

SECTION 230513 - COMMON REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED WORK

- A. All Division 23 sections.

1.2 WORK SEQUENCE

- A. Install mechanical piping, duct, controls, equipment and accessories as construction progresses so cutting and patching of new construction will not be required. See also paragraph "Sequencing and Scheduling" herein.
- B. The existing building will be occupied during construction. The Contractor shall schedule work so as to minimize disruption to the normal operation of the facility in accordance with instructions and schedules provided by the Architect and/or Owner.

1.3 SUBMITTALS

- A. Provide submittals in accordance with Section 013300 - Submittal Procedures.
- B. Submittal data containing manufacturer's data shall be sent to the Architect, Engineer and Owner for review.
- C. Electronic submittal data shall be assembled in Adobe Acrobat's Portable Data Format (PDF) for review.
- D. Electronic submittal data shall be assembled in one (1) complete PDF file and shall include an index sheet (TOC) listing each submittal item by specification number and its content. Each file shall also be organized with "Bookmarks" of each section. Submittals that do not have each submittal item referenced by "Bookmarks" shall be rejected.
- E. All electronic submittal data for a trade shall be submitted at one time except as noted herein.
- F. Data not submitted shall have a statement explaining why the data was not submitted.
- G. Submittals not conforming to any of the above requirements shall be rejected.
- H. The contractor shall go to each specification section to determine all technical information/data required and organize information/data using tabs for major headings as follows:
 - 1. Section 230529 - Hangers and Supports for HVAC Piping and Equipment
 - a. Upper attachments
 - b. Pipe attachment (hangers and clamps)
 - c. Lower pipe supports
 - d. Metal framing channel
 - e. Roof mounted equipment supports
 - 1) Roof curbs for RTAC units
 - 2) Roof curbs for pipe box assemblies and pipe box/hood assemblies
 - 3) Equipment support rail for ductless condensing units
 - 4) Equipment support rail for electrical disconnects.
 - 5) Pipe box assemblies
 - 6) Acoustic roof curbs
 - f. Vibration isolators
 - g. Non-penetrating type equipment supports
 - 1) Condensate pipe on roof
 - 2. Section 230593 - Testing, Adjusting, and Balancing for HVAC
 - a. TAB Agent NEBB or AABC Certificate (Do not submit samples of TAB forms)
 - 3. Section 230716 - HVAC Equipment Insulation
 - a. Insulation Product Information
 - b. Jackets and Accessories Product Information
 - c. Proof of Insulation Contractor's Three Years Experience

- d. System sheet for each system identifying material, thickness and finish for each system.
 - 4. Section 230900 - Instrumentation and Controls for HVAC
 - a. Control Product Data
 - b. Sequence of Control
 - 5. Section 232300 - Refrigerant Piping
 - a. Single sheet indicating piping system and application and the pipe material intended to be used. Do not submit data sheets on piping.
 - 6. Section 233113 - Metal Ducts
 - a. Fiberglass ductwork liner for interior duct
 - b. Note Concerning Duct Shop Drawings: The Contractor may generate ductwork shop drawings for their use in coordination with structural, sprinkler, electrical, plumbing, etc., but these are not required for submittal review and shall not be submitted to the Engineer for review.
 - 7. Section 233300 - Air Duct Accessories
 - a. Backdraft dampers.
 - b. Volume control dampers, manual type.
 - c. 90-degree straight saddle tap.
 - d. Fire dampers.
 - e. Low pressure flexible ducts.
 - f. Bellmouth take-off collars.
 - g. 45-degree take-off collars.
 - 8. Section 233423 - HVAC Power Ventilators
 - a. Ceiling Mounted Exhaust Fans
 - 9. Section 233713 - Diffusers, Registers, And Grilles
 - a. Diffusers, Registers and Grilles
 - 10. Section 233723 - HVAC Gravity Ventilators
 - a. Wall caps.
 - 11. Section 234100 - Particulate Air Filtration and Bi-Polar Ionization Units
 - a. Medium Efficiency (MERV 6 & 8) Filters
 - b. Bi-Polar Ionization Units
 - 12. Section 238119 - Self-Contained Air-Conditioners
 - a. Rooftop Air Conditioning Units
 - 13. Section 238126 - Split-System Air-Conditioners
 - a. Ductless Wall Mounted Fan Coil Units
 - b. Ductless Heat Pumps and Condensing Units
 - 14. Section 238240 - Electric Heaters
 - a. Electric wall heaters
 - 15. Letter from Contractor stating submittals have been checked and comply with the Contract Documents
 - 16. Certification that all items are furnished under this contract are free of hazardous materials (e.g. asbestos, PCBs)
- I. Manufacturer's data sheets shall be marked to clearly indicate the manufacturer, model number, size, color, accessories, required clearances, field connection details, weight loading, electrical characteristics, capacities, etc. being submitted. Submittals shall only include the products relevant to this specific project. Submittals shall not include other products produced by the manufacturer which are not specified on this project. Submittals containing several products on the same sheet shall have an arrow or other marker to identify the specific product

submitted. Also, submittals for a single product that have options shall have an arrow or other marker to identify that the specified options are being provided. Submittals that include products not specified for this project, or that include several products on one sheet without being marked, or that do not show options selected shall be rejected. Variations from specifications shall be explained. Submittal preparer's name and telephone number shall be listed on the index sheet.

- J. Review, Corrections, or Comments made on the Submittals do not relieve the Contractor from compliance with the requirements of the Drawings, Specifications and Addendums (Contract Documents). By entering into this Contract, the Contractor agrees that the purpose of submittals is to demonstrate to the Engineer that the Contractor understands the design concept and that he demonstrates his understanding by indicating which equipment and material he intends to furnish and install and use. Review of shop drawing will be general only for basic conformance with the design concept. The review of such drawings, schedules or cuts shall not relieve the Contractor from the responsibility for correcting all errors of any sort contained in the submittals. The Contractor is responsible for confirming and correlating all quantities and dimensions; selecting proper fabrication processes, construction methods and installation techniques; coordinating this work with that of all other trades; and performing all work in a safe, workmanlike and satisfactory manner.
- K. Below are the submittal item codes that will be used when reviewing the submittal data. These codes show up on the "Submittal Review" sheet. Only one copy of the submittal review sheet is returned upon completion of the review for each trade.
 - 1. RNE - Reviewed, No Exceptions Noted
 - a. Indicates the information provided has been reviewed and no exceptions are taken. Contractor must still comply with the contract documents.
 - b. No corrective action required at this time.
 - 2. FNC - Furnish with Noted Corrections
 - a. Indicates the contractor shall ensure that all necessary or noted corrections are incorporated into equipment furnished to the project.
 - b. Contractor shall incorporate items requested in review comments, but re-submittal not required.
 - 3. RES - Revise and Resubmit
 - a. Indicates item is not presently acceptable as submitted, but may be accepted provided additional information and/or changes are made.
 - b. Contractor shall revise and resubmit item to Engineer with additional information indicating compliance with Contract Documents prior to proceeding with work.
 - 4. PSD - Provide Submittal Data
 - a. Indicates submittal data was not provided for this item or section.
 - b. Contractor shall provide submittal data meeting the explicit requirements of the plans, specifications, and all addenda.
- L. Shop drawings and data submittals for materials requiring extra long delivery time shall be submitted for approval as soon as possible after execution of contract. All items shall be submitted for approval in a timely manner (prior to other submittals if necessary) so they may be properly incorporated in the building's structure. Allow a minimum of three weeks for review. No substitutions of materials or extensions of contract time will be allowed for Contractor's failure to submit or order such materials sufficiently in advance of the work. See Architectural specification section for additional requirements for submittals.

1.4 REGULATORY REQUIREMENTS

- A. All work installed under Division 23 shall conform to the current adopted Edition of Building/Mechanical Codes and their appropriate amendments:
 - 1. Life Safety Code, NFPA 101
 - 2. International Building Code with Georgia Amendments
 - 3. International Mechanical Code with Georgia Amendments

4. Standard for the Installation of Air Conditioning and Ventilating Systems, NFPA 90A
 5. International Gas Code with Georgia Amendments
 6. National Fuel Gas Code, NFPA-54
 7. City of McDonough and Henry County Codes
 8. Requirements of the State of Georgia Fire Marshall's Office.
 9. ASHRAE 62.1, Ventilation for Acceptable Indoor Air Quality.
 10. GA State Minimum Standard Energy Code.
- B. Obtain and pay for all permits, and request inspections from all authorities having jurisdiction, in a timely manner.
- C. Materials and Equipment included in Underwriter's Label Service shall bear that label. Electrical equipment shall be UL approved as installed, and bear the UL label, unless noted otherwise herein. All fans shall be AMCA certified and bear that label for performance and sound. All air conditioning equipment shall be AHRI certified and bear that label.
- D. Where requirements of these specifications differ from specified codes and ordinances, conform to the more stringent requirements.

1.5 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on Drawings, unless prevented by Project conditions. Shift or relocate equipment or systems to avoid conflicts with other trades. Modifications to the work required to accommodate project conditions encountered in the field shall be made at no additional cost to the contract.
- B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission of Architect/Engineer before proceeding.
- C. Install items so that there are no obstructions (e.g., pipes, conduits, etc.) blocking service panels of the equipment, or preventing the removal of the equipment.

1.6 SEQUENCING AND SCHEDULING

- A. Contractor shall coordinate work so as to avoid conflicts with other work in progress.
- B. Work shall progress in a manner that will not interfere with other trades. The Division 23 Contractor shall have coordination meetings with all other Contractors to ensure that all systems installed in "share areas" (e.g., ceiling plenums, mechanical rooms, etc.) are coordinated and installed to insure proper fit and access. All costs required for the coordination of the work between trades shall be borne solely by the Contractor.
- C. Contractor shall provide confirmation letters from the factory (not from the contractor) to the Owner that long lead items have been ordered. Long lead items are defined as items having longer than twelve-week fabrication schedules. See Division 1 - Summary for additional requirements.
- D. Phasing: Contractor shall conform to phasing plans as stated in the Architectural contract documents.

1.7 ACCEPTABLE PRODUCTS

- A. Basis of Design: Model numbers indicated herein or shown on the drawings are the Basis of Design and are based on the most recent literature provided to the Engineer from the Manufacturer's Representative. The Contractor may substitute equal and approved equipment from the basis of design manufacturer or manufacturers listed in this specification (or set forth in an addendum) provided said equipment has all features which are inherent with the "Basis of Design" equipment, meets all requirements of the plans and specifications, has like electrical characteristics (e.g., same voltage, phase, ampacity/fusing/circuit breaker requirements, single or multiple points of connection as indicated on the electrical drawings), and will properly fit in

the available spaces in the building or on the roof. If the Contractor chooses to provide equipment which meets all of the aforementioned requirements, but has different characteristics, from that shown on the Contract Electrical Drawings, he shall bear all costs associated with that substitution. Electrical costs include, but are not limited to materials (breakers, fuses, disconnects, wiring, conduits, panels, starters, contactors, and the like) installation costs and re-engineering. All electrical connections shall be coordinated with the Engineer and with the electrical subcontractor. Other costs may include, but are not limited to, additional structural support for heavier equipment than basis of design.

- B. Prior Approval: Substitutions of specified items and prior approvals of other manufacturers will not be considered.
- C. Acceptable Products: Where a manufacturer has been listed as being acceptable in the various specification sections (or addendums) hereinafter for a certain product, it shall be understood that the manufacturer has been approved as being capable of producing this product. This does not necessarily constitute approval of their standard product. The manufacturer's product shall still comply with all of the requirements and standards of this specification and not necessarily their standard specification, to the extent that it might require special custom manufacture to meet the requirements and standards of this specification, the requirements of the drawings and the inherent features of the "Basis of Design". Submitted products, not complying with the explicit requirement of these specifications and drawings and with the features of the "Basis of Design" will be rejected even if their manufacturer is listed in the specifications.

1.8 DRAWINGS

- A. General: Both the drawings and specifications shall be considered supplemental to one another so that materials and labor required by one but not the other shall be supplied and installed as though specifically called for by both. Where drawings and specification conflict, Contractor shall conform to the more stringent or costly of the two requirements.
- B. Scaling: The drawings are diagrammatic only and show generally the location of the equipment, ducts and pipes but are not to be scaled. All dimensions shall be verified at the building site. Prefabrication of work from the drawings shall be at the Contractor's risk.
- C. Existing Conditions: It shall be the Contractor's responsibility to visit the site prior to bidding the project and prior to beginning work to make himself familiar with existing conditions.

1.9 SPACE CONDITIONS AND SERVICE CLEARANCE

- A. All equipment and materials shall fit into the available spaces in the building and must be introduced into the building so as not to cause damage to the structure. All equipment normally requiring service shall be made readily accessible by not locating it above (behind, etc.) piping, ductwork, conduit or other systems. Contractor shall also provide access by means of access panels, doors, etc. to be provided under this section of specifications where required or specified. Provide sufficient space to allow service (e.g. filter removal) of all equipment. Coordinate with all trades to ensure accessibility and service of all equipment. Equipment located above lift out ceilings shall be considered to be accessible. Equipment located above hard (unremovable) ceilings shall be considered to be inaccessible and access panels shall be provided as specified herein.
- B. The contractor shall be responsible for verifying that the particular manufacturer's equipment that he chooses will fit in the available space, and shall verify (prior to submitting equipment) that the service clearances that the manufacturer requires are available, and shall not submit equipment that will not allow the manufacturer's service clearances. This also applies to roof-mounted equipment. During construction, the contractor shall install the equipment such that the manufacturer's service clearances are provided by reading the installation instructions. The contractors shall bear all costs associated with providing equipment that requires service clearances different from the basis of design equipment. If the manufacturer's service clearances are not provided, the contractor shall remove the equipment and provide equipment with service clearances equal to the basis of design equipment. The contractor shall submit a

detailed sketch and description of any modifications to install the particular manufacturer's equipment that he chooses, to demonstrate that the equipment will fit and have the manufacturer's service clearances. The sketch is not submitted for review or approval or for confirmation that it is correct, only to certify that the contractor has completely considered the installation of substitute equipment.

