at the active heating setpoint by modulating the airflow between the active heating minimum airflow setpoint to the maximum heating airflow setpoint. Based on the VAV controller occupancy mode, the active heating setpoint shall be one of the following:

| **Setpoint** | **Default Value** |
|---|---|
| Occupied Heating Setpoint | 71.0 deg. F |
| Unoccupied Heating Setpoint | 60.0 deg. F |
| Occupied Standby Heating Setpoint | 67.0 deg. F |
| Occupied Min Heating Airflow Setpoint | See VAV Schedule |
| Occupied Max Heating Airflow Setpoint | See VAV Schedule |

2. The VAV controller shall use the measured space temperature and the active heating setpoint to determine the requested heating capacity of the unit. The outputs will be controlled based on the unit configuration and the requested heating capacity.

I. Reheat Control:

1. Reheat will only be allowed when the primary air temperature is 5.0 deg. F below the configured reheat enable setpoint of 70.0 deg. F (adj.). The reheat shall be enabled when the space temperature drops below the active heating setpoint and the minimum airflow requirements are met. During reheat the VAV shall operate as follows:

J. Silicon Controlled Rectifier (SCR):

1. If the space temperature is at the heating setpoint, the electric heater shall modulate as required to maintain space temperature at the active heating setpoint while the VAV operates at its minimum heating airflow setpoint. If the discharge air temperature reaches the design heating discharge air temperature setpoint (adj.), the VAV shall modulate airflow between the minimum heating airflow setpoint and the maximum heating airflow setpoint as required to maintain space temperature at the active heating setpoint, while the electric heater modulates to maintain discharge air temperature at the design heating discharge air temperature setpoint. If the airflow reaches the maximum heating airflow setpoint, the VAV shall modulate the electric heater as required to maintain space temperature at the active heating setpoint, while the VAV operates at its maximum heating airflow setpoint.

K. Space Sensor Failure:

1. If there is a fault with the operation of the zone sensor an alarm shall be annunciated at the BAS. Space sensor failure shall cause the VAV to drive the damper to minimum air flow if the VAV is in the occupied mode, or drive it closed if the VAV is in the unoccupied mode.

L. Cooling Mode:

1. When the unit is in cooling mode, the VAV controller shall maintain the space temperature at the active cooling setpoint by modulating the airflow between the active cooling minimum airflow setpoint to the maximum cooling airflow setpoint. Based on the VAV controller occupancy mode, the active cooling setpoint shall be one of the following:

| Setpoint | Default Value |
|---|---|
| Occupied Cooling Setpoint | 74.0 deg. F |
| Unoccupied Cooling Setpoint | 85.0 deg. F |
| Occupied Standby Cooling Setpoint | 78.0 deg. F |
| Occupied Min Cooling Airflow Setpoint | See VAV Schedule |
| Occupied Max Cooling Airflow Setpoint | See VAV Schedule |

2. The VAV shall use the measured space temperature and the active cooling setpoint to determine the requested cooling capacity of the unit. The outputs will be controlled based on the unit configuration and the requested cooling capacity.

**2.1 PROCESS AREA (100% OUTSIDE AIR) CONSTANT VOLUME ROOFTOP UNITS:**

A. Building Automation System Interface:

1. The Building Automation System (BAS) shall send the controller Morning Warm-up / Pre-Cool, Occupied / Unoccupied and Heat / Cool modes. If a BAS is not present, or communication is lost with the BAS the controller shall operate using default modes and setpoints.

B. Occupied Mode:

1. During occupied periods, the supply fan shall run continuously and the outside air damper shall open. DX cooling and gas heat shall stage to maintain the current space temperature setpoint.

C. Unoccupied Mode:

1. When the space temperature is below the unoccupied heating setpoint of 55.0 deg. F (adj.) the supply fan shall start, the outside air damper shall open and the gas heat shall be enabled. When the space temperature rises above the unoccupied heating setpoint of 55.0 deg. F (adj.) plus the unoccupied differential of 4.0 deg. F (adj.) the supply fan shall stop and the gas heat shall be disabled.

D. Optimal Start:

1. The BAS shall monitor the scheduled occupied time, occupied space setpoints and space temperature to calculate when the optimal start occurs.

E. Smoke Detector Shutdown: The unit shall shut down in response to a signal from either smoke detector indicating the presence of smoke. The smoke detectors shall be interlocked to the unit through the dry contacts of the smoke detectors. A manual reset of the smoke detectors shall be required to restart the unit.

F. Filter Status: A differential pressure switch shall monitor the differential pressure across the filter when the fan is running. If the switch closes for 2 minutes after a request for fan operation a dirty filter alarm shall be annunciated at the BAS.

**2.4 EXHAUIST FANS and INTAKE LOUVERS IN PROCESS ARES:**

A. Provide an exhaust fan control panel on the wall of Area 1 near the entry from the Administration Area. Whenever an exhaust fan is indexed to ON it's associated intake louver shall open and vice versa. Provide pushbutton control on the panel board to allow for the following:

AREA 1 (existing Fiber Tipping): Fans shall operate in unison and be on/off and set to run continuously whenever indexed ON.

AREA 2 (existing Sorting): Fans shall have two speed settings (high/summer and low/winter). Fans shall operate in unison at the speed determined at the control panel and run continuously whenever indexed to high or low speed.

AREA 4 (new Tipping): Fans shall operate in unison and be on/off and set to run continuously whenever indexed ON.

AREA 5: (new Bale Storage): Fans shall have two speed settings (high/summer and low/winter). Fans shall operate in unison at the speed determined at the control panel and run continuously whenever indexed to high or low speed.

B. All Fans and louvers shall be monitored by the BMS for status of operation and position respectively.

C. Exhaust fans shall be interlocked with fire alarm system and shut down upon fire alarm activation.

**2.5 UNIT HEATERS IN PROCESS AREAS:**

A. The DDC controller shall control the unit heater to maintain space temperature set points (adjustable). When the space temperature is below the heating set point, the unit heater fans and gas heating section shall be enabled.

**2.6 RADIANT TUBE HEATERS**

A. Through DDC, the space temperature sensor shall enable the radiant tube heater to maintain occupied space temperature. Occupied-unoccupied modes shall be determined by the BMS.

**2.7 SPLIT SYSTEM AC UNIT:**

A. The system shall be controlled by the unit manufacturer's space thermostat. The BMS contractor shall install and wire thermostat.

B. The BMS contractor shall provide the low voltage control interlock wiring between indoor and outdoor units.

C. The BMS contractor shall wire the unit manufacturer provided remote alarm contact to the BMS.

D. The BMS contractor shall monitor the space temperature in each room for alarming during abnormal conditions. Consult owner for alarm parameters. The system shall be controlled from the DDC controller at each unit. It shall provide all control functions.

**2.8 TOILET/GENERAL EXHAUST FANS:**

A. Exhaust fan shall be interlocked with the operation of the rooftop unit so as to run whenever in the Occupied mode.

**2.9 MECHANICAL ROOM HEATING / EXHAUST:**

A. Room heating/cooling thermostat shall control system operation.

B. Exhaust fan shall start and intake louver damper shall open on a call for cooling.

C. Unit heater shall operate on a call for heating.

**PART 3 -EXECUTION (Not Applicable)**

**END OF SECTION**

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## SECTION 231123
## FACILITY NATURAL-GAS PIPING

### PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

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

### 1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Manual gas shutoff valves.
5. Motorized gas valves.
6. Pressure regulators.
7. Dielectric fittings.

### 1.3 DEFINITIONS

A. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Piping specialties.
2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.

### 1.5 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

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

### 1.6 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

### 1.7 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: 0.5 psig or less.

### 2.2 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless-steel underground.
5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
6. Mechanical Couplings:
    a. Stainless Steel flanges and tube with epoxy finish.
    b. Buna-nitrile seals.
    c. Stainless Steel bolts, washers, and nuts.
    d. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    e. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

B. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.

1. Tubing: ASTM A240/A240M, corrugated, Series 300 stainless steel.

2. Coating: PE with flame retardant.
    a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
        1) Flame-Spread Index: 25 or less.
        2) Smoke-Developed Index: 50 or less.
3. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
4. Striker Plates: Steel, designed to protect tubing from penetrations.
5. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.

## 2.3 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches (1830 mm.)

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

## 2.4 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

## 2.5 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig (862 kPa).
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.

1. CWP Rating: [125 psig (862 kPa)] <Insert pressure>.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.

1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated brass.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Separate packnut with adjustable-stem packing threaded ends.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. CWP Rating: 600 psig (4140 kPa).
8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. CWP Rating: 600 psig (4140 kPa).
8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
   1. Body: Bronze, complying with ASTM B584.
   2. Ball: Chrome-plated bronze.
   3. Stem: Bronze; blowout proof.
   4. Seats: Reinforced TFE.
   5. Packing: Threaded-body packnut design with adjustable-stem packing.
   6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   7. CWP Rating: 600 psig (4140 kPa).
   8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. Bronze Plug Valves: MSS SP-78.
   1. Body: Bronze, complying with ASTM B584.
   2. Plug: Bronze.
   3. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   4. Operator: Square head or lug type with tamperproof feature where indicated.
   5. Pressure Class: 125 psig (862 kPa).
   6. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
   7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

H. Valve Boxes:
   1. Cast-iron, two-section box.
   2. Top section with cover with "GAS" lettering.
   3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
   4. Adjustable cast-iron extensions of length required for depth of bury.
   5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

## 2.6 PRESSURE REGULATORS

A. General Requirements:
   1. Single stage and suitable for natural gas.
   2. Steel jacket and corrosion-resistant components.
   3. Elevation compensator.
   4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.
   1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
   2. Springs: Zinc-plated steel; interchangeable.
   3. Diaphragm Plate: Zinc-plated steel.
   4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.

5. Orifice: Aluminum; interchangeable.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
9. Overpressure Protection Device: Factory mounted on pressure regulator.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
11. Maximum Inlet Pressure: 100 psig (690 kPa).

C. Line Pressure Regulators: Comply with ANSI Z21.80.
1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
9. Overpressure Protection Device: Factory mounted on pressure regulator.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
11. Maximum Inlet Pressure: 2 psig (13.8 kPa).

D. Appliance Pressure Regulators: Comply with ANSI Z21.18.
1. Body and Diaphragm Case: Die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber.
5. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
6. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
8. Maximum Inlet Pressure: 2 psig (13.8 kPa).

## 2.7 SERVICE METERS

A. Diaphragm-Type Service Meters: Comply with ANSI B109.1.
1. Case: Die-cast aluminum.
2. Connections: Steel threads.
3. Diaphragm: Synthetic fabric.
4. Diaphragm Support Bearings: Self-lubricating.
5. Compensation: Continuous temperature and pressure.

6. Meter Index: Cubic feet.
7. Meter Case and Index: Tamper resistant.
8. Remote meter reader compatible.
9. Maximum Inlet Pressure: 100 psig (690 kPa).
10. Pressure Loss: Maximum 0.5-inch wg (124 Pa).
11. Accuracy: Maximum plus or minus 1.0 percent.