1.10 MOISTURE INTEGRITY

- A. Roof: All roof penetrations shall be watertight and comply with the roof manufacturer's requirements and recommendations so as to be covered by the roof "Bond". All roof penetrations shall be made inside roof curbs (conforming to the requirements of Division 23 - Hangers and Supports for HVAC Piping and Equipment). Pitch pockets are not acceptable.
- B. Wall: All wall penetrations shall be sealed and caulked watertight.

1.11 NOISE AND VIBRATION

- A. When in operation, all systems included in this section of specifications shall be free from objectionable or abnormal noise and vibration. See Division 23 - Hangers and Supports for HVAC Piping and Equipment of the specifications for specific vibration isolation requirements.

1.12 PROTECTION OF MATERIALS AND EQUIPMENT

- A. Delivery, Storage and Handling: Deliver products to site in factory-fabricated protective containers, with (where appropriate) factory-installed shipping skids and lifting lugs. Store in clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- B. Maintenance of Filters: The Contractor shall be responsible for maintaining all air filters until Architect's Final Certificate. No air system shall be operated at any time without air filters and filters shall not be allowed to become overloaded with dust and dirt. For throwaway filters, new clean filters shall be installed. See also paragraph "Air Handling Equipment Operation During Construction Period".
- C. During Construction: Pipe openings shall be closed with caps or plugs. All open duct shall be sealed tight with polyethylene. All equipment and material shall be stored in accordance with manufacturer's recommendations. No equipment, ductwork, piping, or materials shall be stored inside or outside the building unless it is properly protected from the weather. The Engineer reserves the right to reject any items furnished under Division 23 which have been damaged or are not in "like-new" condition. To minimize the potential for humidity damage to ceiling tiles and other hygroscopic material, during construction all outdoor air intake openings at HVAC equipment shall be closed, and temporary means shall be used to ensure openings cannot be opened. Openings shall be opened immediately prior to turning work over to Owner.
- D. Suspended Ductwork, Suspended Equipment and Suspended Piping: Installation of suspended HVAC ductwork in areas where the roof is not "dried in" is only acceptable if the Contractor coats each joint of the supply, return, outdoor air and exhaust duct with duct sealant as specified. Contractor is also required to wrap suspended ductwork, equipment and piping on three sides with a minimum 4 mil thickness polyethylene taped to the bottom of the ductwork, equipment and piping. Polyethylene covering is required to protect from the weather, water, dirt, roof tar, concrete, etc.
- E. Non-Suspended Ductwork, Equipment and Piping: Contractor is required to wrap mechanical equipment, ductwork and piping that is not suspended with two layers of 4 mil polyethylene.
- F. Prior to Final Construction Review: All materials and equipment shall be cleaned. Chipped or scraped paint shall be retouched to match. All dents and sags in ductwork and equipment casings shall be straightened or replaced.
- G. Equipment Painting: Equipment which has been damaged beyond the point of retouching or has been retouched not to match the original finish shall be repainted in accordance with the Architectural painting section.

1.13 AIR HANDLING EQUIPMENT OPERATION DURING CONSTRUCTION PERIOD

- A. For the purpose of this paragraph, air handling equipment shall include, but is not limited to, air moving equipment such as fan coil units, rooftop air conditioning units, PTAC units, etc. Air handling equipment shall not be operated for space heating or cooling or air filtering during construction. Equipment shall be operated only to provide start up, check out, balancing, testing etc., in order to meet "Substantial Completion" goals and provide a complete working system to turn over to Owner. If air handling equipment must be operated during construction to "dry out" the building or to maintain temperature conditions required by flooring, paint, or other building compartment products, mechanical contractor shall have written permission from General contractor and Owner prior to operating.
- B. Permanently installed air handling equipment used during construction shall not be operated during sanding, masonry cutting, or other operations generating airborne particulate. Where air handling equipment is utilized during construction, units shall be provided with filtration media with a minimum efficiency reporting value (MERV) of 8 at each return grille/duct as determined by ASHRAE 52.2. Air filtration shall be replaced as specified prior to Occupancy. If air handling cooling/heating coils are found to be overloaded with dirt/dust it shall be the mechanical contractor's responsibility to clean coils to ensure maximum performance. If equipment must be operated during these activities mechanical contractor shall have written permission from General contractor and Owner prior to operating.
- C. Permanently installed supply duct and air handling equipment conveying 65°F or less supply air shall be insulated as specified and building construction shall be near completion (tightly sealed) prior to operating air handling equipment. This requirement is included to limit the possibility of condensation on ductwork, HVAC equipment, on the exterior of duct insulation, grilles, building structure, etc., especially in the presence of uncontrolled outdoor air entering the building prior to sealing. Mechanical contractor shall be responsible for any damage caused by duct/equipment condensation (e.g. insulation, building materials, ceiling tiles or sheetrock ceilings, flooring etc.). If equipment must be operated prior to duct insulation and vapor barrier on ducts/equipment being complete and building sealing not finalized, mechanical contractor shall have written permission from General contractor and Owner prior to operating.

1.14 ELECTRICAL

- A. General: Motors, controls, relays and switches required for proper operation of equipment covered under this section shall be furnished and installed under this division of the specifications.
- B. Wiring: All control and interlock wiring shall be furnished and installed under Divisions 23 - Mechanical. Power wiring through the disconnect and starter and to the motor shall be furnished and installed under Electrical Section. All control wiring and conduit shall conform to the material and installation requirements of Division 26.
- C. Electrical Connections: Voltage, phase, ampacity and connection arrangement (e.g. single or multiple point) of each item of electrically driven equipment provided under this section of specifications shall conform to that shown on the Electrical drawings.
- D. Electrical Characteristics: The horsepower, voltages and phases shown on the drawings and specified herein, are the estimated power requirements of all equipment furnished herein and is the basis of the design shown on the electrical drawings. If the Contractor provides equipment from the "Basis of Design" manufacturer or from other approved manufacturers with larger horsepower, different voltages, different phases or ampacity, he shall coordinate with other trades to provide any additional wiring, circuitry, starters, breakers, transformers, etc., as required at no additional cost to the Contract.

1.15 MOTORS

- A. General: This paragraph is applicable to all Division 23 specification sections. Motors less than 250 watts and used for intermittent service may be manufacturer's standard.

- B. Motor Enclosures: Motor enclosure shall be appropriate for the environment that the motor will be in. In the absence of specifically identified motor enclosure style, the following requirements shall apply. Motors located in exterior locations, wet air streams, etc. shall be totally enclosed fan cooled (TEFC). Motors located in interior locations, in mechanical rooms, in dry air streams, etc. shall be open drip proof (ODP).
- C. Motors Efficiency: Each motor 1 hp and above shall have a guaranteed minimum efficiency complying with the Energy Independence and Security Act of 2007 (EISA), and as specified below, and a minimum power factor of 82.5. Multi-speed motors do not have to comply with these efficiencies. Each motor's NEMA nominal efficiency shall be shown on the motor nameplate. Efficiency and losses shall be determined in accordance with the latest revision of IEEE Standard 112, Method B, using "Accuracy improvement by segregated loss determination including stray load loss measurement." Motors shall meet the minimum NEMA premium motor efficiency, as outline in MG1 Table 12-12, which is higher than the EPACT efficiency. Each submittal shall show that motor meets this guaranteed minimum efficiency, and that efficiency was measured according to this specification. Minimum efficiencies for 4-pole 1750 rpm motors are listed below:
 - 1. Motor HP 1: Minimum Premium Efficiency: 85.5
- D. Motor Service Factor: Motor service factor for all equipment 1/8 hp and above shall be 1.15 for ODP motors and 1.0 for totally enclosed motors.
- E. Motor Speed: Maximum 1800 rpm. Single phase, ODP motors shall be equipped with speed controllers as specified on plans.
- F. Motor Thermal Overload Protection: All single-phase motors shall be provided with integral overload protection. Internal protection shall 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.
- G. Bearings (Single Phase Motors): Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, pre-lubricated-sleeve type for other single-phase motors.
- H. Bearings (Three Phase Motors): Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.
- I. Motor Nameplate: Provide on all motors 1/4 hp and above a permanent visible engraved nameplate indicating horsepower, RPM, voltage, phase, amps, cycles, full load amps, locked rotor amps, frame size, service factor, power factor and efficiency.
- J. Motor Type: All single-phase motors shall be provided with motor type suitable for starting and operating torque. Shaded pole motors shall be allowed on 1/20 hp or less motors only. Split-phase, capacitor start, permanent split capacitor and capacitor start/capacitor run shall be provided on all single-phase motors above 1/20 hp based on specific torque requirements.
- K. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.
- L. 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. Whenever starting requirements exceed operating requirements, the motor shall be large enough to start the equipment without overheating. As a minimum, motors shall be sized at 120% of design BHP requirements, except that motors controlled by VFD's shall be sized at 115% of design BHP. Each motor shall be sized to drive the equipment taking into account belt losses.

- M. Motors controlled by Variable Frequency Drives: All motors that are controlled by a variable frequency drive shall be either premium efficiency type or inverter duty rated. Motor windings shall be insulated with Class F insulation or Class H insulation. General high efficiency motors and motors with Class B insulation shall not be allowed. Motor manufacturer shall certify in writing with motor submittal that motor is compatible with variable frequency drive usage.
- N. Motor Hz Design Requirements: Manufacturer's that utilize variable frequency drives for fan control shall submit design operating frequency (Hz) of fan. Fans designed for constant speed operation, which utilize a VFD for balancing purposes, shall not be allowed to be above 65 Hz so that adjustment to increase fan speed may be made.

1.16 PAINTING

- A. All bare steel piping, pipe fittings, pipe hangers, supports and miscellaneous metal exposed to view provided under this section of specifications, shall be cleaned and painted under the Architectural painting section of the specifications.

1.17 CLEANING

- A. The Contractor shall keep the site reasonably clean and free of excessive debris and leftover materials at all times. All trash and debris shall be hauled from the job site on a daily basis for disposal. Prior to testing and adjusting, equipment shall be clean and free of any construction debris and litter.
- B. Contractor shall meet all contractual requirements related to site cleanliness including dust control.

1.18 ACCESS PANELS

- A. Some mechanical systems may be made inaccessible by the installation of "hard" ceilings or by walls above the ceiling. See the finish schedule and the floor plans (architectural drawings) for the location of all "hard" ceilings and walls which extend above the ceiling. Provide access panels in these ceilings or walls (and any other locations where mechanical items are made inaccessible by ceilings or walls) for access to mechanical equipment and items requiring access above these ceilings.

1.19 STRUCTURAL COORDINATION

- A. The party responsible for the installation of the system furnished under Division 23 shall provide the General Contractor with the weight of all mechanical equipment and ductwork and piping and the exact location. General Contractor shall then ensure all structural members are properly sized and all mechanical penetrations are properly framed to support the full perimeter of the equipment. See also paragraph "Acceptable Products".

1.20 ROOM NUMBERS

- A. The room numbers indicated on the Contract Documents were provided by the Architect to assist in identifying spaces during construction. These room numbers may not necessarily be the Owner's final choice of room numbers. The contractor shall obtain from the Owner the final choice of room numbers, and shall use these numbers wherever required. (For example, room numbers are used in programming of control systems, and shall match the Owner's final choice.)

END OF SECTION 230513

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SECTION 230514 - CLOSEOUT DOCUMENT REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Mechanical Closeout Document Requirements which are specifically applicable to all Division 23 Sections, in addition to the requirements of Division 1 - General Requirements.
- B. HVAC Closeout document requirements.
- C. Record Document Submittals "As-Built".
- D. Contractor Guarantee.
- E. Manufacturer Warranties.
- F. Operation and Maintenance (O&M) Manuals.
- G. Manufacturer's Field Services and Start-up by Factory Authorized Personnel

1.2 RELATED WORK

- A. All Division 23 sections.

1.3 RECORD DOCUMENT SUBMITTALS "AS-BUILTS"

- A. The contractor shall be required to maintain a clean, undamaged set of blue or black line white prints of contract drawings and shop drawings.
- B. The HVAC contractor shall mark the set to show the actual installation where the installation varies substantially from the work as originally shown. Mark whichever drawing is most capable of showing conditions fully and accurately; where Shop Drawings are used, record a cross-reference at the corresponding location on the Contract Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.
 - 1. Mark record sets with red erasable pencil; use other colors to distinguish between variations in separate categories of the work.
 - 2. Mark new information that is important but was not shown on Contract Drawings or Shop Drawings.
 - 3. Note related Change Order numbers where applicable.
 - 4. Organize record drawing sheets into manageable sets, bind with durable paper cover sheets, and print suitable titles, dates and other identification on the cover of each set.
 - 5. "As-builts" shall be submitted to the architect/engineer for review of the mechanical as installed upon completion of the work. Changes on "as-builts" are to be shown using standard engineering drafting practices. Freehand drawn changes will not be accepted.