B. Rotary-Type Service Meters: Comply with ANSI B109.3.
1. Case: Extruded aluminum.
2. Connection: Flange.
3. Impellers: Polished aluminum.
4. Rotor Bearings: Self-lubricating.
5. Compensation: Continuous temperature.
6. Meter Index: Cubic feet.
7. Tamper resistant.
8. Remote meter reader compatible.
9. Maximum Inlet Pressure: 100 psig (690 kPa).
10. Accuracy: Maximum plus or minus 2.0 percent.

## 2.8 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
1. Description:
a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
1. Description:
a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

## 2.9 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

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

### 3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 requirements for prevention of accidental ignition.

### 3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

E. Copper Tubing with Protective Coating:

1. Apply joint cover kits over tubing to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

F. Install fittings for changes in direction and branch connections.

G. Install pressure gage downstream from each service regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

### 3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.

2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches (38 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.

3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.

4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:

a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

b. Do not install natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

### 3.5 SERVICE-METER ASSEMBLY INSTALLATION

A. Install service-meter assemblies aboveground, on concrete bases.

B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.

C. Install strainer on inlet of service-pressure regulator and meter set.

D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.

E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.

F. Install service meters downstream from pressure regulators.

G. Install metal bollards to protect meter assemblies. Comply with requirements in Section 055000 "Metal Fabrications" for pipe bollards.

### 3.6 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

### 3.7 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.

3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End Pipe and Fittings: Use butt fusion.

2. Plain-End Pipe and Socket Fittings: Use socket fusion.

## 3.8 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install hangers for corrugated stainless-steel tubing, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping within 12 inches (300 mm) of each fitting.

F. Support vertical runs of steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

G. Support vertical runs of corrugated stainless-steel tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

## 3.9 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

## 3.10 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

## 3.11 PAINTING

A. Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Alkyd System: MPI EXT 5.1D.
      a. Prime Coat: Alkyd anticorrosive metal primer.
      b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
      c. Topcoat: Exterior alkyd enamel flat.
      d. Color: Gray.

C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
   1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
      a. Prime Coat: Alkyd anticorrosive metal primer.
      b. Intermediate Coat: Interior latex matching topcoat.
      c. Topcoat: Interior latex flat.
      d. Color: Gray.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

**3.12 FIELD QUALITY CONTROL**

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

**3.13 DEMONSTRATION**

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

**3.14 OUTDOOR PIPING SCHEDULE**

A. Underground natural-gas piping shall be the following:
   1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground natural-gas piping shall be the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

C. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper tube with wrought-copper fittings and brazed joints. Install piping embedded in concrete with no joints in concrete.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

### 3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 5 PSIG (34.5 kPa)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:
   1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
   2. Annealed-temper, tin-lined copper tube with flared joints and fittings.
   3. Annealed-temper, copper tube with wrought-copper fittings and brazed joints.
   4. Aluminum tube with flared fittings and joints.
   5. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with steel welding fittings and welded joints.
   3. Drawn-temper copper tube with wrought-copper fittings and brazed joints.

C. Underground, below building, piping shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

### 3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.
   2. Two-piece, full-port, bronze ball valves with bronze trim.
   3. Bronze plug valve.

B. Valves for pipe sizes NPS 2-1/2 (DN 65) and larger at service meter shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.
   3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.
   2. Two-piece, full-port, bronze ball valves with bronze trim.
   3. Bronze plug valve.

D. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.

E. Valves in branch piping for single appliance shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.
   2. Two-piece, full-port, bronze ball valves with bronze trim.
   3. Bronze plug valve.

**END OF SECTION**

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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 for Air-Conditioning Applications: 185 psig.
2. Hot-Gas and Liquid Lines: 325 psig.

### 1.3 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.

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.

C. Field quality-control test reports.

D. Operation and maintenance data.

### 1.4 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

### 1.5 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.

### PART 2 - PRODUCTS

### 2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.

5. Maximum Operating Temperature: 250 deg F.

## 2.2 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:
   1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
   2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
   3. Operator: Rising stem and hand wheel.
   4. Seat: Nylon.
   5. End Connections: Socket, union, or flanged.
   6. Working Pressure Rating: 500 psig.
   7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:
   1. Body and Bonnet: Forged brass or cast bronze.
   2. Packing: Molded stem, back seating, and replaceable under pressure.
   3. Operator: Rising stem.
   4. Seat: Non-rotating, self-aligning polytetrafluoroethylene.
   5. Seal Cap: Forged-brass or valox hex cap.
   6. End Connections: Socket, union, threaded, or flanged.
   7. Working Pressure Rating: 500 psig.
   8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:
   1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
   2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
   3. Piston: Removable polytetrafluoroethylene seat.
   4. Closing Spring: Stainless steel.
   5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
   6. End Connections: Socket, union, threaded, or flanged.
   7. Maximum Opening Pressure: 0.50 psig.
   8. Working Pressure Rating: 500 psig.
   9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:
   1. Body: Forged brass with brass cap including key end to remove core.
   2. Core: Removable ball-type check valve with stainless-steel spring.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Copper spring.
   5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
   1. Body and Bonnet: Plated steel.
   2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Threaded.

5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig].

H. Straight-Type Strainers:
1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

I. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. Moisture/Liquid Indicators:
1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in PPM.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 PPM.

5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

K. Replaceable-Core Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: 1.5 tons.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

L. Permanent Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Rated Flow: 1.5 tons.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

M. Liquid Accumulators: Comply with ARI 495.
1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

## PART 3 - EXECUTION

### 3.1 VALVE AND SPECIALTY APPLICATIONS

A. Install valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at strainers if they are not an integral part of strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.

2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.

3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.

2. Thermostatic expansion valves.

3. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

L. Install flexible connectors at compressors.

**3.2 PIPING INSTALLATION**

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Division 23 Sections “Facility Management and Control System (FMCS)" and "Sequence of Operation for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 8 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. 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.

O. 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.

P. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

S. Seal pipe penetrations through exterior walls according to Division 7 Section "Joint Sealants" for materials and methods.

T. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

## 3.3 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.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

## 3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 23 Section "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. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.

## 3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections 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.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

### 3.6 SYSTEM CHARGING

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

### 3.7 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
    1. Open shutoff valves in condenser water circuit.
    2. Verify that compressor oil level is correct.
    3. Open compressor suction and discharge valves.
    4. Open refrigerant valves except bypass valves that are used for other purposes.
    5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

**END OF SECTION**

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# SECTION 233113
# METAL DUCTS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Sheet metal materials.
3. Sealants and gaskets.
4. 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, sound-control devices, duct-mounting access doors and panels, 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.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ANSI/ASHRAE 62.1.

### 1.3 ACTION SUBMITTALS

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

B. Shop Drawings:

1. Duct layout indicating sizes, configuration, and static-pressure classes.
2. Elevation of top of ducts.
3. Dimensions of main duct runs from building grid lines.
4. Penetrations through fire-rated and other partitions.
5. Equipment installation based on equipment being used on Project.
6. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
7. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

### 1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.

4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
    a. Luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Access panels.
    e. Perimeter moldings.

## 1.5 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

# 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 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: G60.
    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. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
    1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

## 2.3 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: 3 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 (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.

3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

## 2.4 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. 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.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

# PART 3 - EXECUTION

## 3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

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 DUCT SEALING

A. Seal ducts at a minimum 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. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

## 3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

## 3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

## 3.6 DUCT CLEANING

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

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

## 3.7 START UP

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

## 3.8 DUCT SCHEDULE

A. Supply Ducts:
   1. Ducts Connected to Constant-Volume Air-Handling Units:
      a. Pressure Class: Positive 2-inch wg.
      b. SMACNA Leakage Class for Rectangular: 6.
      c. SMACNA Leakage Class for Round: 6.
   2. Ducts Connected to Variable-Air-Volume Air-Handling Units Insert equipment:
      a. Pressure Class: Positive 3-inch wg.
      b. SMACNA Leakage Class for Rectangular: 3.
      c. SMACNA Leakage Class for Round: 3.

B. Return Ducts:
   1. Ducts Connected to Air-Handling Units:
      a. Pressure Class: Positive or negative 2-inch wg.
      b. SMACNA Leakage Class for Rectangular: 6.
      c. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Exhaust Ducts:
   1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
      a. Pressure Class: Negative 1-inch wg.
      b. SMACNA Leakage Class for Rectangular: 12.
      c. SMACNA Leakage Class for Round and Flat Oval: 6.

D. Intermediate Reinforcement:
   1. Galvanized-Steel Ducts: Galvanized steel.

E. Elbow Configuration:
   1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
      a. Velocity 1000 fpm or Lower:
         1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
         2) Mitered Type RE 4 without vanes.
      b. Velocity 1000 to 1500 fpm:
         1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
         2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
         3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

F. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.

b. Rectangular Main to Round Branch: Spin in.

**END OF SECTION**

## SECTION 233300
## AIR DUCT ACCESSORIES

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Manual volume dampers.
2. Fire dampers.
3. Flange connectors.
4. Turning vanes.
5. Duct-mounted access doors.
6. Flexible connectors.
7. Duct accessory hardware.

### 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: G60.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

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

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

### 2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flexmaster U.S.A., Inc.
   b. McGill AirFlow LLC.

c. Nailor Industries Inc.

d. Ruskin Company.

2. Standard leakage rating.

3. Suitable for horizontal or vertical applications.

4. 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.

5. 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.

6. Blade Axles: Galvanized steel.

7. Bearings:

a. Oil-impregnated bronze.

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.

8. Tie Bars and Brackets: Galvanized steel.

B. Jackshaft:

1. Size: 0.5-inch diameter.

2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-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 FIRE DAMPERS

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

1. Greenheck Fan Corporation.

2. Nailor Industries Inc.

3. Ruskin Company.

4. Ward Industries; a brand of Hart & Cooley, Inc.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.05 thick, as indicated, 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.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. 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.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

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

## 2.5 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CL WARD & Family Inc.
   2. Ductmate Industries, Inc.
   3. Ward Industries; a brand of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

## 2.6 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aero-Dyne Sound Control Co.
   2. Ductmate Industries, Inc.
   3. Duro Dyne Inc.
   4. METALAIRE, Inc.

B. 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.

C. 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.

D. 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."

E. Vane Construction: Double wall.

## 2.7 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CL WARD & Family Inc.
   2. Ductmate Industries, Inc.
   3. Greenheck Fan Corporation.
   4. Nailor Industries Inc.

B. 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-inchbutt 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: Two hinges and two sash locks.
    c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
    d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

## 2.8 FLEXIBLE CONNECTORS

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

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. Ventfabrics, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. 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.

E. 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.

## 2.9 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.

E. Install test holes at fan inlets and outlets and elsewhere as indicated.

F. Install fire 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. At outdoor-air intakes and mixed-air plenums.
2. At drain pans and seals.
3. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
4. Adjacent to and close enough to fire dampers, to reset or reinstall fusible links. Access doors for access to fire 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.
5. At each change in direction and at maximum 50-foot spacing.
6. Upstream from turning vanes.
7. Control devices requiring inspection.
8. 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.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 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 with maximum 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. Connect flexible ducts to metal ducts with liquid adhesive plus tape.

O. 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**

# SECTION 233346
# FLEXIBLE DUCTS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Non-insulated flexible ducts.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For flexible ducts.

1. Include plans showing locations and mounting and attachment details.

### 1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, and coordinated with each other, using input from installers of the items involved.

## 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.

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E 96/E 96M, "Test Methods for Water Vapor Transmission of Materials."

### 2.2 NON-INSULATED FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc;.
2. McGill AirFlow LLC;.
3. Thermaflex; a Flex-Tek Group company;.

B. Non-Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

### 2.3 FLEXIBLE DUCT CONNECTORS

A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

B. Non-Clamp Connectors: Liquid adhesive plus tape.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

D. Connect flexible ducts to metal ducts with liquid adhesive plus tape.

E. Install duct test holes where required for testing and balancing purposes.

F. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

G. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

**END OF SECTION**

## SECTION 233416
## CENTRIFUGAL HVAC FANS

### 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. Square in-line centrifugal fans.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Certified fan performance curves with system operating conditions indicated.
4. Certified fan sound-power ratings.
5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
6. Material thickness and finishes, including color charts.
7. Dampers, including housings, linkages, and operators.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in normal operation, emergency operation, and maintenance manuals with replacement parts listing.

### PART 2 - PRODUCTS

### 2.1 SQUARE IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Greenheck Fan Corporation.
2. Loren Cook Company.

B. Description: Square in-line centrifugal fans.

C. Housing:

1. Housing Material: Reinforced galvanized steel.
2. Housing Coating: None.
3. Housing Construction: Side panels shall be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

E. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.

F. Motor Enclosure: Totally enclosed, fan cooled.

G. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
4. Companion Flanges: For inlet and outlet duct connections.
5. 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.
6. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
7. Side Discharge: Flange connector and attachment hardware to provide right-angle discharge on side of unit.

## 2.2 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. AMCA Compliance: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.

C. Fan Sound Ratings: Comply with AMCA 311 and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.

D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.

E. Operating Limits: Classify fans according to AMCA 99.

# PART 3 - EXECUTION

## 3.1 INSTALLATION OF CENTRIFUGAL HVAC FANS

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Support duct-mounted centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

## 3.2 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

## 3.3 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

## 3.4 FIELD QUALITY CONTROL

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

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

C. Perform tests and inspections.

D. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that there is adequate maintenance and access space.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
6. Adjust belt tension.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
11. Remove and replace malfunctioning units and retest as specified above.

E. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

## 3.5 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

## 3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

**END OF SECTION**

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## SECTION 233423
## HVAC POWER VENTILATORS

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Centrifugal roof ventilators.

### 1.2 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

### 1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

### 1.4 QUALITY ASSURANCE

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

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

### PART 2 - PRODUCTS

### 2.1 CENTRIFUGAL ROOF VENTILATORS

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

1. Greenheck Fan Corporation.
2. Aerovent; a division of Twin City Fan Companies, Ltd.
3. Carnes Company.

B. Description:

1. Downblast fan shall be for roof mounted applications
2. Performance capabilities up to 4,300 cubic feet per minute (cfm) and static pressure to 1 inches of water gauge
3. Fans are available in sixteen sizes with nominal wheel diameters ranging from 8 inches through 18 inches (071 - 180 unit sizes)
4. Maximum continuous operating temperature is 180 Fahrenheit
5. Each fan shall bear a permanently affixed manufacturer's engraved metal nameplate containing the model number and individual serial number.

C. Wheel:

1. Constructed of aluminum
2. Non-overloading, backward inclined centrifugal
3. Statically and dynamically balanced in accordance to AMCA Standard 204-05
4. The wheel cone and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency.

D. Motors:
    1. Electronically Commutated Motor
        a. Motor enclosure: ODP
        b. Motor to be a DC electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors
        c. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase
        d. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor
        e. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal
        f. Motor shall be a minimum of 85% efficient at all speeds
E. Housing:
    1. Motor cover, shroud, curb cap, and lower windband shall be constructed of heavy gauge aluminum
    2. Shroud shall have an integral rolled bead for extra strength
    3. Shroud shall be drawn from a disc and direct air downward
    4. Lower windband shall have a formed edge for added strength
    5. Motor cover shall be drawn from a disc
    6. All housing components shall have final thicknesses equal to or greater then preformed thickness
    7. Curb cap shall have pre-punched mounting holes to ensure correct attachment
    8. Rigid internal support structure
    9. Leak proof
F. Housing Supports and Drive Frame:
    1. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators
G. Vibration Isolation:
    1. Rubber isolators
    2. Sized to match the weight of each fan
H. Disconnect Switches:
    1. NEMA rated: NEMA 1: indoor application no water. Factory standard.
    2. Positive electrical shut-off
    3. Wired from fan motor to junction box installed within motor compartment
I. Options/Accessories:
    1. Roof Curb adaptors:
        a. Welded, straight sided curb with 2 inches of flashing flange and wood nailer
        b. Mounted onto roof with fan
        c. Material: Galvanized
        d. Insulation thickness: 1 inches
        e. Coating Type: Permatector

2. Dampers:
    a. Type: WD-100, Gravity
    b. Prevents outside air from entering back into the building when fan is off
    c. Balanced for minimal resistance to flow
    d. Galvanized frames with prepunched mounting holes
3. Finishes:
    a. Permatector - thermo-setting polyester urethane

## 2.2 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.

## 2.3 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Equipment Mounting:
    1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

## 3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## 3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

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

D. Prepare test and inspection reports.

## 3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

**END OF SECTION**

## SECTION 233600
## AIR TERMINAL UNITS

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Shutoff, single-duct air terminal units.
2. Casing liner.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

B. Shop Drawings: For air terminal units.

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.

### 1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

B. Field quality-control reports.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

### PART 2 - PRODUCTS

### 2.1 SYSTEM DESCRIPTION

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

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

### 2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

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

1. Anemostat Products; a Mestek company.
2. ENVIRO-TEC; by Johnson Controls, Inc.
3. METALAIRE, Inc.
4. Trane.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.040-inch- thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass duct liner.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.

4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: AHRI 880 rated, 1 percent of nominal airflow at 4-inch wg inlet static pressure.
2. Damper Position: Normally open.

E. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
1. SCR controlled.
2. Access door interlocked disconnect switch.
3. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
4. Nickel chrome 80/20 heating elements.
5. Airflow switch for proof of airflow.
6. Fan interlock contacts.
7. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
8. Mercury contactors.
9. Magnetic contactor for each step of control (for three-phase coils).

## 2.3 CASING LINER

A. Casing Liner: Fibrous-glass duct liner, complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
1. Minimum Thickness: 1 inch.
a. Maximum Thermal Conductivity:
1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

## 2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.
1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

# PART 3 - EXECUTION

## 3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.

5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

## 3.2 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

E. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

## 3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.

2. 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.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

## 3.4 DEMONSTRATION

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

**END OF SECTION**

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## SECTION 233713.13
## AIR DIFFUSERS

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Rectangular and square ceiling diffusers.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### PART 2 - PRODUCTS

### 2.1 RECTANGULAR AND SQUARE CEILING DIFFUSERS

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

1. Anemostat Products; a Mestek company.
2. Hart & Cooley Inc.
3. METALAIRE, Inc.
4. Price Industries.

B. Ceiling diffusers shall be high performance, high induction, mixing type and shall have a square or rectangular neck. Diffusers shall have a fixed, horizontal air discharge pattern, and shall be configured with a 1,2, 3 or 4 way core / discharge pattern as scheduled. The diffuser core shall be removable, without tools, for cleaning or re-configuring the space air distribution. No screw holes shall be visible. Induction vanes shall be factory welded to the core to prevent tampering or alteration. The induction vanes shall extend to the face of the diffuser and be designed to compress the supply air into jets which will induce room air. Jets from adjacent channels shall alternate in direction from the center outward to promote rapid mixing of room and supply air.

C. Diffusers shall be constructed from steel or aluminum as scheduled. Steel components / hardware required for design integrity are acceptable for aluminum construction.

D. Accessories shall be provided as required and scheduled to meet the design intent. Square to round duct adapters shall be used in transitioning to round duct. Adapters shall be of sufficient height to include opposed blade volume control dampers, and equalizing deflectors as scheduled. Dampers shall be adjustable from the room side by removing, without tools, the inner core assembly.

E. The manufacturer shall provide performance data obtained in accordance with current ANSI/ASHRAE standard 70.

F. The baked-on finish shall be Arctic White, or color as scheduled. If custom, a sample color chip shall be provided to the diffuser manufacturer.

### PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install diffusers level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

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

**3.2 ADJUSTING**

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

**END OF SECTION**

## SECTION 233713.23
## REGISTERS AND GRILLES

### PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Fixed face grilles.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
2. Section 233713.13 "Air Diffusers" for various types of air diffusers.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

### PART 2 - PRODUCTS

### 2.1 GRILLES

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

1. Anemostat Products; a Mestek company.
2. Hart & Cooley Inc.
3. METALAIRE, Inc.
4. Price Industries.

B. Perforated Grille:

1. Provide sizes and mounting types as scheduled. For surface mounting applications, countersunk mounting holes shall be provided in the border, with oval head screws also provided by the grille manufacturer. The perforated face pattern shall be 3/16" diameter holes on 1/4" centers with a 51% free area. Grilles shall be constructed from steel, extruded aluminum, or 304 stainless steel as scheduled.
2. Provide a baked-on, arctic white finish, or match color as selected by the architect.

C. Grid Core Grille:

1. The return grilles shall integrate with the ceiling style as scheduled. The core shall be an aluminum grid consisting of a 1/2" x 1/2" x 1/2" cells, and shall have a minimum free area of 90%. For surface mounting applications, the border shall be extruded aluminum, and shall include countersunk screw holes for installation. Lay-in models shall include extension panels where required for the scheduled duct size and grid system module size. The grilles shall have a baked-on arctic white finish.

### PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install grilles level and plumb.

B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install 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 grilles to air patterns indicated, or as directed, before starting air balancing.

**END OF SECTION**

## SECTION 235523.13

## LOW-INTENSITY, GAS-FIRED, RADIANT 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 low-intensity, gas-fired, forced-draft radiant heaters.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

### 1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas-fired, radiant heaters to include in emergency, operation, and maintenance manuals.

### 1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of radiant heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Period: All warranty periods listed below are from date of Substantial Completion.

a. Burner Assembly: Three years.

b. Combustion and Emitter Tubes: Three years.

c. Heater Controls: Three year(s).

### PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. CSA certified, with CSA Seal and certification number clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.

B. UL listed and labeled, with UL label clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.

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

### 2.2 FORCED-DRAFT HEATERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Roberts-Gordon, Inc.

B. Description: Factory-assembled, indoor, overhead-mounted, electrically controlled, low-intensity, infrared radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup.

C. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.

D. Equipment

1. Burner Box
2. Reflectors
3. Radiant Tubing - Heat Exchanger
4. Suspension Materials

5. Heat Demand Control Devices

E. Components

1. Burner Box:

Agency approved burner shall be available in either Natural Gas or Propane models. Enclosed box design with silicone gasketed doors and internally mounted blower, burner cup to be nickel plated finished 16ga. cold rolled steel, factory installed outside air adapter collar for sealed combustion (if outside air is supplied to burner), hot surface ignition module, four-try ignition, door interlock safety switch, all components easily accessed, durable spot welded construction, mica flame observation window, gas and electric controls are separated from the combustion air stream and combustion chamber with spot welded complete barrier, and CSA approved. Burner box paint shall be electrostatically applied epoxy-polyester powder coat for corrosion resistance. Heater shall be equipped with permanently lubricated, internally mounted blower motor with thermal overload protection. Stainless steel flexible gas line and high-pressure gas shutoff assembly included, for U.S. models only. Rubber (Type 1) Gas Hose and high-pressure gas shutoff assembly available for Canadian models.

a. Burner Controls:

1) Factory Wired:

All burners shall be factory wired for 120 Vac operation, Hot Surface Ignition and modulating gas valve, variable speed combustion air blower and control for burner operation sequencing and modulation.