1.4 CONTRACTOR GUARANTEE

- A. All equipment and materials furnished (and/or installed under this section) and all work performed under this section of specifications, shall be guaranteed to be free of defective materials and workmanship for a period of one year (unless a longer period is specified elsewhere) after date of substantial completion. Upon notice of failure of any part of the guaranteed equipment during the guarantee period, the affected part or parts shall be promptly replaced with new parts by the Contractor at no additional cost to the Owner. All labor required to perform guarantee shall be included as part of the complete guarantee warranty.

1.5 MANUFACTURER'S WARRANTIES

- A. Provide as a minimum a one (1) year manufacturer's equipment warranty against defective components for each piece of equipment and its components installed under their respective specification section prior to final inspection in accordance with each of the trades listed below. Equipment warranties shall commence on the date of Substantial Completion as established in

the Certificate of Substantial Completion issued by the Architect. Contractor shall note that there may be more than one certificate of Substantial Completion and date of Substantial Completion for this contract. Any parts which fail during the first year shall be replaced by the Contractor at no additional cost to the Owner.

- B. Each piece of equipment and its components furnished shall carry a minimum one (1) year warranty for replacement of parts and the labor required to complete such warranty work. Equipment and parts requiring warranties longer than one (1) year will be listed below.
 - 1. All HVAC equipment containing compressors shall have a five (5) year manufacturer's parts only warranty on the compressor.
 - 2. Rooftop Air Conditioner: 5 year manufacturer's parts only warranty on refrigeration compressors, 10 year non-prorated materials only on gas fired heat exchangers
 - 3. Pipe Box Assembly: 20 year manufacturer's parts only warranty.

1.6 OPERATING AND MAINTENANCE (O&M) MANUALS

- A. Operating and maintenance manuals shall comply with Division 1 - Operation and Maintenance Data.
- B. One bound and indexed Operating and Maintenance Manual and two electronic (PDF format on CD or thumb drive) copies shall be prepared by the Contractor and be submitted for approval prior to delivery to operating personnel. Binder shall be 3-ring commercial grade, complete with inside storage pockets, sheet protectors, spine and front cover labels.
- C. Each Manual shall contain the following information, data and drawings. The exact format and order of the following information shall comply with Division 1's requirements. If no Division 1 requirement exists, format and order shall be as listed below.
 - 1. List of Contents. Insert under clear front cover of binder.
 - 2. Contractors one (1) year guarantee.
 - 3. Manufacturer's equipment warranties (provide a warranty for each piece of equipment).
 - 4. Installation, operating and maintenance instructions for each item of equipment. Provide trouble shooting checklist guide.
 - 5. Manufacturer's list of renewal parts for each item of equipment with recommended stock items and quantities indicated.

1.7 MANUFACTURER'S FIELD SERVICES AND START-UP BY FACTORY AUTHORIZED PERSONNEL

- A. Refer to each specification section for additional requirements the manufacturer shall provide under the provisions of this specification.
- B. Upon completion of the equipment installation the Contractor shall obtain the services of the factory authorized and trained representative at no additional cost to the owner to perform a start-up of the piece of installed equipment. The factory authorized and trained representative shall submit a certificate or letter stating the equipment has been successfully started, adjusted and tested in accordance with the manufacturer's recommendations. Contractor shall refer to each specification section to determine which equipment/systems require start-up by factory authorized personnel. Some representative equipment/systems which require start-up are listed below.
 - 1. Rooftop Air Conditioning Units
 - 2. Controls

END OF SECTION 230514

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following hangers, supports and accessories for mechanical system piping and equipment:
 - 1. Coatings
 - 2. Upper attachments
 - 3. Pipe attachment (hangers and clamps)
 - 4. Metal Framing Channel
 - 5. Hanger Rods
 - 6. Insulation Shields
 - 7. Sleeves
 - 8. Roof Mounted Equipment Supports

1.2 PERFORMANCE REQUIREMENTS

- A. All supports utilized under Division 23 shall meet the sizing criteria specified herein. No support shall be loaded to more than 20% of its yield strength (thereby providing a safety factor of 5). All support sizes specified herein (for hanger rods, trapeze hangers, pipe attachments, etc.) are minimum sizes required. Contractor shall utilize larger size supports where actual loads dictate a larger support.

1.3 SUBMITTALS

- A. Submit and product data under provisions of Division 23 - Common Requirements for HVAC Equipment.
- B. Submit product data on roof equipment curbs and supports and non-penetrating roof supports.

1.4 WELDING REQUIREMENTS

- A. Welding Requirements: All welding performed to support Mechanical piping and equipment shall comply with AWS D1.1, "Structural Welding Code - Steel". Welders shall be qualified per AWS and welding certificates shall be posted at the jobsite.

1.5 COATINGS

- A. All supports for piping and equipment, hangers and accessories, including but not limited to bolts, nuts, washers, rods, beam clamps, etc., shall be galvanized, except as indicated in the following paragraphs.
- B. Hangers and supports in direct contact with copper piping shall be copper plated.

PART 2 - PRODUCTS

2.1 UPPER ATTACHMENT

- A. Steel Beams:
 - 1. Piping 2" and smaller: Malleable Iron C-Clamp with Lock Nut.
 - a. B-Line: B 3033 or B3034
 - b. C&P: 192
 - c. Anvil: 92
 - d. Erico/Michigan: 280
 - e. PHD: 350 or 360
 - f. FNW: 7203 or 7204
- B. Steel Bar Joist: Malleable Iron C-Clamp with Lock Nut.
 - 1. B-Line: B 3033 or B3034
 - 2. C&P: 192
 - 3. Anvil: 92

4. Erico/Michigan: 280
5. PHD: 350 or 360
6. FNW: 7203 or 7204

2.2 PIPE ATTACHMENT

- A. Copper tubing hangers: Size pipe hangers for refrigerant suction and condensate piping to fit outside insulation, with insulation shield installed between the hanger and the pipe insulation.
 1. B-Line: B3170CT
 2. C&P: 800CT
 3. Anvil: CT-69
 4. Erico/Michigan: 101
 5. PHD: 152
 6. FNW: 7015EC

2.3 METAL FRAMING CHANNEL

- A. Where possible and practical, piping may be supported with trapeze hangers consisting of a metal framing system of channel, fittings, and hardware as defined in the Metal Framing Manufacturer's Association Standard Publication MFMA-1. Length of trapeze supports shall not exceed 4 feet unless contractor performs and submits calculations which indicate the channel is within the manufacturer's recommendations with a safety factor of 30% added to the load.
- B. Vertical Pipe Supports: Where shown on the drawings, vertical routed piping shall be supported and/or stabilized by steel channel meeting the requirements for channel as specified herein.
- C. Channel shall be constructed of 12-gauge steel. Nominal width shall be 1-5/8" x 1-5/8" with a 9/16" wide and 7/8" long slot face opening, with slots on 2" centers. Channel shall be pre-galvanized in accordance with ASTM A 653 G90, or have a factory applied electro-deposited epoxy finish.
- D. Pipe clamps shall be sized as follows:
 1. Non-insulated Steel Piping: Sized to fit piping.
 2. Insulated Piping: Sized to fit outside of insulation.
 3. Copper Piping: Sized to fit outside of piping plus elastomeric isolation material.
- E. Approved Manufacturers: B-Line Model B22SH, Elcen, Unistrut, and Superstrut by Midland-Ross.

2.4 HANGER RODS

- A. Steel Hanger Rods: Continuous threaded rod. Size as indicated in individual piping specification sections.
- B. If no size is given, rod size shall be minimum 3/8", unless actual load dictates a larger rod. No support shall be loaded to more than 20% of its yield strength (thereby providing a safety factor of 5).
- C. Rod couplings shall be:
 1. B-Line: B3220
 2. C&P: 167
 3. Anvil: 136, 136R
 4. Erico/Michigan: 26
 5. PHD: 100, 105

2.5 INSULATION SHIELD

- A. Provide insulation shields at all pipe hangers installed on the exterior of the insulation and at all pipe clamps and trapeze supports. Shields shall be fabricated from minimum 18-gauge galvanized steel. Shields at pipe hangers shall be 12" long with a 180-degree arc. Shields at pipe clamps shall cover entire pipe. Contractor may utilize the following shields:
 1. B-Line: B3151

2. C&P: 265P
3. Anvil: 167
4. Erico/Michigan: 121
5. PHD: 170
6. FNW: 7750

2.6 SLEEVES

- A. Pipe Sleeves: Pipe sleeves thru walls shall be fabricated as shown on mechanical drawings. Sleeve shall be flush with both sides of walls, unless noted otherwise on drawings.

2.7 ROOF MOUNTED EQUIPMENT SUPPORTS (CURB TYPE)

- A. General: Furnish and install roof mounted equipment supports as specified below. Unless otherwise indicated, the supports shall be installed on the roof deck before the application of roofing insulation materials. All roofing membranes shall be continuous up to the nailer.
- B. Roof Curbs: 18-gauge galvanized steel, unitized construction with full mitered corners and all seams welded or bolted/screwed. Provide 1-1/2" thick, 3 lb. density rigid fiberglass insulation on the exterior or interior surfaces. Provide a 1-1/2" wide pressure treated wood nailer strip around the top perimeter above the insulation and below the top of the curb. 45° fiber cants, minimum of 4" high around perimeter of curb shall be provided under Architectural Section. Curbs shall have vertical sides. THESE CURBS SHALL NOT BE USED WHERE DRAWINGS INDICATE ACOUSTIC TYPE ROOF CURB. Provide curbs for the following roof mounted equipment:
1. Rooftop air conditioning units
 2. Pipe Box Assemblies
- C. Equipment Support Rails: 18-gauge galvanized steel, unitized construction with integral base plate and all seams welded. Provide continuous pressure treated wood nailer along the length of each support, 1-1/2" thick, minimum 4" wide (and minimum 10" wide for ductless heat pumps/condensing units), with counter flashing held in place with cadmium plated lag screws. Supports shall be internally reinforced as required for the equipment load. Provide 1-1/2" thick, 3 lb. density rigid fiberglass insulation on the interior of the support rail. Supports shall have vertical sides similar to Pate Style ES-2B. Provide supports for the following roof mounted equipment:
1. Ductless heat pump/condensing unit
 2. Electrical disconnect support
- D. Pipe Box Assembly: Pipe box assembly shall be constructed of heavy gauge powder coated welded aluminum with gaskets and stainless-steel hardware and minimum 20" tall curb. Unit shall be a three-piece configuration, consisting of a removable vandal resistant lid, middle housing, and wide flanged curb. Exit seals are of an aluminum, or stainless-steel configuration, utilizing SilX14 gasket seal, to accommodate the appropriate size of pipe, cable, or desired penetrant. The Exit Seals™ must be installed per the manufacturer's installation instructions. Verify Exit Seal™ seal size and quantity before ordering. Exit seals and housing shall be warranted for 20 years for parts. Pipe box shall be "The Vault" model number AW201412 as manufactured by RPH, with Silx exit seals., or equal model number AL201412 by Alta with Sigrist exit seals. All penetrations must use the specified manufacturer furnished exit seals for the warranty to apply. All penetrants exiting the Vault™ must be supported within 12" after exiting. Penetrants must only pass through the housing portion of the assembly. Any deviations from the above requirements must be discussed with the factory before proceeding.
- E. Height: Roof mounted equipment supports shall be a minimum of 14" high from the base plate to the top of the curb and 12" above the roof surface. Exact height shall be determined by the supplier, by selecting a curb height that will ensure the top of the flashing is a minimum of 12" above the highest elevation of adjacent roof surface.

- F. Slope: Roof mounted equipment supports shall be fabricated to incorporate a slope to match the roof slope, so that the top of the curb is level with its base plate resting flat on the roof deck. Refer to the Architectural drawings for the exact roof slope. Where roof equipment is installed on moderately to steep sloped roofs (greater than 2 in 12 pitch), the shortest side of the curb may be reduced to 6" high.
- G. Insulation: If roof curb provider does not furnish factory installed insulation, contractor shall notify insulation contractor so that insulation contractor can indicate this in submittals and provide insulation.
- H. Manufacturer's: Pate, MicroMetl, A.E.S., Thy, Custom Curb, Curbs Plus, S & L Manufacturing, Creative Metals, Metal Form, Shipman, Roof Products and Systems or by the equipment manufacturer of the rooftop equipment.

2.8 ACOUSTIC TYPE ROOF CURB

- A. 18-gauge galvanized steel with fully welded one-piece construction. Provide one-inch thick 3.0 lb./ft.³ density fiberglass insulation of four perimeter walls. Provide solid steel bottom (except at supply and return locations for units with supply and return duct connections located inside the curb). Bottom shall be covered with four layers of 1/2" (minimum) gyp board, then two-inches minimum of fiberglass or rock wool insulation. Provide full height rails from floor to top of curb around supply and return duct connections, with 2" thick insulation around rails. Provide pressure treated wood nailer around perimeter of curb. Curb shall have vertical sides with 45° cants provided under Architectural section. Acoustic curbs shall be a manufactured standard product of curb manufacturer, and may not be regular curb field constructed by the contractor or provided by the equipment manufacturer. Curb height shall be 14-inch minimum and 12" above finished roof. Slope shall match roof slope so that top of curb is level. Acoustic curb outer perimeter shall be same as rooftop manufacturers standard curb dimensions so that rooftop unit base overlaps curb, and allows for installation of roof membrane and flashing. Perimeter dimensions shall not be larger than RTAC footprint. Acoustic curbs with hat channels on top of curb (which elevate RTAC above roof curb) shall not be allowed. Acoustic type roof curbs shall be manufactured by AES, MGM Metal Products, Aladdin Metal Products, Kinetics or Vibro Acoustics or prior approved equal.

2.9 ROOF MOUNTED EQUIPMENT SUPPORTS (NON-PENETRATING TYPE)

- A. Adjustable Condensate Pipe and Conduit Support on Roof: UV stabilized EPDM rubber block with tool free installation, minimum 4" long x 6" wide with adjustable height from 4" to 7" in 1/2" increments, spaced on maximum 7' centers and within 18" of fittings. Erico Caddy Pyramid Model #RPSE or equal by Pate, Curbs Plus or RPS.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support spacing requirements are specified in Sections specifying piping systems and equipment.
- B. Use galvanized hangers and supports for piping and equipment that will not have field-applied finish.
- C. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Hanger Shield Installation: Install shield in pipe hanger or shield for insulated piping.
- C. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

- D. Install lateral bracing with pipe hangers and supports to prevent swaying.
- E. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

3.3 PIPE HANGER ADJUSTING

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

3.4 PAINTING

- A. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 Painting Section.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.5 SLEEVES AND PENETRATIONS

- A. Provide pipe sleeves for all piping and conduit penetrations through walls.
- B. Set sleeves in position during construction of walls, prior to placement of brick, concrete block or cast-in-place concrete.
- C. Piping and Conduit Penetrations through Rated Walls or Floors: Firestopping methods and materials shall be in accordance with Architectural "Through-Penetration Firestop System" specification section. Assembly shall meet the wall or floor rating as specified by the Architect. See Architectural drawings for rating requirements. Sleeve's size and material shall be coordinated with Architectural "Through-Penetration Firestop System" specification section.
- D. Piping and Conduit Penetrations through Non-rated Walls or Floors: Pack space between pipe or conduit and sleeve with fiberglass batts and with a minimum of 1-inch thick, non-sagging caulking material on one side. Caulk material is not required to be fire rated but shall comply with Architectural caulking specification section.
- E. Install chrome plated steel escutcheons at finished surfaces for piping.
- F. Duct Penetrations through Walls: All duct penetrations through non-rated walls shall be neatly finished off on both sides of the wall. Provide sheet metal angle around full perimeter of rectangular duct on both sides of the wall and provide sheet metal escutcheon around full perimeter of round duct on both sides of the wall and seal off with FSK tape. See also detail on the drawings. Penetrations through rated walls shall be provided with fire dampers, smoke dampers, or combination fire/smoke dampers as required to provide the appropriate protection for the wall penetration. See Architectural drawings for identification of rated walls. See Division 23 - Air Duct Accessories, for damper material and installation requirements.
- G. Division 23 Contractor shall furnish the General Contractor with the clear opening dimensions and elevations and locations of all penetrations through walls and floors, so that the General Contractor may provide appropriate wall and floor openings for these penetrating items. Penetrating items include, but are not limited to, ducts and piping. Clear opening dimensions and elevations and locations shall be furnished in a timely manner to allow General Contractor to frame openings during wall and floor construction, and to prevent the need for removing new work. Contractor is warned that the project may contain shear walls which require steel reinforcing/framing around perimeter that must be installed during the construction of the wall, and which cannot be installed after the wall is constructed without significant demolition of the wall and reconstruction of the wall. Coordinate with General Contractor to determine location of shear walls.

3.6 SUSPENDED EQUIPMENT, DUCTWORK AND PIPING SUPPORTS

- A. Provide steel drop rod supports or angle iron supports, secured (spot welded or clamped in bar joist areas) to building main structural components for all suspended mechanical equipment, ductwork and piping. Supplemental angle iron framing shall be provided where required between bar joists and shall be minimum 3 x 3 x 1/4 for equipment and large piping (4" and larger), and minimum 2 x 2 x 1/4 for large ductwork, small equipment and small piping, and 2 x 2 x 1/8 for small ductwork and refrigerant and condensate drain piping. 1-5/8 x 1-5/8 x 12-gauge channel may be used to span bar joist in lieu of 2 x 2 x 1/4 angle provided that previous paragraph "Performance Requirements" are met. Contractor shall note that supplemental angle sizes are minimum. Contractor shall provide larger size supplemental angle iron framing as appropriate to safely and appropriately support equipment. Provide vibration isolation where specified. Coordinate all mechanical equipment, duct and pipe supports with steel fabricator/erector and do not overload any building structural members or supplemental framing members. Provide securely tightened lock nuts on all drop rod supports and connections.

3.7 ROOF MOUNTED EQUIPMENT SUPPORTS

- A. Coordinate with General Contractor to ensure full perimeter structural steel framing is provided either under Division 5 or herein, around all new roof mounted equipment supports. Framing must comply with requirements of Division 5.
- B. All curb mounted equipment shall be anchored to the curb/nailer with cadmium plated anchors, minimum 5/16" x 1-1/2" hex head screws, on 12" centers. Provide minimum two screws per side. Where roof mounted equipment manufacturer's requirements exceed the above requirements, provide installation complying with manufacturer's requirements.
- C. Coordinate with General Contractor for installation of roof curbs. See Architectural drawings and specifications for coordinating metal curb (under Division 23) with roof insulation, roof membrane, roof deck, roof blocking, etc. (under Architectural).

END OF SECTION 230529

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 COORDINATION

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

PART 2 - PRODUCTS

2.1 NAMEPLATES

- A. General: Provide nameplates for all equipment and panel mounted controls. Location shall be accessible and visible.
- B. Equipment Nameplates: Metal with data engraved or stamped, permanently attached to equipment. As a minimum, nameplate shall include manufacturer, model number, serial number and electrical data.

2.2 EQUIPMENT MARKERS

- A. Markers shall be Contractor fabricated to have equipment "tag" or number (e.g., EF-1, RTAC-2, etc.) on marker.
- B. Designation:
 - 1. Equipment tag shall be etched in 1/4" maximum, 1/8" minimum height letters and mounted on or adjacent to device cover or attached to the item of equipment. For items above ceiling, marker shall be attached to ceiling on t-bar grid in location approved by Owner.
 - 2. Type: White core black bakelike secured with epoxy glue or screws, unless otherwise noted.

PART 3 - EXECUTION

3.1 EQUIPMENT IDENTIFICATION

- A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible.
- B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.
 - 1. Letter Size: Minimum 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 2. Data: Equipment "tag".
 - 3. Locate markers where accessible and visible.

END OF SECTION 230553

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SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes TAB to produce design objectives for the following:
 - 1. Air Systems:
 - 2. Verifying that automatic control devices are functioning properly.
 - 3. Reporting results of activities and procedures specified in this Section.

1.2 SUBCONTRACTOR COORDINATION

- A. Testing, Adjusting and Balancing (TAB) work shall be performed by NEBB/AABC agent as described in this section of the specifications; however, all devices that the TAB agent will be required to perform work on described in this section, shall be provided by the Contractors' Division 23 mechanical sub-contractor(s). These devices include, but are not limited to: balancing dampers, re-insulation of ductwork after duct test holes are drilled by TAB agent, adjustable sheaves, pulleys, belts, etc. and the labor to install these devices. Sub-contractor(s) providing the Division 23 HVAC systems must provide labor to support the TAB Agent. The mechanical systems shall be fully operational and ready for TAB work to begin a minimum of four weeks prior to the Contractual date of "Substantial Completion". Additionally, the Division 23 Contractor(s) shall furnish a qualified technician(s)/mechanic(s) to assist the TAB agent in the performance of his duties until all work specified herein is accomplished. The Division 23 sub-contractor(s) shall correct all deficiencies found by the TAB agent.

1.3 DEFINITIONS

- A. Adjusting: The varying of system flows by partially closing balancing devices, such as dampers and varying fan speeds to achieve optimum system operating conditions within design and installation limits.
- B. Balancing: The methodical proportioning of air flows through the system's main branches, and terminal devices using acceptable procedures to achieve the specified airflow within installation, testing and design limitations.
- C. TAB: Testing, adjusting, and balancing. A systematic process or service applied to HVAC systems and other environmental systems, to achieve and document air and hydronic flow rates.
- D. Test: A procedure to determine quantitative performance of systems or equipment.
- E. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

- A. Qualification Data: Within 45 days from Contractor's Notice to Proceed, submit 4 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Sample Report Forms: Submit one set of sample TAB report forms. Forms are to be project specific for the systems to be TAB'd.
- C. Contract Documents Examination Report: Within 45 days from Contractor's Notice to Proceed, submit 4 copies of the Contract Documents review report as specified in Part 3.
- D. Certified Final TAB Reports: Submit four copies of reports prepared on approved forms certified by TAB firm.

1.5 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB. Test and balancing by non-AABC or non-NEBB firms is not allowed.

- B. TAB Report Forms: Use standard forms from AABC's "National Standards for Total System Balance" or NEBB's most recent "Procedural Standard for Testing, Adjusting, and Balancing of Environmental Systems."
- C. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Total System Balance" or NEBB's most recent copy of "Procedural Standard for Testing, Adjusting, and Balancing of Environmental Systems," Section 4, "Standards for Instruments and Calibration."
- D. Instrumentation Calibration: Calibrate instruments at least every twelve months or more frequently if required by instrument manufacturer.
 - 1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 OCCUPANCY DURING TAB PROCEDURE

- A. Owner Occupancy: TAB agent shall verify if Owner will occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

- A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times. Test and Balance Agent shall contact Engineer and Owner 48 hours prior to test and balance work to allow (but not require) Engineer and owner to be present during TAB work.

1.8 WARRANTY

- A. Performance Guarantee:
 - 1. Provide one of the following:
 - a. For AABC Certified Firms: Provide a guarantee stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.
 - b. For NEBB Certified Firms: Provide a guarantee stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee for either AABC or NEBB shall include the following provisions:
 - 1) The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2) Systems are balanced to optimum performance capabilities within design and installation limits.
- B. TAB work shall be guaranteed by AABC or NEBB. Submit copy of AABC or NEBB National Performance Guaranty when final balance report is submitted. If for any reason, the TAB agency fails to comply with the specifications, with the exception of termination of business by the TAB agency, equipment malfunction or inadequacy, which prevents proper balancing of the systems, the Associated Air Balance Council or NEBB shall provide supervisory personnel to assist the TAB agency to perform work in accordance with AABC or NEBB standards. As part of this Performance Guaranty, the engineer or building owner may call upon AABC or NEBB to assist him with any technical and/or field problems pertaining to the final balanced condition of the systems. These services will be made available at no additional charge by the TAB agency or by AABC or NEBB.

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. Provide Contract Documents Examination Report to report on acceptability and/or deficiencies in Contract Documents.
 - 1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
 - 2. Verify that balancing devices, such as manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- D. Examine HVAC system and equipment installations to verify that indicated manual volume dampers are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- E. Report deficiencies discovered before and during performance of TAB procedures.

3.2 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" or NEBB's most recent "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
- B. Cut insulation, ducts and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.3 GENERAL PROCEDURES FOR TESTING ADJUSTING AND BALANCING

- A. Air and Hydronic systems shall be Tested and Balanced using the procedures outlined in NEBB's most recent copy of "Procedural Standard for Testing Adjusting and Balancing of Environmental Systems", or AABC's "National Standards for Total System Balance".

3.4 TOLERANCES

- A. Set HVAC system airflow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 10 percent to minus 10 percent.
 - 2. Air Outlets and Inlets: Plus 10 percent to minus 10 percent.

3.5 CERTIFIED FINAL TAB REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. The content for the Certified TAB Report shall include all content and data required by the firms certifying agency (AABC or NEBB) for each system or component included in the scope of work. In addition to this data and content, the Final TAB Report shall contain all content and data listed in this section.

- C. Functional Performance Testing: Provide written verification of complete sequence of control system operation.

3.6 INSPECTIONS

- A. Initial Inspection:
1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
 2. Randomly check the following for each system:
 - a. Measure airflow of at least 10 percent of air outlets.
 - b. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - c. Verify that balancing devices are marked with final balance position.
 - d. Note deviations to the Contract Documents in the Final Report.
- B. Final Inspection:
1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner and Architect.
 2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner and Architect.
 3. Owner and Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
 4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than $\pm 10\%$, the measurements shall be noted as "FAILED."
 5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
 6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
 7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.7 ADDITIONAL TESTS

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

3.8 REPORT

- A. Provide four copies of the Test and Balance report to the Architect/Engineer by the earlier of the following two dates:
1. A minimum of 48 hours prior to the semi-final on-site project construction site review by the Architect/Engineer.
 2. Four weeks prior to the date the facility is scheduled to be turned over to the Owner.