2) Fail-Safe Controls:

To assure a fail-safe operation, the design shall include an air proving safety pressure switch to verify blower operation before gas valve opens. Combustion air pressure shall be continuously monitored and measured by a pressure sensor. A sensed reduction in pressure shall result in corresponding modulated reduction in gas input for maximum safety and combustion quality.

3) Ignition Controls:

All units shall be equipped with a fully automatic Hot Surface Ignition (HSI). The ignition control shall have a pre-purge and timed trial for ignition with 4 ignition trials before lockout occurs. Heater shall have blower post-purge after burner shutdown. Burner shall have a 1 hour automatic reset from lockout.

4) Burner Modulation Controls:

All units shall be equipped with a control to modulate both gas input and combustion air simultaneously to maintain proper combustion and continuously modulate burner input smoothly (not staged or stepped) throughout input range from minimum rated input to maximum rated input. Control shall be configurable for modulating burner input by the following methods: 24V thermostat; zone sensor input; programmable modulating thermostat; remote analog signal (0-10V or 4-20mA) from building management controls; or potentiometer.

2. Reflectors:

   Provide .024' thick commercially pure, hardened aluminum for maximum reflectivity and rigidity, or .025" thick stainless steel reflectors, installed to provide continuous coverage over entire length of heat exchanger. Reflectors shall be a parabolic shape with 11 bends to ensure maximum reflectivity and reflector rigidity. In order to maximize radiant output and minimize convection losses, reflectors are to extend below the bottom of the heat exchanger pipe. Manufacturer shall include end cap fittings are provided as standard equipment with all heaters to minimize convection losses and maintain heat exchanger temperatures.

   a. Cover Elbow Fittings:

      For linear models provide reflector joint pieces over heat exchanger elbows so reflector covers heat exchanger continuously.

   b. End Cap Fittings:

      All reflectors at terminate of the heat exchanger and any elbows shall have end caps to prevent convective heat from escaping.

3. Radiant Tubing – Heat Exchanger:

   a. Burner Tube:

      Shall be ALUMITHERM® steel (aluminized steel/titanium alloy) tube for the first 10 ft. of each radiant heater.

   b. Radiant Tube:

      Shall be 4" OD. Heat Treated Aluminized steel tube 16 gauge wall with an emissivity factor of 0.80 or greater.

   c. Couplings:

      Couplings shall be 12" in length, 28 gauge, 430 Stainless Steel.

4. Suspension Materials:

   The following hanging components to be provided by original manufacturer of heating equipment.

   a. Tube and Reflector Hangers:

      Hangers to be nickel plate finish .312 thick Cold Rolled Steel Rod. Hangers shall provide the option of hanging reflectors at 45°, with 2 connection points. The entire system will be supported by the hangers.

   b. S-Hook:

      For each Tube and Reflector Hanger, manufacturer shall include an S-Hook to attach Tube and Reflector Hanger to chain or other hanging material.

   c. Clamp Package:

      The first Tube and Reflector Hanger to be no more than 4" from the burner and shall include a Clamp Package, provided by manufacturer and installed to prevent burner and tube movement or rotation due to expansion and contraction of system.

   d. Reflector Support Strap & Wire Form:

      Manufacturer shall include as standard a Reflector Support Assembly to hold reflectors in place and prevent against shifting of reflectors as a result of contraction and expansion of system during heating and cooling heating of system and components.

5. Heat Demand Control Devices:

   Provide where indicated, low voltage type heat demand control device for each “central” radiant heater.

   a. 24V Programmable Modulating Thermostat:

      24V electronic modulating thermostat with 7 day time clock and setback features shall be wired to one heater per zone designated as the “central” heater. Communication wiring shall be wired in series from “central” heater to each “satellite” heater in the zone via control wiring. Separate ON/OFF switch optional for “satellite” heaters (not supplied by manufacturer). Thermostat shall control modulation of heater(s) according to the actual space temperature and desired setpoint. Zone averaging and outdoor sensors may be added per the engineer’s specification. LonWorks feature for communication to building management system may be added per the engineer’s specification.

F. Accessories/ Options

1. Outside Air- Separated Combustion

   Provide option of fresh outside air to supply each burner for the support of combustion air. Manufacturer shall install an outside air duct connection collar for connection of fresh air supply for all heaters.

2. Venting:

   Provide option of venting combustion air through an outside wall or roof.

G. Source Quality Control

1. Performance Verification

   Each burner shall be fired and tested and recorded for proper sequence of operation and proper functionality in accordance with manufacturer’s requirements before leaving manufacturing facility.

H. Installation of Gas Fired Radiant Heaters

1. General

   All installations and service of low-intensity infrared heating equipment must be performed by a contractor qualified in the installation and service of equipment sold and supplied by Roberts-Gordon and conform to all requirements set forth in the equipment manuals and all applicable governmental authorities pertaining to the installation, service and operation of the equipment. Allow adequate space for servicing or removal of the unit without disturbing other piping or equipment.

2. Support

   Suspend heat exchanger, burner, gas piping, conduit, and reflectors from building substrate as indicated, or if not indicated, in manner to provide durable and safe installation; and in accordance with ROBERTS GORDON® installation instructions. Minimum mounting height above floor level to be indicated in equipment manual. All tube must be supported in accordance with acceptable practices, local codes, seismic requirements, and as shown on plans. Heat exchanger tube shall pitch down at least 1/2” in 20’ away from burner box.

3. Clearance To Combustibles

   Maintain or exceed clearance to combustibles outlined and printed on burner label, and in ROBERTS GORDON® product data. Measure clearance distance from surface of heat exchanger.

4. Outside Air

   Install outside air piping for sealed combustion as indicated on plan, using only materials indicated in the Installation Operation and Service Manual. 4" diameter outside air supply required for 80,000 or 115,000 BTU/h units, 5" diameter outside air supply required for 150,000 or 200,000 BTU/h units.

5. Venting

   Install vent piping as indicated. Terminate where indicated on the drawings with a vent terminal assembly as supplied by the manufacturer.

6. Gas Piping

   Install gas piping as indicated and in accordance with Z233.1/ NFPA 54 National Fuel Gas Code (latest edition).

   a. Required Gas Supply Inlet Pressures:

| Natural Gas Units | Required Min. Gas Pressure | Max. Gas Pressure |
|---|---|---|
| 80,000-150,000 Btu/h | 5.5" wc | 14" wc |
| 200,000 Btu/h | 6.0" wc | 14" wc |

   b. Local Codes:

      Gas supply piping must meet local requirements and be sized in accordance with Btu demand, available pressure and total length of supply required for the installation. Connection from supply to burner unit must be made in accordance with installation instructions. Gas shut-off, as supplied with SS Gas Line or Rubber Gas Hose, and controls in unit must not be subjected to more than 1/2 psi. or 14" wc pressure.

7. Electrical Wiring

   Install electrical wiring as indicated. Connect power wiring to burners and control wiring between burners and thermostats in accordance with manufacturer's wiring diagrams.

8. Heat Demand Control Devices

   Provide where indicated, low voltage type heat demand control device connected to "central" radiant heater. Mount heat demand control device 5'– 6' above finish floor or otherwise as noted on the drawing. Heat demand control device wiring must follow local codes. Install low voltage ON/OFF switch near heat demand control device. If using zone temperature sensors, ON/OFF switch shall be incorporated into sensor design.

9. Thermostat Guards

   Thermostats to be covered with a locking thermostat cover when required.

I. Field Quality Control

1. Start-Up

   Start-up, test, and adjust gas fired radiant heaters in accordance with ROBERTS GORDON® start-up instructions, and Utility Company's requirements. Check controls, adjust burners if applicable according to ROBERTS GORDON® instructions for maximum efficiency.

2. Closeout Procedures

   Provide services of a ROBERTS GORDON® technical representative to instruct operating personnel in operation and maintenance of gas fired radiant heaters.

   a. Building Owner:

      Schedule instruction with operating building owner, provide at least 7 days notice.

3. Annual Maintenance And Cleaning

   To help facilitate optimum performance and safety, Roberts-Gordon recommends that a qualified contractor annually inspect your ROBERTS-GORDON® equipment and perform service where necessary, using only replacement parts sold and supplied by Roberts-Gordon.

4. Codes And Standards

   a. American National Standard / CSA Standard for Gas-Fired Low-Intensity Infrared Heaters:
      Construct and certify gas fired radiant heaters in accordance with latest edition ANSI Z83.20 / CSA 2.34 "Gas-Fired Low-Intensity Infrared Heaters" including all current supplements.

   b. Installation Compliance:
      Install gas fired radiant heaters in accordance with the Installation Operation and Service Manual and the Z223.1/ NFPA 54 National Fuel Gas Code (latest edition).

   c. Compliance:

   d. Provide seal affixed to each burner name plate and provide certification of heater design as vented or unvented infrared heater for indoor installation.

   e. National Standard Gas Piping Compliance:

   f. Install and connect gas piping to gas fired radiant heaters in accordance with Z223.1/ NFPA 54 National Fuel Gas Code (latest edition).

   g. National Electrical Code Compliance:

   h. Install and connect electrical wiring to gas fired radiant heaters in accordance with NFPA 70 "National Electrical Code®" (latest edition).

5. Warranty

   Provide written warranty, by manufacturer, agreeing to replace/repair, within warranty period, components of gas fired radiant systems furnished by manufacturer, which are defective in either material or workmanship, provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty periods follows:

   a. Terms:

      1) Three (3) year warranty on the burner system and on the tubing from date of final acceptance of the infrared heaters.

      2) Three (3) years from date of final acceptance of all other components including electrical.

**END OF SECTION**

## SECTION 235533.16
## GAS-FIRED 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 gas-fired unit heaters.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of gas-fired unit heater.

1. Include rated capacities, operating characteristics, and accessories.

### 1.4 CLOSEOUT SUBMITTALS

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

### 1.5 MAINTENANCE MATERIAL SUBMITTALS

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

### 1.6 QUALITY ASSURANCE

A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

### 1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of gas-fired unit heater that fails in materials or workmanship within specified warranty period.

1. Warranty Period: two years from date of Substantial Completion.

### PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

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

B. Capacities and Characteristics – see schedule on the drawings.

### 2.2 MANUFACTURED UNITS

A. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.

B. Gas Type: Design burner for natural gas having characteristics same as those of gas available at Project site.

C. Type of Venting: Indoor, separated combustion.

D. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.

1. External Casings and Cabinets: Powder coating over corrosion-resistant-treated surface.
2. Discharge Louvers: Independently adjustable, horizontal blades.
3. Discharge Nozzle: Discharge at 25 to 65 degrees from horizontal.

E. Accessories:

1. Four-point suspension kit.
2. Power Venter: Centrifugal aluminized-steel fan, with stainless-steel shaft; 120-V ac motor.

3. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.

F. Heat Exchanger: Stainless steel.

G. Burner Material: Stainless steel.

H. Propeller Unit Fan:

1. Aluminum propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.

2. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.

I. Centrifugal Unit Fan:

1. Steel, centrifugal fan dynamically balanced and resiliently mounted.

2. Belt-Driven Drive Assembly:

a. Resiliently mounted to housing, with the following features:

1) Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

2) Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3) Pulleys: Cast-iron, adjustable-pitch motor pulley.

J. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2. Enclosure Materials: Rolled steel.

3. Efficiency: Premium efficient.

K. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Gas Control Valve: Two stage.

2. Ignition: Electronically controlled electric spark with flame sensor.

3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.

4. Vent Flow Verification: Differential pressure switch to verify open vent.

5. Control transformer.

6. High Limit: Thermal switch or fuse to stop burner.

7. Thermostat: Devices and wiring are specified in Section 230923.27 "Temperature Instruments."

L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install and connect gas-fired unit heaters and associated gas and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written instructions.

### 3.2 EQUIPMENT MOUNTING

A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

## 3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to gas-fired unit heater, allow space for service and maintenance.

C. Vent Connections: Comply with Section 235123 "Gas Vents."

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 test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

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

C. Gas-fired unit heater will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

## 3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

## 3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain gas-fired unit heaters.

**END OF SECTION**

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

### PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. Package roof top unit.

B. Heat exchanger.

C. Refrigeration components.

D. Unit operating controls.

E. Roof curb.

F. Electrical power connections.

G. Operation and maintenance service.

### 1.2 RELATED SECTIONS

A. Section 230513 – Common Motor Requirements for HVAC Equipment.

B. Section 230713 - Duct Insulation.

C. Section 230923 – Direct Digital Control (DDC) System for HVAC.

### 1.3 REFERENCES

A. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.

B. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.

C. ANSI/ASHRAE 37 - Testing Unitary Air Conditioning and Heat Pump Equipment.

D. ANSI/ASHRAE/IESNA 90.1-1999 - Energy Standard for New Buildings Except Low-Rise Residential Buildings.

E. ANSI Z21.47/UL1995 - Unitary Air Conditioning Standard for safety requirements.

F. AHRI 210/240 - Unitary Air-Conditioning Equipment and Air- Source Heat Pump Equipment.

G. AHRI 270 - Sound Rating of Outdoor Unitary Equipment.

H. ANSI/NFPA 70-1995 - National Electric Code.

### 1.4 SUBMITTALS

A. Submit unit performance data including: capacity, nominal and operating performance.

B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.

C. Submit shop drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.

E. Shop drawings submitted for approval shall be accompanied by a copy of the purchase agreement between the Contractor and an authorized service representative of the manufacturer for check, test and start up and first year service.

### 1.5 DELIVERY, STORAGE and HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory-shipping covers in place until installation.

## 1.6 WARRANTY

A. Provide parts warranty (excluding refrigerant) for one year from start-up or 18 months from shipment, whichever occurs first.

B. Provide five-year extended warranty for compressors.

C. Provide five-year heat exchanger limited warranty.

## 1.7 REGULATORY REQUIREMENTS

A. Unit shall conform to ANSI Z21.47/UL1995 for construction of packaged air conditioner

1. In the event the unit is not UL approved, the manufacturer must, at his expense, provide for a field inspection by a UL representative to verify conformance to UL standards. If necessary, contractor shall perform modifications to the unit to comply with UL, as directed by the UL representative, at no additional expense to the Owner.

## 1.8 EXTRA MATERIALS

A. Provide 2 set of filters.

# PART 2 PRODUCTS

## 2.1 SUMMARY

A. The contractor shall furnish and install package rooftop 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. APPROVED MANUFACTURERS

1. Trane
2. Johnson Controls / York
3. Daikin

## 2.2 GENERAL UNIT DESCRIPTION

A. Unit(s) furnished and installed shall be gas-fired heating/DX cooling packaged rooftop (s) as scheduled on contract documents and these specifications. Cooling capacity ratings shall be based on AHRI Standard. Unit(s) shall consist of insulated weather-tight casing with compressor(s), air-cooled condenser coil, condenser fans, evaporator coil, return-air filters, supply motors and microprocessor unit controls.

B. Unit(s) shall be 100% factory run tested and fully charged with R-410A.

C. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

D. Units shall be convertible airflow design as manufactured.

E. Wiring internal to the unit shall be colored and numbered for identification.

## 2.3 UNIT CASING

A. Cabinet: Galvanized steel, phosphatized, and finished with a pre-applied baked polyurethane enamel. Structural members shall be 18 gauge with access doors and removable panels of a minimum 20 gauge.

B. Unit's cabinet surface shall be tested 672 hours in salt spray test in compliance with ASTM B117.

C. Cabinet construction shall allow for all service/ maintenance from one side of the unit.

D. Cabinet top cover shall be one piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.

E. Access Panels: Water- and air-tight panels with handles shall provide access to filters, heating section, return air fan section, supply air fan section, evaporator coil section, and unit control section.

F. Unit's base pan shall have a raised 1 1/8 inch high lip around the supply and return openings for water integrity.

G. Provide ½ inch foil faced, fire retardant permanent, odorless glass fiber material. All edges must be captured so that there is no insulation exposed in the air stream.

H. The base pan shall have no penetrations within the perimeter of the curb other that the raised 1 1/8 inch high down flow supply/return openings to provide and added water integrity precaution.

I. Provide openings either on side of unit or through the base for power, control, condensate, and gas connections.

J. The base of the unit shall have 3 sides for forklift provisions. The base of the units shall have rigging/lifting holes for crane maneuvering.

**2.4 AIR FILTERS**

A. Air Filters: Factory installed filters shall mount integral within the unit and shall be accessible through access panels. Two-inch thick glass fiber disposable media filters shall be provided.

B. Filters shall be two inch MERV 8.

**2.5 FANS AND MOTORS**

A. Provide evaporator fan section with forward curved, double width, double inlet, centrifugal type fan.

B. Provide self-aligning, grease lubricated, ball or sleeve bearings with permanent lubrication fittings.

C. Plenum Fan: All 6-10 ton high efficiency units shall be equipped with a direct drive plenum fan design. Plenum fan design shall include a backward-curved fan wheel along with an external rotor direct drive variable speed indoor motor. All plenum fan designs will have a variable speed adjustment potentiometer located in the control box.

D. Outdoor and Indoor Fan motors shall be permanently lubricated and have internal thermal overload protection.

E. Outdoor fans shall be direct drive, statically and dynamically balanced, draw through in the vertical discharge position.

F. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

**2.6 GAS FIRED HEATING SECTION**

A. Completely assembled and factory installed heating system shall be integral to unit, UL or CSA approved specifically for outdoor applications for use downstream from refrigerant cooling coils. Threaded connection with plug or cap provided. Provide capability for gas piping.

B. Heating section shall be factory run tested prior to shipment.

C. Induced draft combustion type with direct spark ignition system, redundant main gas valve, and modulating gas heat control.

D. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, and continuous flame supervision. Provide flame rollout switches.

E. Induced draft blower shall have combustion air proving switches and built-in thermal overload protection on fan motor.

F. Units shall be suitable for use with natural gas.

G. Heat Exchanger: Provide tubular section type constructed from 18-gauge aluminized steel.

H. Through the base gas piping- the units shall include a standard through the base gas provision. This option shall have all piping necessary including black steel, manual gas shut off valve, elbows, and union. The manual shutoff valve shall include a 1/8 NPT pressure tap.

I. Burners: Burners shall be of the in-shot type constructed of stainless steel.

J. Limit controls: High temperature limit controls will shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow or loss of indoor airflow.

## 2.7 EVAPORATOR COIL SECTION

A. Provide configured aluminum fin surface mechanically bonded to copper tubing coil.

B. Provide an independent expansion device for each refrigeration circuit. Factory pressure tested at 450 psig and leak tested at 200 psig.

C. Provide a removable, reversible, cleanable double sloped drain pan for base of evaporator coil constructed of PVC.

## 2.8 CONDENSER SECTION

A. Provide vertical discharge, direct drive fans with aluminum blades. Fans shall be statically balanced. Motors shall be permanently lubricated, with integral thermal overload protection in a weather tight casing.

B. Condenser coils shall be of a fully brazed, all-aluminum tube and fin construction. (Microchannel).

C. Provide tool-less factory installed corrosion resistant louvered hail/vandalism guards to protect condenser coils from hail or physical damage.

## 2.9 REFRIGERATION SYSTEM

A. All units shall have direct drive hermetic, scroll type compressors with centrifugal type oil pumps. Motor shall be suction gas cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate.

B. Provide with thermostatic temperature motor winding control for protection against excessive temperatures caused by over/under voltage operation or loss of charge. Also provide high and low pressure switches.

C. Thermal Expansion valves are standard for all models.

D. Units shall have cooling capabilities down to 0 degree F as standard with microprocessor controls. For field-installed low ambient accessory, the manufacturer shall provide a factory-authorized service technician that will assure proper installation and operation.

E. Provide each unit with 2 refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, suction and liquid line pressure ports.

F. Provide Rawal APR Valves or hot gas bypass on each refrigerant circuit to allow modulation at part load from 100% to 25% of rated capacity..

## 2.10 OUTDOOR AIR SECTION

A. Provide adjustable minimum outside air position control.

B. Provide spring return motor for outside air damper closure during unit shut down or power interruption.

## 2.11 OPERATING CONTROLS

DDC CONTROLS

A. General: Provide microprocessor controls to allow interconnection with building wide DDC BMX. Resident control algorithms shall make all heating and cooling decisions in response to electronic signals from the BMS as well as zone sensors measuring indoor and outdoor temperatures. The control algorithm shall maintain accurate temperature control, minimizes drift from setpoint and provide better building comfort. A centralized microprocessor shall provide anti-short cycle timing and time delay between compressors to provide a higher level of machine protection.

B. Constant Volume Controls: Provide all necessary controls to operate rooftop from a zone Based temperature sensor, including microprocessor unit control.

C. Clogged filter indication: Provide factory installed differential pressure switch to indicate filter replacement status. Differential pressure switch shall cause a contact closure to display a service indication and unit will continue to operate normally.

D. Provide Discharge Air Temperature Sensing Tube: Provides true discharge air temperature sensing in heating models. This sensor is a status indicator readable through Tracer or Tracker. For Microprocessor controlled units only.

D. Provide factory-installed indoor evaporator defrost control to prevent compressor slugging by interrupting compressor operation.

**2.12 STAGING CONTROLS**

A. Provide NEC Class II, electronic, adjustable zone control to maintain zone temperature setting.

B. Provide programmable electronic micro-computer-based zone control.

1. Zone control shall incorporate:
    a. Automatic changeover from heating to cooling based on signal from BMS.
    b. Remote reset of heating and cooling temperatures setpoints.
    c. Instant override of setpoint for continuous or timed period from one hour to 31 days.
    d. Switch selection features including Fahrenheit display, 12 or 24-hour clock, keyboard disable, remote sensor, fan on-auto.
    e. Smart Fan Operation: Allows the unit fan operation to default to the Auto Mode during unoccupied periods, regardless of the Fan switch position.
2. Zone sensor display shall be capable of:
    a. Time of day.
    b. Actual room temperature.
    c. Programmed temperature.
    d. Programmed time.
    e. Duration of timed override.
    f. System mode indication: heating, cooling, low battery, and fan on.

C. Provide remote temperature sensor capability.

**2.13 BUILDING MANAGEMENT SYSTEM**

A. Lontalk or BACnet Interface control module to Energy Management System to be furnished and mounted by rooftop unit manufacturer. Through this interface module, all Energy Management functions (specified in Energy Management Section) shall be performed. See Building Automation and Automatic Temperature Control System Specifications. The interface module with necessary controls and sensors shall all be factory mounted (not field mounted). If not furnished by rooftop unit manufacturer, this shall be furnished by Energy Management System Contractor for factory mounting by rooftop unit manufacturer in rooftop unit and rated for service up to 140 F. The only field connection to Energy Management System shall be a single communication link.

B. Control Functions: Include unit scheduling, occupied/unoccupied mode, start-up and coast-down modes, nighttime free-cool purge mode, demand limiting, night setback, discharge air set point adjustment, timed override and alarm shutdown.

C. Diagnostic Functions: Include supply fan status, Diagnostic Functions shall Include: Unit operating mode, unit failure status, cooling failure , Heating failure, emergency service stop indication, supply fan proving, timed override activation, high temperature thermostat status, Zone temperature, supply air temperature, cooling status, Stage activation or not, Stage locked out by UCP/HPC status for that stage, compressor disable inputs, Number of stages activated, high temperature limit status, Economizer status, Enthalpy favorability status, Requested minimum position, Damper position, Dry bulb. Enthalpy input status, outside air temperature, outside relative humidity,

D. Sensor failure: Humidity sensor, oat sensor, SAT sensor, RAT sensor, zone temperature sensor, mode input, cooling/heating setpoints from sensors (cv only), static pressure transducer, Unit mounted Potentiometer, SAT from potentiometer , high temp input status, local setpoint, local mode,

E. Provide capabilities for Boolean Processing and trend logs as well as "template" reports and logs.

### 2.14 ROOF CURB ADAPTOR

A. Contractor shall provide factory supplied roof curb adaptor, 16-gauge perimeter made of zinc coated steel with supply and return air gasketing and wood nailer strips. Ship knocked down and provided with instructions for easy assembly.

B. Curbadaptor shall be manufactured in accordance with the National Roofing Contractors Association guidelines.

## PART 3 EXECUTION

### 3.1 EXAMINATION

A. Contractor shall verify that roof is ready to receive work.

B. Contractor shall verify that proper power supply is available.

### 3.2 INSTALLATION

A. Contractor shall install in accordance with manufacturer's instructions.

B. Mount units on factory-built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

### 3.3 ELECTRICAL

A. Phase Monitoring Protection: units with 3-phase power are equipped with phase monitoring protection as standard.

B. Through the base electrical with disconnect switch will be installed in the unit in a water tight enclosure with access through a swinging door. Wiring will be provided from the switch to the unit high voltage terminal block. The switch will be cULus agency recognized.

C. Through the base Electrical with circuit Breaker: A thermal magnetic, molded case, HSCR circuit breaker with provisions for through the base electrical connections. The circuit breaker will be installed in a water tight enclosure in the unit with access through a swinging door. Wiring will be provided from the switch to the unit high voltage terminal block. The circuit breaker will provide overcurrent protection, be sized per NEC and cULUS guidelines, and be agency recognized by cULus.

D. Through the Base Electrical Access: An electrical service entrance shall be provided allowing electrical access for both control and power connects inside the curb and through the base of the unit.

E. Powered Convenience outlet: A GFCI 120V/15 amp, 2 plug, convenience outlet. The convenience outlet is powered from the line side of the disconnect or circuit breaker, and will not be affected by the position of the disconnect or circuit breaker. This option can only be ordered when the through the base electrical option is ordered.

E. Wiring internal to the unit shall be colored and numbered for identification.

**END OF SECTION**

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

### PART 1 GENERAL

### 1.1 SECTION INCLUDES

A. Package roof top unit.

B. Heat exchanger.

C. Refrigeration components.

D. Unit operating controls.

E. Roof curb.

F. Electrical power connections.

G. Operation and maintenance service.

### 1.2 RELATED SECTIONS

A. Section 230513 – Common Motor Requirements for HVAC Equipment.

B. Section 230713 - Duct Insulation.

C. Section 230923 – Direct Digital Control (DDC) System for HVAC.

### 1.3 REFERENCES

A. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.

B. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.

C. ANSI/ASHRAE 37 - Testing Unitary Air Conditioning and Heat Pump Equipment.

D. ANSI/ASHRAE/IESNA 90.1-1999 - Energy Standard for New Buildings Except Low-Rise Residential Buildings.

E. ANSI Z21.47/UL1995 - Unitary Air Conditioning Standard for safety requirements.

F. AHRI 210/240 - Unitary Air-Conditioning Equipment and Air- Source Heat Pump Equipment.

G. AHRI 270 - Sound Rating of Outdoor Unitary Equipment.

H. ANSI/NFPA 70-1995 - National Electric Code.

### 1.4 SUBMITTALS

A. Submit unit performance data including: capacity, nominal and operating performance.

B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.

C. Submit shop drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.

E. Shop drawings submitted for approval shall be accompanied by a copy of the purchase agreement between the Contractor and an authorized service representative of the manufacturer for check, test and start up and first year service.

### 1.5 DELIVERY, STORAGE and HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units from physical damage. Leave factory-shipping covers in place until installation.

## 1.6 WARRANTY

A. Provide parts warranty (excluding refrigerant) for one year from start-up or 18 months from shipment, whichever occurs first.

B. Provide five-year extended warranty for compressors.

C. Provide five-year heat exchanger limited warranty.

## 1.7 REGULATORY REQUIREMENTS

A. Unit shall conform to ANSI Z21.47/UL1995 for construction of packaged air conditioner

1. In the event the unit is not UL approved, the manufacturer must, at his expense, provide for a field inspection by a UL representative to verify conformance to UL standards. If necessary, contractor shall perform modifications to the unit to comply with UL, as directed by the UL representative, at no additional expense to the Owner.

## 1.8 EXTRA MATERIALS

A. Provide 2 set of filters.

# PART 2 PRODUCTS

## 2.1 SUMMARY

A. The contractor shall furnish and install package rooftop 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. APPROVED MANUFACTURERS

1. Trane
2. York/Johnson Controls
3. Daikin

## 2.2 GENERAL UNIT DESCRIPTION

A. Unit(s) furnished and installed shall be gas-fired heating/DX cooling packaged rooftop (s) as scheduled on contract documents and these specifications. Cooling capacity ratings shall be based on AHRI Standard. Unit(s) shall consist of insulated weather-tight casing with compressor(s), air-cooled condenser coil, condenser fans, evaporator coil, return-air filters, supply motors and microprocessor unit controls.

B. Unit(s) shall be 100% factory run tested and fully charged with R-410A.

C. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

D. Units shall be convertible airflow design as manufactured.

E. Wiring internal to the unit shall be colored and numbered for identification.

## 2.3 UNIT CASING

A. Cabinet: Galvanized steel, phosphatized, and finished with a pre-applied baked polyurethane enamel. Structural members shall be 18 gauge with access doors and removable panels of a minimum 20 gauge.

B. Unit's cabinet surface shall be tested 672 hours in salt spray test in compliance with ASTM B117.

C. Cabinet construction shall allow for all service/ maintenance from one side of the unit.

D. Cabinet top cover shall be one piece construction or where seams exits, it shall be double-hemmed and gasket-sealed.

E. Access Panels: Water- and air-tight panels with handles shall provide access to filters, heating section, return air fan section, supply air fan section, evaporator coil section, and unit control section.

F. Unit's base pan shall have a raised 1 1/8 inch high lip around the supply and return openings for water integrity.

G. Provide ½ inch foil faced, fire retardant permanent, odorless glass fiber material. All edges must be captured so that there is no insulation exposed in the air stream.

H. The base pan shall have no penetrations within the perimeter of the curb other that the raised 1 1/8 inch high down flow supply/return openings to provide and added water integrity precaution.

I. Provide openings either on side of unit or through the base for power, control, condensate, and gas connections.

J. The base of the unit shall have 3 sides for forklift provisions. The base of the units shall have rigging/lifting holes for crane maneuvering.

**2.4 AIR FILTERS**

A. Air Filters: Factory installed filters shall mount integral within the unit and shall be accessible through access panels. Two-inch thick glass fiber disposable media filters shall be provided.

B. Filters shall be two inch MERV 8.

**2.5 FANS AND MOTORS**

A. Provide evaporator fan section with forward curved, double width, double inlet, centrifugal type fan.

B. Provide self-aligning, grease lubricated, ball or sleeve bearings with permanent lubrication fittings.

C. Plenum Fan: All 6-10 ton high efficiency units shall be equipped with a direct drive plenum fan design. Plenum fan design shall include a backward-curved fan wheel along with an external rotor direct drive variable speed indoor motor. All plenum fan designs will have a variable speed adjustment potentiometer located in the control box.

D. Outdoor and Indoor Fan motors shall be permanently lubricated and have internal thermal overload protection.

E. Outdoor fans shall be direct drive, statically and dynamically balanced, draw through in the vertical discharge position.

F. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

**2.6 GAS FIRED HEATING SECTION**

A. Completely assembled and factory installed heating system shall be integral to unit, UL or CSA approved specifically for outdoor applications for use downstream from refrigerant cooling coils. Threaded connection with plug or cap provided. Provide capability for gas piping.

B. Heating section shall be factory run tested prior to shipment.

C. Induced draft combustion type with direct spark ignition system, redundant main gas valve, and 2-staged heat.

D. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, and continuous flame supervision. Provide flame rollout switches.

E. Induced draft blower shall have combustion air proving switches and built-in thermal overload protection on fan motor.

F. Units shall be suitable for use with natural gas.

G. Heat Exchanger: Provide tubular section type constructed from 18-gauge aluminized steel.

H. Through the base gas piping- the units shall include a standard through the base gas provision. This option shall have all piping necessary including black steel, manual gas shut off valve, elbows, and union. The manual shutoff valve shall include a 1/8 NPT pressure tap.

I. Burners: Burners shall be of the in-shot type constructed of stainless steel.

J. Limit controls: High temperature limit controls will shut off gas flow in the event of excessive

temperatures resulting from restricted indoor airflow or loss of indoor airflow.

## 2.7 EVAPORATOR COIL SECTION

A. Provide configured aluminum fin surface mechanically bonded to copper tubing coil.

B. Provide an independent expansion device for each refrigeration circuit. Factory pressure tested at 450 psig and leak tested at 200 psig.

C. Provide a removable, reversible, cleanable double sloped drain pan for base of evaporator coil constructed of PVC.

## 2.8 CONDENSER SECTION

A. Provide vertical discharge, direct drive fans with aluminum blades. Fans shall be statically balanced. Motors shall be permanently lubricated, with integral thermal overload protection in a weather tight casing.

B. Condenser coils shall be of a fully brazed, all-aluminum tube and fin construction. (Microchannel).

C. Provide tool-less factory installed corrosion resistant louvered hail/vandalism guards to protect condenser coils from hail or physical damage.