- B. TAB work shall be guaranteed by AABC or NEBB. Submit copy of AABC or NEBB National Performance Guaranty when final balance report is submitted. If for any reason, the TAB agency fails to comply with the specifications, with the exception of termination of business by the TAB agency, equipment malfunction or inadequacy, which prevents proper balancing of the systems, the Associated Air Balance Council or NEBB shall provide supervisory personnel to assist the TAB agency to perform work in accordance with AABC or NEBB standards. As part of this Performance Guaranty, the engineer or building owner may call upon AABC or NEBB to assist him with any technical and/or field problems pertaining to the final balanced condition of the systems. These services will be made available at no additional charge by the TAB agency or by AABC or NEBB National Headquarters.

END OF SECTION 230593

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SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes mechanical insulation for duct, equipment, and pipe, including the following:
 - 1. Insulation materials
 - 2. Fitting materials.
 - 3. Insulation finish materials
 - 4. Accessories

1.2 SUBMITTALS

- A. Product data shall be submitted under provisions of Division 23 - Common Requirements for HVAC Equipment for each type of product indicated; identify thermal conductivity, thickness, and jackets (both factory and field applied, if any). Provide a sheet that identifies each system (e.g., supply duct, etc.), and the submitted material, thickness, and finish for each system.
- B. Submit proof of three years minimum experience in insulation installation.

1.3 QUALITY ASSURANCE

- A. Insulation and related materials shall meet the requirements of NFPA-90A.
- B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing products per ASTM E 84. Factory label insulation and jacket materials and adhesive, mastic, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
- C. Applicator: Company specializing in insulation application with three years minimum experience.

1.4 GENERAL INSULATION NOTES

- A. Any HVAC equipment which is factory insulated, and which has sweating/condensation forming on the equipment while operating under design conditions, shall be replaced or field insulated by the contractor until the condensation is eliminated.
- B. Piping and ductwork is considered concealed for purposes of this Specification Section when located above ceilings or in chases.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Certain Teed, Owens-Corning, Johns Manville, Armacell, IMCOA, Nomaco, Knauf, Pittsburg Corning, The Dow Chemical Company, Dyplast, Foster, Childers and Hi-Therm.
- B. Substitutions: Under provisions of Division 23 - Common Requirements for HVAC Equipment.

2.2 INSULATION MATERIALS

- A. I2: Preformed flexible elastomeric expanded closed-cell pipe insulation having a flame spread rating of 25 or less and a smoke density of 50 or less when tested by ASTM E-84 method. Temperature range -40°F to 220°F. Insulation shall be CFC and HCFC free and formaldehyde free. Thermal conductivity of 0.27 btu-in/hr sq. ft °F at 75°F mean temperature. All seams and butt joints shall be sealed with factory applied adhesive. Provide insulation shield on exterior of insulation at all hangers.

- B. I3: Blanket Insulation: Glass fiber blanket insulation minimum 3/4 lb. density, installed R3.5 per inch, with FSK facing. On ductwork, wrap blanket insulation around duct, being careful not to compress it more than 25% at the corners, butting insulation and overlapping facing jacket 2" minimum at all joints. Two-inch (2") thick insulation shall have a minimum R5.3 at 25% compression. Staple the overlap with outward clinching staples a maximum of 3" on centers. For ducts over 30" wide, additionally support insulation on bottom of horizontal ducts and sides of vertical ducts with rows of welded or adhered clips and washers on not more than 18" centers. Seal all joints and clips with pressure sensitive FSK tape. Seal all penetrations, such as at duct supports, and all terminations of insulation with pressure sensitive FSK tape.

2.3 INSULATION FINISH MATERIALS

- A. F1: Two coats of Armacell Armaflex finish or equal

2.4 ACCESSORIES

- A. Adhesives: Compatible with insulation materials, jackets and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Insulation Shields: Provided in accordance with Division 23 - Hangers and Supports for HVAC Piping and Equipment.
- C. Mastics: Materials shall be compatible with insulation materials, jackets, and substrates.
- D. Tapes: FSK foil face, vapor retardant type tape matching factory applied jacket with acrylic adhesive; complying with ASTM C1136 and UL listed. Width shall be three inches; thickness shall be 6.5 mils.

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 COMMON INSTALLATION REQUIREMENTS

- A. Install insulation, fitting materials, finish materials and accessories in accordance with manufacturer's installation requirements and recommendations.
- B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- C. Install insulation with longitudinal seams at top and bottom of horizontal runs. Install multiple layers of insulation with longitudinal and end seams staggered. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- D. Keep insulation materials dry during application and finishing.
- E. Install insulation with least number of joints practical.
- F. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- G. 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.
- H. Continue insulation with vapor barrier through penetrations. At fire dampers, smoke dampers, and fire/smoke dampers, extend insulation to wall on both sides of wall and seal.
- I. Insure duct access panels are not blocked by the installation of external duct insulation.

- J. Internal Acoustical duct liner is specified in certain ducts for acoustical purposes to reduce high frequency noise. These ducts may also be specified with external duct insulation. The Contractor is not permitted to omit specified external duct insulation (duct wrap, duct board, etc.) just because the duct is also lined.

3.3 INSULATION SCHEDULE

Service/Location	INSULATION Pipe/Duc Fitting t		Thickne ss	FINISH Pipe/Duct Fitting	
PIPING:					
Refrigerant Suction and Liquid Piping Serving Ductless Split Systems	I2	I2	3/4"	F1	F1
Condensate Piping:					
Rooftop A/C Unit Condensate Piping	--	--	--	--	--
All Other Condensate Piping, Concealed Copper	I2	I2	1/2"	--	--
All Other Condensate Piping, Exposed Copper	I2	I2	1/2"	F1	F1
All Other Condensate Piping, Exposed PVC	--	--	--	--	--
All Other Condensate Piping, Concealed PVC	I2	I2	1/2"	--	--
DUCT:					
General Exhaust Duct	--	--	--	--	--
Return Air Duct	--	--	--	--	--
Supply Duct Concealed	I3	I3	2"	--	--
Transfer Air Duct	--	--	--	--	--

EQUIPMENT:

Mechanical Equipment

Shall have factory installed insulation to prevent condensation or excessive heat loss/gain

Supply Diffusers

Provide 2" of I3 insulation blanket atop ceiling supply diffusers that are not specified to be factory insulated

Roof Curbs

If contractor utilizes roof curbs furnished by equipment manufacturers, and if roof curbs are not factory insulated, insulation contractor shall insulate curbs with 1-1/2" thick 3 pound density rigid fiberglass insulation on the interior or exterior surfaces.

END OF SECTION 230716

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SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for equipment not supplied with factory-wired controls.

1.2 WORK INCLUDED

- A. Project Scope Description: New RTAC units, exhaust fans, and other HVAC equipment is being installed in the existing building. All new HVAC equipment shall be controlled by new DDC system that is connected to the existing county wide DDC system as described herein.
- B. All control components shall be provided under this section of the specifications unless specifically provided elsewhere.
- C. This system shall include all devices specified herein and shall include, but is not limited to; conventional thermostats, humidity sensors, relays, switches, contactors, transformers, etc.

1.3 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Division 23 - Common Requirements for HVAC Equipment to the Owner and Architect/Engineer.
- B. Controls contractor shall not order material or begin field installation until receiving approved submittals.
- C. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and terminal to terminal control wiring, clearly indicating factory-installed and field-installed wiring associated with all equipment. Wiring diagrams shall show all point-to-point wiring connections between all components of the control system. **No devices, conduit or wiring shall be installed until Contractor has received approved shop drawings from the Architect/Engineer.**
- D. Space Temperature Sensor Confirmation Letter: Prior to submitting control submittal to the Architect/Engineer for review, the controls contractor shall confirm with the Owner's HVAC maintenance department supervisor the type of sensor (wired or wireless) that the Owner desires, and all features (flat plate with no adjustment, adjustable, pushbutton override, wireless, etc.) that the Owner desires. Some sensor features may be indicated in this specification section or on the drawings for certain areas, but contractor shall arrange meeting with Owner to obtain sensor information for all areas. Provide signed letter from Owner's HVAC maintenance department supervisor with sensor submittals confirming Owner has approved sensor types and features for all sensors.

1.4 COORDINATION

- A. Coordinate location of thermostats, humidity sensors, override timers, and other exposed control sensors and devices with plans and room details before installation.

1.5 WARRANTY

- A. See Division 23 - Closeout Document Requirements for HVAC for warranty information.
- B. Emergency Service: The controls contractor shall restore the control system to proper operating condition within 24 hours after receiving a request for service.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Since the Henry County School System has a county-wide Delta "iNTREO" energy management and control system, The Contractor shall provide Delta iNTREO BACnet controls (no equal) as the sole manufacturer and Controls Concepts, Inc. (contact Rob Blain at 770-296-3236) shall be the sole installer of the control system for all work specified herein. These controls, including field installed microprocessors at each piece of HVAC equipment.

2.2 WIRING

- A. All control wiring (including but not limited to control, interlock, sensor, thermostat, etc.) shall be provided under this section of these specifications. The control contractor is responsible for providing 120-volt AC as specified herein.

2.3 CONTROL COMPONENTS AND THEIR FUNCTION

- A. Cabinets: Provide and install control cabinets constructed of heavy gauge steel or aluminum and consisting of a one piece rectangular or square ring, a sub-panel and a door with continuous hinge, and quick turn latch with keyed lock. Unless otherwise specified, all controllers, and other equipment furnished as part of the control system which are not required to be mounted on mechanical equipment shall be cabinet mounted. All wiring connections shall be made inside the cabinet. All electrical devices shall be wired to a numbered terminal strip. No field wiring shall be required within the cabinet except to the terminal strip.
- B. Conduit and Raceway: Provide and install under this section.
 - 1. Refer to Division 26 - Electrical for material requirements for conduit and flexible conduit. Conduit sleeves with bushing shall be provided at all control wiring penetrations through walls.
 - 2. Outlet Boxes: Refer to Division 26. Provide and install under this section.
- C. Conductors:
 - 1. 50 to 600 volts: Refer to Division 26 for requirements.
 - 2. Below 50 volts: Minimum size for individual conductors is AWG. No. 18. Minimum conductor sizes for multiconductor cables is AWG No. 22. Provide shielded cable as required to avoid EMI where conduits natural shielding effect is insufficient. Conductors shall be sized within acceptable voltage drop parameters.
 - 3. Plenum Rated Cable: Plenum rated cable with flame spread of 25 or less and smoke development of 50 or less as tested by ASTM-E84.
 - 4. Conductor Insulation: "TFFN", unless noted otherwise.
 - 5. Taps and Joints: Mechanically and electrically sound.
 - 6. Tape: Per Division 26. Provide and install under this section.
 - 7. Lacing: Per Division 26. Provide and install under this section.
 - 8. Lubricants: Per Division 26. Provide and install under this section.
 - 9. Color Code: All low voltage control conductors shall be color coded by factory or provided with numbered ends.
- D. Contactors and Disconnects:
 - 1. All contactors for equipment specified in Division 23 shall be provided under this section of the specifications unless explicitly shown furnished by Electrical on the Electrical Drawings. Provide herein all relays and contactors necessary for the proper operation of all Division 23 equipment.
 - 2. All electrical disconnects for equipment specified in Division 23 shall be provided under this section of the specifications unless explicitly shown furnished by Electrical on the Electrical Drawings.

3. Control Relays and Contactors: Relays for control purposes shall be the plug-in type with plastic enclosure surrounding the relay with contacts rated for a minimum of 110VAC and 24VDC. Relay shall operate properly over -25°C to 55°C ambient. Relay shall be UL recognized. Pick up voltage shall be a maximum of 80% of nominal and drop off voltage shall be a maximum of 30% of nominal. Contact rating, in-rush current, number of poles, coil voltage, etc. shall be appropriate for the application. Provide neon or LED "ON" indicator lamp.
- E. Conventional Thermostats: All conventional thermostats shall be mounted on wall at 4'-6" above finished floor, unless noted otherwise. All setpoints shall be adjustable.
 1. Ductless Fan Coil Unit Thermostats: Shall be provided by ductless fan coil unit manufacturer and shall be 24V standalone digital wired controller with LCD display to operate all aspects for the equipment.
- F. Control Transformer: Provide transformers at all equipment as necessary to power control system. Transformers shall be protected with in-line fuses on both the primary and secondary sides in accordance with Table 450.3(B) of the National Electric Code unless the following primary current conditions apply. Transformers with a primary current less than 2 amperes shall be permitted to be fused on the primary side only provided the fuses do not exceed 300% of the transformer's rated primary current. Transformers with a primary current less than 9 amperes shall be permitted to be fuse protected on the primary side only provided the fuses do not exceed 167% of the transformer's rated primary current. If control contractor intends to utilize any on board transformer provided by the HVAC equipment manufacturer, he shall provide signed statement from the equipment manufacturer indicating the allowable additional "VA" load that is available for additional devices.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 54 inches above the floor, unless noted otherwise.

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install all systems in accordance with manufacturer's installation instructions, NFPA-70 and NFPA-90A.
- B. Installation of Conduit and Wiring:
 1. All wiring and conduit installed under this section of the specifications shall be installed by a state-licensed contractor(s) and all work shall be done by state-certified technicians. All wiring systems shall be color coded and conductors shall be tagged at all junctions and terminals. Label cables identification numbers as directed by Owner. The Engineer and Owner reserves the right to move any device fifteen (15) feet without additional costs before the device is installed. All wiring and conduit shall be installed in accordance with Division 26 - Electrical.
 2. All wiring shall be installed in conduit, except for plenum rated cable as specified below.
 3. All conduit shall be concealed, except in mechanical/ electrical rooms.
 4. All control wiring above suspended ceiling, not made inaccessible by equipment, ductwork or structure, may be plenum rated cable with flame spread of 25 or less and smoke development of 50 or less as tested by ASTM-E84. This plenum rated cable is not required to be installed in conduit, but shall be run in a workmanlike manner, parallel to the building lines, properly supported at regular intervals, and not draped over conduit, piping and ductwork. Attach cable above ceiling to structure using appropriate fasteners for type of construction involved. Cable shall not lay atop ceiling. Where physical damage is possible, mechanical protection shall be used. All splices or connections shall be made at equipment served. Where communication loops are run, terminations shall be

at terminal strip on equipment. No splices in field shall be allowed. The use of snap in bushings or connectors is required where cable is entering a knockout or equipment housing. All penetrations through wall sleeves shall be sleeved with conduit with bushings on both ends.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, commission and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

3.4 ADJUSTING

- A. Adjust initial temperature and humidity 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.

3.5 SEQUENCE OF OPERATION

- A. Sequence of Operation for Rooftop Air Conditioners with Gas Heat:
 - 1. Unit functions will be enabled for operation by the DDC system.
 - 2. Supply Fan Control: The supply fan shall run continuously when the DDC system is in the occupied mode. Supply fan shall be staged to operate at lower speed during first stage of cooling. Supply fan cycles as required during unoccupied periods.
 - 3. Compressor Control: The compressor(s) and outdoor fan(s) shall be energized in stages as scheduled upon a call for cooling.
 - 4. Safety Shutdown Control: The units shall be subject to shut down by the following:
 - a. Internal safeties
 - b. Duct mounted smoke detector on units over 2000 cfm.
 - 5. Gas Heating System Control: The gas heating system shall be energized in stages or modulated as scheduled upon a call for heating.
 - 6. For certain units as indicated on the drawings, an internal hot gas reheat coil and internal dehumidification package is specified. For these units, the dehumidification circuit shall be started/stopped by a space humidity sensor.
- B. Sequence of Operation for Exhaust Fans: EF-1 through EF-6 shall be started/stopped by a motion detector provided by the fan manufacturer.
- C. Sequence of Operation for Ductless Fan Coil Units/Ductless Condensing Units (DFCU-1): DFCU shall operate under the dictates of its own wall mounted low voltage space thermostat to cycle the compressor and reversing valve to maintain space temperature setpoint.
- D. Sequence of Operation for Bi-Polar Ionization Unit: Bi-polar ionization unit shall be enabled whenever airflow is enabled at associated equipment (e.g. RTAC units). Once airflow is enabled, bi-polar ionization units shall operate to produce ions to kill mold, bacteria, viruses, and neutralize odors. (No work required by controls contractor)
- E. Sequence of Operation for Electric Wall Heater: Electric wall heater(s) shall cycle their blower (after heating element warm up) and heating element to satisfy integral thermostat.
- F. Additional System Monitoring and Control Functions:
 - 1. General: In addition to the equipment previously specified to be controlled by the control system, the following additional items shall be monitored and/or controlled by the control system. All points shall be available for display from the operator interface. All alarms shall be sent to the Owner's on site and remote off site central computer.
 - 2. Supply Air Temperature Monitoring: On certain pieces of HVAC equipment as specified herein, provide a supply duct mounted temperature sensor to allow for diagnostics and troubleshooting. The following equipment shall be provided with supply duct mounted temperature sensors:
 - a. Rooftop Air Conditioning Units (RTAC-1 thru RTAC-4)

3. IDF Space Temperature Monitoring: DDC system shall monitor space temperature in data rooms as noted on drawings. DDC system shall send alarm signal to Owner if space temperature rises above Owner's setpoint.

END OF SECTION 230900

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SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods and piping specialties as described below:
 - 1. Air conditioning condensate-drain piping.

PART 2 - PRODUCTS

2.1 SOLDER

- A. Solder shall be lead free having composition of minimum 94% tin, 4% to 5% copper and 0.4% to 0.2% silver or selenium. Solder shall have a minimum tensile strength of 6,900 psi at 70°F, melting temperature of between 410°F and 440°F maximum to protect valve seat material. Solder shall conform to ASTM B-32 and shall be applied in conformance with ASTM B-828. Flux shall conform to ASTM B-813. Solder shall be manufactured for the HVAC industry not circuit board industry. Solder shall be Taramet Sterling Lead Free as manufactured by Taracorp, Dutch Boy Silver as manufactured by Taracorp or Lenox Sterling Lead Free.

2.2 AIR CONDITIONING CONDENSATE DRAIN PIPING

- A. Copper Tubing: ASTM B88 type "L" hard drawn copper tubing. Fittings: Sweat type, wrought copper. Joints: Lead free solder as specified herein.
- B. PVC Pipe: ASTM D1785, Schedule 40 PVC. Fittings: ASTM D2665, Schedule 40 PVC, Drainage pattern. Joints: ASTM D2855 Solvent Weld.

PART 3 - EXECUTION

3.1 PIPING INSTALLATIONS

- A. Drawings show the general arrangement, layout and location, of piping, appurtenances, etc., but do not show all required fittings and offsets that may be necessary to connect piping to equipment, etc., offset around obstructions, and to coordinate with other trades. Fabricate and install piping, appurtenances, etc., based on field measurements. Provide all necessary fittings and offsets at no additional cost to the Owner. Coordinate with other trades, existing building conditions, etc., for space available and relative location of piping, appurtenances, etc. Pipe, appurtenances, etc., locations shown on drawings shall be altered by Contractor where required to avoid interference and clearance difficulties.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise. Route piping in an orderly manner.
- D. Install piping at indicated slopes.
- E. Install piping free of sags and bends.
- F. Install fittings for changes in direction and branch connections.
- G. Install piping to allow application of insulation.
- H. Mitered Fittings and Tapped Pipes: Mitered fittings and tapped pipes are not allowed. All changes in direction and pipe branches shall be accomplished by the use of fittings.

3.2 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 23 - Hangers and Supports for HVAC Piping and Equipment. Comply with the following requirements for maximum spacing of supports.

- B. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 3/8 inch.
 - 2. NPS 1: Maximum span, 6 feet; minimum rod size, 3/8 inch.
 - 3. NPS 1-1/4: Maximum span, 6 feet; minimum rod size, 3/8 inch.
- C. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions and also maximum span of five feet. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- D. Install a hanger within 12-inches of each horizontal elbow.

3.3 PIPE JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems. Joints shall be determined by the equipment connections or by the valve or fitting specified herein.
- 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. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Non-pressure Piping: Join according to ASTM D 2855.
- 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.
 - 3. Use threaded pipe only in accessible locations.

3.4 INSTALLATION OF CONDENSATE DRAIN PIPING

- A. General: Slope piping a minimum of 1/4" per one foot of run. As a minimum, drain piping size shall match unit connection, but size shall be increased where shown on the drawings. For equipment discharging condensate inside the building, discharge at nearest drain as shown on drawings. Do not install the condensate drain pipe in a manner which interferes with equipment access panels or restricts access to equipment. Install condensate drain piping in a manner which will minimize the possibility of pipe being a tripping hazard or walking obstruction. At each piece of equipment, provide minimum 3" deep open (cleanable) trap at condensate connection. Trap shall be constructed as shown on drawings. Piping material shall be copper or PVC as shown on the drawings or as specified in this specification.
- B. Roof Mounted Equipment Condensate Installation: Roof mounted unit's condensate drain shall be routed to spill at roof drain. Condensate shall be supported by non-penetrating type supports as specified in Section 230529 - Hangers and Supports for HVAC Piping and Equipment. Roof mounted unit's condensate piping shall be PVC unless specifically identified otherwise on the drawings.

- C. Ductless Wall Mounted Fan Coil Unit Condensate Installation: Condensate trap shall not be provided for ductless wall mounted fan coil units. Connect piping directly to unit or to external condensate pump as shown on the drawings. Provide clear transparent PVC drain pipe and stainless steel worm gears to transition from unit connection to drain pipe.

END OF SECTION 232113

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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 and associated refrigerant piping specialties, brazing alloy and refrigerants.

1.2 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

1.3 SUBMITTALS

- 1. Product Data: Submit under provisions of Division 23 Section "Common Requirements for HVAC Equipment."

1.4 QUALITY ASSURANCE

- A. Brazing: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

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, either soft temper annealed seamless coil or hard temper drawn seamless hard straight lengths. Tube shall be cleaned and dehydrated and positively pressurized with nitrogen, and ends capped.
- B. Wrought-Copper Fittings: ASME B16.22.

2.2 BRAZING ALLOY

- A. Brazing alloy shall be copper and phosphorous with minimum 15% silver, minimum melting temperature of 1190°F. Brazing alloy shall meet AWS BcuP-5 classification.

2.3 VALVES AND SPECIALTIES

- A. Manufacturers: Alco, Henry or Sporlan.
- B. Provide all solenoid valves, thermostatic expansion valves, moisture/liquid indicators as required by manufacturer. Items shall be approved by HVAC equipment manufacturer.
- C. 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 or charcoal.
 - 4. Designed for reverse flow (for heat-pump applications).
 - 5. End Connections: Socket.
 - 6. Working Pressure Rating: 500 psig.
 - 7. Maximum Operating Temperature: 240 deg F.

2.4 REFRIGERANTS

- A. R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Provide and install all refrigeration piping and specialties in accordance with manufacturer's recommendations and instructions. Refrigeration piping shall be brazed, and shall be installed in accordance with ASME Standard B31.5, "Refrigeration Piping."
- B. Refrigerant piping indicated on Drawings is schematic only. Contractor shall size piping and design actual piping layout, including oil traps, double risers, slopes of horizontal runs, 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. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- D. Install refrigerant piping according to ASHRAE 15.
- E. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- F. 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.
- G. Install piping to conserve building space and not to interfere with use of space. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- H. Install piping adjacent to machines to allow service and maintenance.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Insulate piping in accordance with Division 23 Section "HVAC Equipment Insulation."
- M. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- N. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection.
- O. Slope refrigerant piping as required by manufacturer.
- P. When brazing, do not apply heat near components prohibited by manufacturer.
- Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- R. Seal penetrations through fire and smoke barriers according to Division 7 Section "Through-Penetration Firestop Systems."
- S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- U. Seal pipe penetrations through exterior walls according to Division 7 Section "Joint Sealants" for materials and methods.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install valves and refrigerant specialties as required in manufacturer's installation manual and recommendations.

- B. Install moisture/liquid indicators in liquid line for all systems 7-1/2 nominal tons and greater.
- C. Install filter dryers in liquid line between compressor and thermostatic expansion valve, unless prohibited by equipment manufacturer.

3.3 PIPE 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. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Braze 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 BA_g, cadmium-free silver alloy for joining copper with bronze or steel.
- E. Compression Joints: Compression joints shall be allowed only for ductless split systems and shall be torqued as required in manufacturer's installation instructions.

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. 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, 5 feet; minimum rod size, 3/8 inch.
 - 2. NPS 5/8: Maximum span, 5 feet; minimum rod size, 3/8 inch.
 - 3. NPS 1: Maximum span, 6 feet; minimum rod size, 3/8 inch.
 - 4. NPS 1-1/4: Maximum span, 6 feet; minimum rod size, 3/8 inch.
 - 5. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

3.5 PRESSURE TESTS

- A. Piping systems shall be subjected to constant inspection and final approval of the Owner, Engineer and Code Authorities having jurisdiction. Contact Architect/Engineer and all code authorities 48 hours before making any pressure tests. Tests, in addition to those included in this section required to show compliance, shall be performed as directed at no additional cost.
- B. Tests and Inspections:
 - 1. Comply with ASME B31.5, Chapter VI.
 - 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in 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. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 - 2. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 - 3. Fully charge system with refrigerant

3.7 ADJUSTING

- A. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

END OF SECTION 232300

SECTION 233113 – METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch w.g. Metal ducts include the following:
 - 1. Low pressure galvanized steel ducts
 - 2. Ductwork liner.

1.2 SYSTEM DESCRIPTION

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

1.3 SUBMITTALS

- A. Submit product data under provisions of Division 23 - Common Requirements for HVAC Equipment for duct liner. The Contractor may generate ductwork shop drawings for their use in coordination with structural, sprinkler, electrical, plumbing, etc., but these are not required for submittal review and shall not be submitted to the Engineer for review.

1.4 QUALITY ASSURANCE

- A. Construct ductwork to International Mechanical Code.
- B. Construct ductwork to ASHRAE Handbook.
- C. Fabricate ductwork in accordance with SMACNA HVAC Duct Construction Standards.
- D. NFPA Compliance:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

- A. 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: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- D. 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.