## 2.9 REFRIGERATION SYSTEM

A. All units shall have direct drive hermetic, scroll type compressors with centrifugal type oil pumps. Motor shall be suction gas cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate.

B. Provide with thermostatic temperature motor winding control for protection against excessive temperatures caused by over/under voltage operation or loss of charge. Also provide high and low pressure switches.

C. Thermal Expansion valves are standard for all models.

D. Units shall have cooling capabilities down to 40 degree F as standard with microprocessor controls. For field-installed low ambient accessory, the manufacturer shall provide a factory-authorized service technician that will assure proper installation and operation.

E. Provide each unit with 2 refrigerant circuit(s) factory-supplied completely piped with liquid line filter-drier, suction and liquid line pressure ports.

F. Provide Rawal APR Valves or hot gas bypass on each refrigerant circuit to allow modulation at part load from 100% to 25% of rated capacity.

## 2.10 EXHAUST/RETURN SECTION

A. Provide, on down flow units from 3-10 tons, a factory supplied field installed power exhaust assembly that shall assist the barometric relief damper in the economizer in relieving building pressurization.

## 2.11 OUTDOOR AIR SECTION

A. Provide economizer with dual enthalpy control.

B. Provide adjustable minimum position control located in the economizer section of the unit.

C. Provide spring return motor for outside air damper closure during unit shut down or power interruption.

## 2.12 OPERATING CONTROLS

DDC CONTROLS

A. General: Provide microprocessor controls to allow interconnection with building wide DDC BMX. Resident control algorithms shall make all heating and cooling decisions in response to electronic signals from the BMS as well as zone sensors measuring indoor and outdoor temperatures. The control algorithm shall maintain accurate temperature control, minimizes drift from setpoint and provide better building comfort. A centralized microprocessor shall provide anti-short cycle timing and time delay between compressors to provide a higher level of machine protection.

B. VAV: Provide all necessary controls to operate a rooftop unit based on maintaining two temperature setpoints: discharge air and zone. During one zone vav cooling, the unit will maintain zone cooling setpoint by modulating the supply fan speed more or less to meet zone load demand; and the unit will maintain discharge temperature to the discharge cooling setpoint by modulating economizer if available and staging dx cooling.

C. Ventilation Override: Provide factory installed, tested and commissioned ventilation override controls. Binary input from independent fire/life safety panel shall cause unit to override standard operation and assume one of two factory preset ventilation sequences: Purge or pressurization.

D. Clogged filter indication: Provide factory installed differential pressure switch to indicate filter replacement status. Differential pressure switch shall cause a contact closure to display a service indication and unit will continue to operate normally.

E. Provide Wall or duct mounted CO2 sensor to monitor space occupancy levels within the building by measuring the parts per million of CO2 (Carbon Dioxide) in the air. As CO2 Levels increase, the economizer fresh air damper shall modulate to meet the co2 space ventilation requirements.

F. Provide Discharge Air Temperature Sensing Tube: Provides true discharge air temperature sensing in heating models. This sensor is a status indicator readable through Tracer or Tracker. For Microprocessor controlled units only.

D. Provide factory-installed indoor evaporator defrost control to prevent compressor slugging by interrupting compressor operation.

E. Economizer Preferred Cooling - Compressor operation is integrated with economizer cycle to allow mechanical cooling when economizer is not adequate to satisfy zone requirements. Compressors are enabled if space temperature is recovering to cooling setpoint at a rate of less than 0.2 degrees per minute. Compressor low ambient lockout overrides this function.

## 2.13 STAGING CONTROLS

A. Provide NEC Class II, electronic, adjustable zone control to maintain zone temperature setting.

B. Provide programmable electronic microcomputer-based zone control.

1. Zone control shall incorporate:

   a. Automatic changeover from heating to cooling.

   b. Set-up for at least 2 - sets of separate heating and cooling temperatures per day.

   c. Instant override of setpoint for continuous or timed period from one hour to 31 days.

   d. Switch selection features including Fahrenheit display, 12 or 24-hour clock, keyboard disable, remote sensor, fan on-auto.

   e. Smart Fan Operation: Allows the unit fan operation to default to the Auto Mode during unoccupied periods, regardless of the Fan switch position.

   f. Economizer Minimum Position Override: Allows the unit controller to override and close the minimum position setting on the economizer damper during unoccupied time periods.

2. Zone sensor display shall be capable of:
    a. Time of day.
    b. Actual room temperature.
    c. Programmed temperature.
    d. Programmed time.
    e. Duration of timed override.
    f. Day of week.
    g. System mode indication: heating, cooling, low battery, and fan on.

C. Provide remote temperature sensor capability.

D. Provide mixed air sensor in supply air to close outside air damper.

E. Provide Wireless Zone Sensor: LCD display that provides heat, cool, auto or off. Includes two temperature setpoints and a lockable settings.

**2.14BUILDING MANAGEMENT SYSTEM**

A. Lontalk or BACnet Interface control module to Energy Management System to be furnished and mounted by rooftop unit manufacturer. Through this interface module, all Energy Management functions (specified in Energy Management Section) shall be performed. See Building Automation and Automatic Temperature Control System Specifications. The interface module with necessary controls and sensors shall all be factory mounted (not field mounted). If not furnished by rooftop unit manufacturer, this shall be furnished by Energy Management System Contractor for factory mounting by rooftop unit manufacturer in rooftop unit and rated for service up to 140 F. The only field connection to Energy Management System shall be a single communication link.

B. Control Functions: Include unit scheduling, occupied/unoccupied mode, start-up and coast-down modes, nighttime free-cool purge mode, demand limiting, night setback, discharge air set point adjustment, timed override and alarm shutdown.

C. Diagnostic Functions: Include supply fan status, Diagnostic Functions shall Include: Unit operating mode, unit failure status, cooling failure , Heating failure, emergency service stop indication, supply fan proving, timed override activation, high temperature thermostat status, Zone temperature, supply air temperature, cooling status, Stage activation or not, Stage locked out by UCP/HPC status for that stage, compressor disable inputs, Number of stages activated, high temperature limit status, Economizer status, Enthalpy favorability status, Requested minimum position, Damper position, Dry bulb. Enthalpy input status, outside air temperature, outside relative humidity,

D. Sensor failure: Humidity sensor, oat sensor, SAT sensor, RAT sensor, zone temperature sensor, mode input, cooling/heating setpoints from sensors (cv only), static pressure transducer, Unit mounted Potentiometer, SAT from potentiometer, high temp input status, local setpoint, local mode,

E. Provide capabilities for Boolean Processing and trend logs as well as "template" reports and logs.

**2.15 ROOF CURB**

A. Contractor shall provide factory supplied roof curb, 16-gauge perimeter made of zinc coated steel with supply and return air gasketing and wood nailer strips. Ship knocked down and provided with instructions for easy assembly.

B. Curb shall be manufactured in accordance with the National Roofing Contractors Association guidelines.

## PART 3 EXECUTION

### 3.1 EXAMINATION

A. Contractor shall verify that roof is ready to receive work.

B. Contractor shall verify that proper power supply is available.

### 3.2 INSTALLATION

A. Contractor shall install in accordance with manufacturer's instructions.

B. Mount units on factory-built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

### 3.3 ELECTRICAL

A. Phase Monitoring Protection: units with 3-phase power are equipped with phase monitoring protection as standard.

B. Through the base electrical with disconnect switch will be installed in the unit in a water tight enclosure with access through a swinging door. Wiring will be provided from the switch to the unit high voltage terminal block. The switch will be cULus agency recognized.

C. Through the base Electrical with circuit Breaker: A thermal magnetic, molded case, HSCR circuit breaker with provisions for through the base electrical connections. The circuit breaker will be installed in a water tight enclosure in the unit with access through a swinging door. Wiring will be provided from the switch to the unit high voltage terminal block. The circuit breaker will provide overcurrent protection, be sized per NEC and cULUS guidelines, and be agency recognized by cULus.

D. Through the Base Electrical Access: An electrical service entrance shall be provided allowing electrical access for both control and power connects inside the curb and through the base of the unit.

E. Powered Convenience outlet: A GFCI 120V/15 amp, 2 plug, convenience outlet. The convenience outlet is powered from the line side of the disconnect or circuit breaker, and will not be affected by the position of the disconnect or circuit breaker. This option can only be ordered when the through the base electrical option is ordered.

F. Wiring internal to the unit shall be colored and numbered for identification.

**END OF SECTION**

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**SECTION 238126**
**SPLIT-SYSTEM AIR-CONDITIONERS**

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

### 1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.
B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

### 1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

### 1.5 QUALITY ASSURANCE

A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.
B. All wiring shall be in accordance with the National Electrical Code (N.E.C.) and local codes as required.
C. The units shall be rated in accordance with Air-conditioning, Heating, and Refrigeration Institute's (AHRI) Standard 210 and bear the ARI Certification label.
D. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001, which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
E. A dry air holding charge shall be provided in the indoor section.
F. The outdoor unit shall be pre-charged with R-410a refrigerant for 70 feet (20 meters) of refrigerant tubing.- PUY-42NHA4 for 100 feet (30 meters) of refrigerant tubing
G. System efficiency shall meet or exceed SEER values below:

| When used with Indoor Unit | Minimum SEER |
|---|---|
| PKA Wall Mounted Type | 14.0 |

### 1.6 DELIVERY, STORAGE AND HANDLING

A. Unit shall be stored and handled according to the manufacturer's recommendations.
B. The controller shall be shipped separately and shall be able to withstand 105°F storage temperatures and 95% relative humidity without adverse effect.

### 1.7 WARRANTY

A. The units shall have a manufacturer's parts and defects warranty for a period five (5) year from date of installation. The compressor shall have a warranty of seven (7) years 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 does not include labor.
B. Manufacturer shall have over thirty (30) years of continuous experience in the U.S. market.

## PART 2 - PRODUCT

### 2.1 OUTDOOR UNIT DESIGN

A. The outdoor unit shall be compatible with the PKA - wall mounted. The connected indoor unit shall be of the same capacity as the outdoor unit.

B. The outdoor unit shall be equipped with an electronic control board that interfaces with the indoor unit to perform all necessary operation functions.

C. The outdoor unit shall be capable of cooling operation down to 0°F (-18°C) ambient temperature without additional low ambient controls (optional wind baffle shall be required).

D. The outdoor unit shall be able to operate with a maximum height difference of 100 feet (30 meters) between indoor and outdoor units.

E. System shall operate at up to a maximum refrigerant tubing length of 100 feet (30 meters) for the 12,000 and 18,000 BTU/h units between indoor and outdoor units without the need for line size changes, traps or additional oil. Models PUY-A12/18/24/30/36NHA4 shall be pre-charged for a maximum of 70 feet (20 meters) of refrigerant tubing.

F. The outdoor unit shall be completely factory assembled, piped, and wired. Each unit must be test run at the factory.

G. Outdoor unit sound level shall not exceed:

| Model Numbers | Cooling |
|---|---|
| PUY-A12NHA4 | 46 dB(A) |

H. Cabinet

1. The casing shall be constructed from galvanized steel plate, finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection and have a Munsell 3Y 7.8/1.1 finish.
2. Mounting feet shall be provided and shall be welded to the base of the cabinet and be of sufficient size to afford reliable equipment mount and stability.
3. Easy access shall be afforded to all serviceable parts by means of removable panel sections.

a. The fan grill shall be of ABS plastic.
b. Cabinet mounting and construction shall be sufficient to withstand 155 MPH wind speed conditions for use in Hurricane condition areas. Mounting, base support, and other installation to meet Hurricane Code Conditions shall be by others.