2.2 DUCTWORK ACOUSTICAL LINER

- A. "Heavy Duty" Fiberglass Duct Liner: Glass fiber duct liner shall conform to the requirements of ASTM C1071; have a minimum noise reduction coefficient (NRC) value of 0.45 for 1/2" thickness (note that this is thickness associated with noise rating not required thickness for all applications. See insulation specification for required liner thickness.); have a maximum thermal conductivity (k) at 75°F of 0.27 and shall be tested in accordance with ASTM C518 and/or ASTM C177. The duct/plenum liner shall also comply with NFPA 90A and 90B. Sound

attenuation of liner shall be tested in accordance with ASTM E477. Sound absorption shall be tested in accordance with ASTM C423. Liner's composite surface on the air stream surface shall serve as a barrier against infiltration of dust and dirt into the insulation, reducing the potential for microbial growth. Liner shall meet the requirements of ASTM C655 (corrosiveness) and odor emission and fungal resistance, ASTM G21 (fungal) and G22 (bacteria) for resistance to fungal and bacterial attack. Liner shall conform to ASHRAE 62-89. Liner surface shall provide an extremely cleanable surface during the life of the duct system. Heavy duty liner shall be "ToughGard" as manufactured by CertainTeed, "Permacote Linacoustic" as manufactured by Johns Manville, "Aeroflex Plus" as manufactured by Owens Corning, EM as manufactured by Knauf, or prior approved equal. The glass fiber liner shall have a coated or mat-faced, abrasion resistant air stream surface. The liner shall be adhered to the sheet metal ductwork using an adhesive meeting the requirements of ASTM C 916. Adhesive shall be Foster 85-65 Stick Fas, Childers CP-127 Chil Quik or prior approved equal. Mechanical fasteners of the specified type and length shall be used assuring no greater than 10% compression of the liner thickness. Flat black, minimum 26 gauge galvi-grip metal nosings shall be used on the upstream transverse edges when air velocities exceed 2000 fpm or where liner is exposed to view (e.g. at supply/return grille, etc.). Also, all other traverse edges shall be completely sealed and adhered to the duct to prevent corrosion or dust accumulation.

2.3 SEALANT MATERIALS

- A. General: All sealants shall have a maximum flame spread of 25 and smoke development rating of 50. Sealants shall be designed for service temperature that the duct is expected to see.
- B. Water-Based Duct Joint and Seam Sealant Mastic: Flexible, adhesive sealant, and complying with NFPA requirements for Class 1 ducts. Sealant shall be low odor/low VOC with less than 32 grams/liter VOC per ASTM D-6886 or EPA Method 24. Sealant shall be SMACNA pressure class rated for -0.5" w.g. to +10.0" w.g., and shall meet SMACNA class seal for A, B and C classes. Service temperature limits of sealant shall be -10°F to 190°F. Sealant shall be fiber reinforced, and shall meet UL-181A-M and UL-181B-M for mold growth test. Sealant shall use soap and water for clean up. Sealant shall be RCD #6, Foster 95-90 Vapor Safe, Childers CP-181 Comfort Seal or prior approved equal.
- C. Solvent-Based Duct Joint and Seam Sealant: One-part, non-sag, solvent-release-curing, polymerized butyl sealant. Sealant shall contain maximum 420 grams/liter VOC, and comply with ASTM D-2202 and be LEED compliant with SCAQMD Rule 1168 under Sealant category "other" with VOC max of 420 g/l. Sealant shall be SMACNA pressure class rated for +0.5" w.g. to +10.0" w.g., and shall meet SMACNA class seal for A, B and C classes. Service temperature limits of sealant shall be -20°F to 200°F. Sealant shall be Sure Grip 404 by Hard Cast, 32-14 Duct Fas by Foster or prior approved equal.
- D. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- E. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS

- A. Building Attachments: Structural-steel fasteners appropriate for construction materials to which hangers are being attached.
- B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 - 1. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

- E. Upper Supports: Provide supplemental angle iron (minimum size: 2" x 2" x 3/16") or Uni-Strut channels between primary building structural members to support rods and straps connected to ductwork. Size supplemental supports and hanger to adequate support load without overloading or excessive deflection.

2.5 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 - 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 - 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Transverse Joints: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details. Contractor has the option of using prefabricated slide-on joints and components for transverse joints, constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement. Prefabricated slide on joints shall be manufactured by Ductmate Industries, Inc., Nexus Inc., or Ward Industries, Inc.
- C. Longitudinal Seams: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-5.
- D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359-inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
 - 1. Supply Ducts: 1-inch w.g.
 - 2. Return Ducts (Negative Pressure): 1-inch w.g.
 - 3. Exhaust Ducts (Negative Pressure): 1-inch w.g.
- B. All ducts shall be galvanized.

3.2 DUCT INSTALLATION

- A. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the Owner. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
- B. Provide pilot tube openings where required for testing of systems, complete with neoprene plug.
- C. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- D. During construction provide temporary closures of metal or taped 5 mil polyethylene on open ductwork to prevent construction dust from entering ductwork system. Ductwork may not be hung prior to "drying in" of the facility unless all joints are sealed with mastic.

- E. Branches from trunk duct and tap-in connection shall be constructed in accordance with Paragraph "Low Pressure Galvanized Steel Ductwork".
- F. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- G. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.
- H. Install ducts with fewest possible joints.
- I. Install fabricated fittings for changes in directions, size, and shape and for connections.
- J. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.
- K. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- L. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- M. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- N. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- O. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- P. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- Q. Electrical Equipment Spaces: Contractor shall not route ducts over electrical panels.
- R. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.
- S. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 - Air Duct Accessories. Firestopping materials and installation methods are specified in Division 7 - Through-Penetration Firestop Systems.
- T. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."
- U. Paint interiors of metal ducts that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 9 - Painting.

3.3 APPLICATION OF FIBER LINER IN RECTANGULAR DUCTS

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

- G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- H. Secure transversely oriented liner edges facing the air stream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - 1. Fan discharges.
 - 2. Intervals of lined duct preceding unlined duct.
 - 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.
- I. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.
- J. Install in accordance with NAIMA Fibrous Glass and Duct Liner Standard AHS-124 and SMACNA HVAC Duct Construction Standards. Liner shall be kept clean and dry. Liner that has become wet shall be replaced. Duct dimensions indicated on the drawings are net inside dimensions required for airflow, and duct size shall be increased to allow for liner thickness.

3.4 SEAM AND JOINT SEALING

- A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.
- B. Seal all circumferential and longitudinal duct joints in low pressure supply and return ducts with sealant as specified herein in accordance with the manufacturer's installation instructions. This includes, but is not limited to Pittsburgh connections, snap locks (all types), etc. Duct tape is not suitable as a substitute. Notify Engineer for on-site review of ductwork joints prior to insulation application. Where gaps exceed manufacturer's recommendations for sealant only, provide fibrous backing tape.
- C. Seal ducts before external insulation is applied.

3.5 HANGING AND SUPPORTING

- A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
- B. Use double nuts and lock washers on threaded rod supports. Duct hangers shall be constructed in accordance with Figures No. 4-1,2,4,5,6,7 and 8 as well as tables 4-1,2 and 3. Duct shall not be supported directly from metal decks. Provide upper supplemental framing as required between building structural members.

3.6 CONNECTIONS

- A. Make connections to equipment with flexible connectors according to Division 23 - Air Duct Accessories.
- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.
- C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline (Figure 2-2, Type RE-3 and Figure 2-5,2-6). Where there is not sufficient space and at the Contractor's option in all other locations, rectangular elbows with turning vanes may be substituted.
- D. For turning vane construction see Figure 2-2, Type RE-2 and Figure 2-3 and 2-4. Provide at all square elbows in supply, return and exhaust ductwork and where noted.

- E. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees. Provide Type 2 or Type 3 offsets where required. See Figure 2-9.
- F. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two ducts maintaining original duct area. See Figure 2-10 for easement construction.
- G. All branch take-offs of rectangular ducts shall be made with "45-degree entry" fitting in accordance with Figure 2-8 or by means of "parallel flow branches" with turning vanes and locking splitter dampers (Figure 2-7) where indicated. All branch take-offs of round ducts shall be made with "Bellmouth take-off collar," or "45° take-off collars" as specified in Division 23 - Air Duct Accessories.

3.7 DUCT CLEANING

- A. New Duct Systems: Contractor shall ensure interior of all ductwork is clean and free of dust at the time the Certificate of Occupancy is issued and building is turned over to the Owner. Clean duct system and force air at high velocity through duct to remove accumulated dust. Close duct outlets to obtain sufficient air velocities or use portable blowers. Protect coils and equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning. Clean duct systems with vacuum machines as required to remove dust.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Backdraft control dampers.
 - 2. Volume control dampers, manual type.
 - 3. 90-degree straight saddle tap.
 - 4. Fire dampers.
 - 5. Turning vanes.
 - 6. Duct access doors.
 - 7. Flexible connectors.
 - 8. Low pressure flexible ducts.
 - 9. Duct accessory hardware.
 - 10. Bellmouth take-off collars.
 - 11. 45-degree take-off collars.

1.2 SUBMITTALS

- A. Product Data: Submit under provisions of Division 23 - Common Requirements for HVAC Equipment for the following:
 - 1. Volume control dampers, manual type.
 - 2. 90-degree straight saddle tap.
 - 3. Fire dampers.
 - 4. Low pressure flexible ducts.
 - 5. Bellmouth take-off collars.
 - 6. 45-degree take-off collars.
- B. For fire dampers dampers, provide UL ratings for fire resistance, leakage velocity, differential pressure and elevated temperature. Include pressure drop data in accordance with AMCA 500-D.

1.3 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Install in accordance with International Mechanical Code.

PART 2 - PRODUCTS

2.1 BACKDRAFT DAMPERS

- A. Fabricate multi-blade, parallel action backdraft dampers of 18 gage galvanized steel or extruded aluminum, with center pivoted roll formed aluminum blades with felt or flexible vinyl blade seals, linked together with 20-gauge galvanized tie bar in rattle-free manner with 90 degree stop, synthetic (acetal) sleeve bearings, and plated steel pivot pin axles.
- B. Damper manufacturer's printed application and performance data including maximum pressure, velocity and temperature limitations shall be submitted for approval showing damper suitable for pressures to 2" w.g., velocities to 2,500.0ft/min. and temperatures to 180°F. Testing and ratings to be in accordance with AMCA Standard 500. Backdraft damper shall have maximum 3-1/2" depth when blades are in the closed position. Backdraft damper shall be suitable for horizontal air flow (vertical mount) or vertical up or vertical down air flow (horizontal mount) based on the arrangement shown on the drawings. Backdraft dampers shall be provided with no flanged frame unless flange is specifically identified on the drawings. If so, see drawings for location of flange (flange on discharge or flange on intake). Backdraft damper shall be gravity

type, opening by air pressure differential and closing by gravity, unless a motor pack is specified on the drawings. When motor pack is specified, backdraft dampers shall be powered open, spring closed. Motor voltage shall match fan voltage, and quantity and torque requirements of motors shall be determined by manufacturer's installation instructions. Multiple section dampers shall be assembled per manufacturer's installation instructions.

- C. Backdraft dampers shall be manufactured by Airstream, Air Balance, Pottorff, Greenheck, American Warming, Dowco, Louvers and Dampers, Empco, Industrial Louvers, Cesco or Arrow-United. Gravity backdraft dampers, furnished with air moving equipment, may be provided by equipment manufacturer, provided the damper meets the specification above.
- D. Backdraft Dampers Serving Industrial Duty Sidewall Propeller Exhaust Fans: See Division 23 - HVAC Power Ventilators.

2.2 VOLUME CONTROL DAMPERS, MANUAL BALANCING TYPE

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards, and as indicated. See Division 23 - Instrumentation and Control for HVAC for air control damper specifications for automatic dampers. Provide corrosion resistant end bearings. On multiple blade dampers, provide oil-impregnated nylon, molded synthetic or sintered bronze bearings. Provide hexagonal or square steel axles positively locked into the damper blade. Provide locking, indicating quadrant regulators on single and multi-blade dampers. Where rod lengths exceed 30 inches provide regulator at both ends. Mark final position(s) of all damper handles with magic markers on side of duct/insulation after TAB is complete. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
- B. Single Blade: Fabricate single blade rectangular dampers for duct sizes up to 12 inches in height and 36 inches in width. Duct sizes over 12 inches in height and over 36 inches in width shall require multiple blades arranged in opposed blade style. Fabricate single blade round dampers for duct sizes up to 16-inches diameter. Single blade damper frames shall be constructed of 22-gauge steel and blades shall be 20-gauge steel, minimum.
- C. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12 x 72 inches. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware. Frame shall be 16-gauge galvanized steel structural hat channel. Blades shall be single skin 16-gauge galvanized steel.
- D. Performance: Dampers shall be designed for 1500 fpm maximum system velocity; maximum 65 cfm/ft² leakage at 1 inch w.g. pressure per AMCA Standard 500. Wide open pressure drop shall not exceed 0.1" w.g. at scheduled size and airflow.
- E. Manual volume control dampers shall be manufactured by Ruskin, Pottorff, Nailor, Louvers and Damper, Dowco, Prefco, United Air, Arrow, Vent Products, Air Control Products, Phillips-Aire, National Controlled Air, Greenheck, Air Balance or Cesco. Single blade dampers shall be Ruskin Model MD25 (rectangular) or MDRS25 (round), Greenheck Model MBD-10 (rectangular) or Model MBDR-50 (round) or equal by the other above listed manufacturers. Multi-blade damper shall be Ruskin Model MD35 or equal by the above listed manufacturers.