I. Fan

1. Models PUY-A18/24/30/36NHA4 shall be furnished with a single DC fan motor.
2. The fan blade(s) shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated.
3. The outdoor unit shall have horizontal discharge airflow. The fan shall be mounted in front of the coil, pulling air across it from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent external contact with moving parts

J. Coil

1. The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up and allow maximum airflow. The coil shall be protected with an integral metal guard.
2. Refrigerant flow from the condenser shall be controlled by means of an electronic linear expansion valve (LEV) metering device. The LEV shall be controlled by a microprocessor-controlled step motor.
3. All refrigerant lines between outdoor and indoor units shall be of annealed, refrigeration grade copper tubing, ACR Type, meeting ASTM B280 requirements, individually insulated in twin-tube, flexible, closed-cell, CFC-free (ozone depletion potential of zero), elastomeric material for the insulation of refrigerant pipes and tubes with thermal conductivity equal to or better than 0.27 BTU-inch/hour per Sq Ft / °F, a water vapor transmission equal to or better than 0.08 Perm-inch and superior fire ratings such that insulation will not contribute significantly to fire and up to 1” thick insulation shall have a - Flame-Spread Index of less than 25 and a Smoke-development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102.

K. Compressor
1. The compressor for models PUY-A12/18/24/30/36NHA4 shall be a DC twin-rotor rotary compressor with Variable Speed Inverter Drive Technology.
2. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which shall result in significant energy savings.
3. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be automatically, intermittently applied to the compressor motor windings to maintain sufficient heat to vaporize any refrigerant. No crankcase heater is to be used.
4. The outdoor unit shall have an accumulator and high-pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.

L. Electrical
1. The electrical power of the unit shall be 208volts or 230 volts, single phase, 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts.
2. Power for the indoor unit shall be supplied from the outdoor unit via Mitsubishi Electric A-Control using three (3) fourteen (14) gauge AWG conductors plus ground wire connecting the units.
3. The outdoor unit shall be controlled by the microprocessor located in the indoor unit.
4. The control signal between the indoor unit and the outdoor unit shall be pulse signal 24 volts DC.
a. The unit shall have Pulse Amplitude Modulation circuit to utilize 98% of input power supply.

M. Operating Range:

| Operating Range | | Indoor Air Intake Temperature | Outdoor Air Intake Temperature |
|---|---|---|---|
| Cooling | Maximum | D.B. 95°F (35°C) W.B. 71°F (21.7°C) | D.B. 115°F (46°C) |
| | Minimum | D.B. 67°F (19.4°C) W.B. 57°F (13.9°C) | D.B. 0°F (-18°C)* |

* Requires wind baffle – without wind baffle: D.B. 23°F (-5°C)

1. Unit shall be able to provide 100% capacity when operating at 0ºF outdoor air temperature and a wind baffle is used.

**2.2 INDOOR UNIT SELECTION AND SPECIFICATION**

A. PKA Wall Mounted Type

The indoor unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board and fan motor. The unit, in conjunction with the wired wall-mounted controller, wireless wall-mounted controller or wireless handheld controller, 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 purged with dry nitrogen before shipment from the factory.

| **Wall Mounted Type Indoor Units** | |
|---|---|
| Model Number | Cooling Capacity |
| PKA-A12HA4 | 12,000 |

1. Unit Cabinet: The cabinet shall be formed from high strength molded plastic with smooth finish, flat front panel design with access for filter. Cabinet color shall be white – Munsell 1.0Y 9.2/0.2. The unit shall be wall mounted by means of a factory supplied, pre-drilled, mounting plate.
2. Fan: The indoor unit fan shall be high performance, double inlet, forward curve, direct drive sirocco fan with a single -motor. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall consist of three (3) speeds: Low, Mid, and Hi and Auto. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and space temperature.

Indoor unit sound level shall not exceed the levels below:

| Model Number | Low Speed | Mid Speed | High Speed |
|---|---|---|---|
| PKA-A12HA4 | 36 dB(A) | 40 dB(A) | 44 dB(A) |

3. Vane: There shall be a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall significantly decrease downward air resistance for lower sound levels, and shall close the outlet port when operation is stopped. There shall also be a set of vertical vanes to provide horizontal swing airflow movement.
4. Filter: Return air shall be filtered by means of an easily removable washable filter.
5. Coil: The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The multi-angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil. An optional drain pan level switch (DPLS1), designed to connect to the control board, shall be provided if required, and installed on the condensate pan to prevent condensate from overflowing. Option: A condensate mini-pump shall be provided.
6. Electrical: The electrical power of the unit shall be 208 volts or 230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts. The power to the indoor unit shall be supplied from the outdoor unit, using the Mitsubishi Electric A-Control system. For A-Control, a three (3) conductor AWG-14 wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units.
7. Performance: Each system shall perform in accordance to the ratings shown in the table below. Cooling performance shall be based on 80°F DB, 67°F WB (26.7°C DB, 19.4°C WB) for the indoor unit and 95°F DB, 75°F WB (35°C DB, 29.3°C WB) for the outdoor unit.

| **System Model Number** | **Cooling Capacity Btu/h** | **TPW Cooling** | **SEER** | **CFM (Hi/Dry)** |
|---|---|---|---|---|
| PKA-A12HA4 | 6,000 – 12,000 | 1,190 | 15.2 | 425 |

TPW = Total Power Watts

8. System Control: The control system shall consist of a minimum of two (2) microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from a wireless or wired controller, providing emergency operation and controlling the outdoor unit. The control signal between the indoor and outdoor unit shall be pulse signal 24 volts DC. Indoor units shall have the ability to control supplemental heat via connector CN152 and a 12 VDC output.

    a. The indoor unit control board shall have auxiliary control contact connectors to provide:

| Function / Model | PKA |
|---|---|
| CN-2L – Lossnay Control | X |
| CN-24(152) Back-up Heat | X |
| CN-32 – Remote Switch | X |
| CN-51 – Central Control | X |

| | |
|---|---|
| CN-105 – IT Terminal | X |

X = Included

b. Remote Controllers
All remote controllers need to be ordered separately from the unit.

1) Wired Remote Controller (PAR-21MAA)

The Wired Remote Controller (PAR-21MAA) shall be approximately 5” x 5” in size and white in color with a light-green LCD display. The PAR-21MAA shall support a selection from multiple languages (Spanish, German, Japanese, Chinese, English, Russian, Italian, or French) for display information. There shall be a built-in weekly timer with up to 8 pattern settings per day. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Auto/Fan/Dry mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature shall be displayed in either Fahrenheit (°F) or Celsius (°C), and Temperature changes shall be by increments of 1°F (0.5°C). The PAR-21MAA shall have the capability of controlling up to a maximum of 16 systems, as a group with the same mode and set-point for all, at a maximum developed control cable distance of 1,500 feet (500 meters).

The control voltage from the wired controller to the indoor unit shall be 12/24 volts, DC. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. Up to two wired controllers shall be able to be used to control one unit.

The basic functions are:

| **Wired Remote Controller (PAR-21MAA)** | |
|---|---|
| **Item** | **Description** |
| Number of Units Controllable | 16 units as 1 group |
| ON/OFF | Run and stop operation |
| Operation Mode | Switches between Cool/Dry/Auto/Fan/Heat. |
| Temperature Setting<br>(Range and modes depend on connected unit model) | Sets the setpoint temperature in the following range<br>Cool/Dry: 67°F-87°F<br>Heat: 63°F-83°F<br>Auto: 67°F-83°F |
| Fan Speed Setting<br>(Range and modes depend on connected unit model) | Hi/Mid-2/Mid-1/Low/Auto |
| Air Flow Direction Setting<br>(Air flow direction settings depend on the unit model) | Air flow direction angles 100%-80%-60%-40%, Swing. |
| Weekly Scheduler | ON/OFF/Temperature setting can be done up to 8 times one day in the week. The time can be set by the 1-minute interval. |

| Wired Remote Controller (PAR-21MAA) | |
|---|---|
| **Item** | **Description** |
| Operating Conditions Display | Setpoint and room temperature. Sensing can be done at the remote controller or the indoor unit depending on the indoor unit dipswitch setting<br>Liquid, discharge, indoor and outdoor pipe temperatures<br>LEV opening pulses, sub cooling and discharge super heat<br>Compressor Operating Conditions: Running current, frequency, input voltage, On/Off status and operating time |
| Error | When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed |
| Ventilation Equipment | Up to 16 indoor units can be connected to an interlocked system that has one LOSSNAY unit. LOSSNAY items that can be set are “Hi”, “Low”, and “Stop”. Ventilation mode switching is not available. |
| Auto Lock Out Function | Setting/releasing of simplified locking for remote control buttons can be performed.<br>• Locking of all buttons<br>• Locking of all buttons except ON/OFF button |

2) Wireless, hand held remote controller (PAR-FL32MA)

The wireless had held remote controller (PAR-FL32MA) shall perform input functions necessary to operate the system. There shall be a wireless receiver built in the indoor unit.

The controller shall have a Power On/Off switch, Mode Selector – Cool, Dry, Heat, Auto, and Powerful Modes - Temperature Setting, Timer Control, Fan Speed Select and Horizontal and Vertical Vane control selector. There shall be an i-See® Sensor Area Selector control. The indoor unit shall perform Self-diagnostic Function and Check Mode switching. Temperature changes shall be in 1ºF (0.5ºC) increments with a setting range of 61 to 88ºF (16 to 31ºC).

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

## 3.2 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. 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.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

## 3.3 DEMONSTRATION

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

**END OF SECTION**

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## SECTION 238239.16
## PROPELLER 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 propeller unit heaters with electric-resistance heating coils.

### 1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. PTFE: Polytetrafluoroethylene plastic.

C. TFE: Tetrafluoroethylene plastic.

### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

### 1.5 CLOSEOUT SUBMITTALS

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

### PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Airtherm; a Mestek company.
2. Berko Heating Products.
3. Trane.

### 2.2 DESCRIPTION

A. Assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.

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

C. Comply with UL 2021.

D. Comply with UL 823.

### 2.3 PERFORMANCE REQUIREMENTS

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

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

### 2.4 HOUSINGS

A. Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

**2.5 COILS**

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 steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

**2.6 FAN AND MOTOR**

A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

B. Motor: Permanently lubricated.

**2.7 CONTROLS**

A. Control Devices:

1. Wall-mounted thermostat.

**PART 3 - EXECUTION**

**3.1 EXAMINATION**

A. Examine areas to receive propeller 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 propeller unit heaters to comply with NFPA 90A.

B. Install propeller unit heaters level and plumb.

C. Suspend propeller unit heaters from structure with wall mounting bracket.

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

**3.3 FIELD QUALITY CONTROL**

A. Perform the following tests and inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

**3.4 ADJUSTING**

A. Adjust initial temperature set points.

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

## 3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

**END OF SECTION**