2.3 90 DEGREE STRAIGHT SADDLE TAP

- A. Round take-offs from low pressure round ducts shall be made with 90° side take-off fitting constructed of galvanized G90 steel. Fittings shall have 1-inch wide turned out mounting flange with adhesive coated gasket and shall be contoured to fit duct. Fitting shall have a balancing damper with operator handle. Damper shall be factory installed with locking quadrant operator handle. On insulated ducts, provide optional extended neck for damper handle to allow handle to clear specified insulation thickness. Fitting that have air scoops, tab collars, or "spin-in" design are not acceptable.
- B. Manufacturers: 90° pressed saddle tap with damper by Sheet Metal Connectors, Inc., Crown Model #314DSO Take-Off Collar or Southwork Model ATRPWD, Royal Model 173 with Duro Dyne #7206 Sandoff, or equal by Buckley.

2.4 FIRE DAMPERS

- A. Fire dampers shall be tested and classified by Underwriters' Laboratories for 1-1/2 or 3-hour rating (as appropriate based on fire rating of wall or floor as shown on architectural drawings) and shall bear the UL 555 label and meet the requirements of UL Standard 555, 6th Edition, issued June 1, 1999. Fire dampers shall be static rated, unless shown otherwise on the drawings. Dampers shall be the folding blade steel curtain type and shall be fabricated from minimum 24-gauge roll-formed galvanized steel. Each damper shall incorporate a UL listed fusible link rated at 165 degrees F and dampers intended for horizontal installations (vertical airflow) shall include stainless steel closure spring. Dampers shall be type "B" unless otherwise indicated except that type "A" dampers shall be used when connecting directly to wall register or grille, unless otherwise indicated. Each type "B" damper shall be provided with a factory fabricated steel wall sleeve. Wall sleeve length and gauge shall be determined by the contractor, based on the specific conditions of the penetration to be installed in accordance with the fire damper manufacturer's U.L. installation instructions. These specific conditions include, but are not limited to; size of connecting duct, type of duct to sleeve connection, wall or floor thickness, etc. Fire dampers shall be attached to sleeve in accordance with manufacturer's U.L. installation instructions. Clearances required between fire damper sleeves and wall/floor openings shall be in accordance with manufacturer's U.L. installation instructions. Each fire damper shall be furnished with factory provided retaining angles. Angle size and gauge shall be determined by the contractor, based on the specific conditions of the penetration, to be installed in accordance with the fire damper manufacturer's U.L. installation instructions. These specific conditions include but are not limited to; duct size, wall or floor construction, etc. Retaining angles shall be attached to the sleeve in accordance with the manufacturer's U.L. installation instructions. Provide single side retaining angles unless conditions require retaining angles on both sides of the partition. Where round or oval ducts penetrate a wall or floor and require a fire damper, provide a rectangular fire damper with a factory furnished rectangular to round or oval transition on each side of the wall or floor connected to the sleeve. Transition shall be minimum 1" offset type. Transition shall be provided with blade stack out of air stream, and with transition positioned 1" from bottom sleeve. Rectangular damper size shall be appropriate to fit inside sleeve and allow blade stack out of air stream.
- B. Differential Pressure Rating and Velocity Rating: Dampers shall have a minimum UL 555 differential pressure rating of 4" w.g. When project conditions exist that have higher differential pressure conditions, provide dampers with 6" w.g. or 8" w.g. as appropriate. Dampers shall have a minimum UL 555 velocity rating of 2000 fpm. When project conditions exist that have higher velocities than 2000 fpm, provide dampers with minimum UL 555 velocity ratings of 3000 fpm or 4000 fpm as appropriate.
- C. Manufacturers: Fire dampers shall be manufactured by Prefco, Pottorff, Nailor-Hart, National Controlled Air, Phillips, Louvers and Dampers, Safe Air, Ruskin, Carnes, Air Balance, Greenheck, Cesco or United Air.

2.5 TURNING VANES

- A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.
- B. Manufactured Turning Vanes: Fabricate single or double-vane, curved blades of galvanized sheet steel set 2" or 3-1/4" o.c. and set into vane rail runners suitable for duct mounting.
1. Turning Vanes shall be manufactured by Ductmate Industries, Inc., Areo/Dyne Company, Duro Dyne Corp., METALAIRE, Inc., or Ward Industries, Inc.

2.6 DUCT ACCESS DOORS

- A. Doors shall be factory fabricated, meeting requirements of SMACNA HVAC Duct Construction Standards. Contractor has the option of using either hinged/cam type doors or sandwich type doors. Insulated ducts shall be provided with factory insulated duct access doors. Access doors with sheet metal screw fasteners are not acceptable.

- B. Provide rigid and close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. Provide 1/2" wide door to frame gasket and frame to duct gasket. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover. Provide seals from frame to door and frame to duct.
- C. Hinged/camp type access doors smaller than 12-inches square may be secured with sash locks only (not continuous hinge).
- D. Provide continuous piano type hinge and two sash locks for sizes up to 18 x 18 inches, and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide double wall door construction. Access door and frame shall be fabricated from 24-gauge galvanized steel.
- E. Hinged/Cam Type Duct Access Doors for Low Pressure Round Ducts: Access doors shall be factory fabricated, with minimum 16-gauge galvanized steel door and continuous steel piano hinge. Provide plate steel strike and catch locks. Access door shall have factory installed 1" wide x 3/8" thick polyethylene gasket. Contractor shall field cut hole one inch smaller than door width and height.
- F. Sandwich Type Access Doors: Doors shall consist of layers of stamped steel. The inside panel, installed inside duct, shall consist of metal plate with closed cell full perimeter neoprene gasket, bonded to the inside door. Service temperature of gasket shall be -20°F to 200°F. Outer door shall consist of steel, with polypropylene hand knobs with threaded metal inserts, such that door is removable without tools. Springs shall be conical zinc plated, and bolts shall be zinc plated sealed to the inner door. A self-adhesive template shall be provided for the exact size of duct opening required. Doors shall be tested to 20-inch positive and 10-inch negative static pressure with no leakage noted. Doors shall be factory insulated with two layers of interior metal with insulation between the two when duct is specified to be insulated.
- G. Manufacturer:
 - 1. Hinged/cam type doors shall be Model #HAD-10 by Venco or DT by Elmdor or equal by Ductmate, Phillips-Aire, Air Balance, Kees, Pottorff, Ruskin, Nailor, Greenheck, Cesco, National Controlled Air or Safe Air.
 - 2. Sandwich type doors shall be Model D (rectangular) or DR (round) as manufactured by Ductmate or equal by Phillips-Aire, Air Balance, Kees, Pottorff, Ruskin, Nailor, Greenheck, Cesco, National Controlled Air or Safe Air.

2.7 FLEXIBLE CONNECTORS

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards, and as indicated. Flexible connections must be in compliance with appendix "D" NFPA 90A requirements.
- B. Manufacturers:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Corp.
 - 3. Ventfabrics, Inc.
 - 4. Ward Industries, Inc.
- C. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying 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. Select metal compatible with 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.

2.8 FLEXIBLE LOW PRESSURE ROUND DUCTWORK

- A. General: Insulated low pressure flexible duct shall be a factory fabricated assembly consisting of a non-perforated polyester film inner liner, zinc-coated spring steel helix, wrapped with fiberglass insulation and a bi-directional reinforced metalized polyester film outer vapor barrier wrap. The insulation shall have a minimum R of 6.0 except that a R value of 8.0 shall be provided for all flex ducts located outside of the building insulation boundary (for example in attics, crawl spaces, etc.). R value of 8.0 shall also be provided for any flex ducts specifically identified on the drawings with R-8 insulation requirements. Insulation shall have a maximum conductance (C) of 0.238 at 75°F. The insulations thermal performance shall be measured in accordance with the ADC Flexible Duct Performance and Installation Standards (1991) using ASTM C518. The composite assembly, including insulation and vapor barrier, shall meet the Class 1 requirements of NFPA 90-A and be labeled by Underwriters' Laboratories, Inc., with a flame spread rating of 25 or less and a smoke developed rating of 50 or less. Low pressure flexible ductwork shall be manufactured by Certain Teed, Thermaflex, Genflex, Metraflex, Atco or Flexmaster. Flexible duct with R value of 8.0 shall be model G-KM-R-8 as manufactured by Certain Teed, Model UPC-031 as manufactured by Atco, or equal by Thermaflex, Genflex, Metraflex or Flexmaster.

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.

2.10 BELLMOUTH TAKE-OFF COLLARS

- A. General: All take-offs for round ducts from trunk ducts which are minimum 4" deeper than round duct take-off size shall be fabricated in the shape of a "bellmouth" entrance of 26 gauge galvanized G90 steel with 28-gauge body and 26-gauge balancing damper with operator handle. Damper shall be factory installed with quadrant operator handle, retractable spring-loaded threaded bearings and wing lock nut. On insulated ducts, provide optional extended neck for damper handle to allow handle to clear specified insulation thickness. Bellmouth shall include neoprene gasket and a minimum of 5 pre-drilled mounting holes. "Spin-In" fittings with air scoops and dampers are unacceptable unless specifically called out on drawings for ducts 5" and smaller.
- B. Manufacturers: "Bellmouth" fitting shall be model number BM-D (uninsulated ducts) or model number BMD-ISG (insulated ducts) as manufactured by Buckley Air Products or model number 3210-BD (uninsulated ducts) or model number 3210-BDS (insulated ducts) as manufactured by Crown or Model BMD (uninsulated ducts) or Model BMD-E (insulated ducts) as manufactured by United Enertech or Model ATDBM by Southwork. Mini "bellmouth" fittings shall be Model M-BMD by Buckley or Model BTOBD by Stamped Fittings, Inc. No substitutions are permitted.

2.11 45° TAKE-OFF COLLARS

- A. General: Take-offs for round ducts from trunk ducts which are less than 4" deeper than the round duct take-off size shall be made with a 45° side take-off fitting constructed of 26-gauge galvanized steel with G90 lock-forming quality. Fittings shall have 1" wide mounting flange with pre-drilled mounting holes and an adhesive coated gasket to minimize leakage. Fitting shall have a balancing damper with operator handle. A locking quadrant shall be provided for damper rod. On insulated ducts, provide optional extended neck for damper handle to allow handle to clear specified insulation thickness.

- B. Manufacturers: Crown 3300D (uninsulated ducts) or 3300-DS (insulated ducts), Flexmaster STO-D (uninsulated ducts) STO-D-B02 (insulated ducts), Sheet Metal Connectors, Inc. model HET (uninsulated) or model HET with 1.5-inch standoff (insulated), Buckley Model 3300D (uninsulated ducts) or Model 3300D-ISG (insulated ducts), Jer-Air Model AT-502, or Model AT63WD by Southwork.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and in accordance with manufacturer's instructions.
- B. Provide balancing dampers at points on low pressure systems where branches are taken from larger ducts and as required for air balancing. Use splitter dampers where indicated.
- C. Provide air turning devices in all elbows in supply, return, outdoor air and exhaust ducts.
- D. Some branch duct take-offs to ceiling diffusers may be indicated on the plans to be made with square or rectangular duct take-offs out the bottom of the supply ducts due to space restrictions. At these take-offs, provide equalizing grids behind the diffusers to insure uniform airflow behind the diffuser.
- E. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, use stainless-steel accessories in stainless-steel ducts, and use aluminum accessories in aluminum ducts.
- F. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- G. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.
- H. Fire Dampers: Fire dampers shall be installed in accordance with the recommendations of SMACNA Fire Damper and Heat Stop Guide for Air Handling Systems and NFPA 90A and International Mechanical Code. Installation shall also conform to the UL installation instructions furnished by the manufacturer. Provide submittal data on dampers and installation instructions. Provide fire dampers where ducts penetrate fire rated walls. See architectural drawings for location and hour rating of all fire rated walls. Provide fire dampers where ducts penetrate floors.
- I. Duct Access Doors:
 - 1. Access doors shall be sized by contractor to provide appropriate access for service. Access door material and pressure rating shall match ductwork. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories as follows:
 - a. Adjacent to fire dampers, providing access to reset or reinstall fusible links.
 - b. Any other systems requiring access inside duct.
- J. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment unless specifically noted otherwise. Flexible connectors are not required on equipment that has internal flexible connectors.
- K. Install duct test holes where required for testing and balancing purposes.
- L. Branch take-offs of sheet metal ductwork from trunk ducts shall be made with 45-degree branch entries or splitter dampers and elbows with turning vanes as indicated. See Division 23 - Metal Ducts. Air scoops, deflectors, extractors and other devices are prohibited unless noted otherwise.

- M. Bellmouth and 45° Branch Entry Fitting Installation: Gasketed Bellmouth and 45° branch entry fitting take-off collars shall be screwed into the side of sheet metal duct with a minimum of 5 screws. Provide duct sealant around perimeter of take off connection to trunk duct; integral gasketing is not a substitute for duct sealant. Where the supply duct is not 4" deeper than the diameter of the take-off collar, the protruding edges of the bellmouth shall be bent over the top and bottom of the duct with a vice-grip hand brake in accordance with the manufacturer's recommendations. Inner core of flexible duct shall be connected to the bellmouth and 45° branch entry fitting take-off collar with a stainless-steel band and outer vapor barrier with minimum 1/2" wide nylon zip strip. When associated ducts are insulated, insulate entire bellmouth and 45° branch entry fitting (except operator handle) with 2" thick ductwrap. Thickness of ductwrap shall match insulation thickness for the connecting ducts as specified in Section 230716 "HVAC Equipment Insulation."

3.2 ADJUSTING

- A. Adjust duct accessories for proper settings.
- B. Adjust fire dampers for proper action.
- C. Final positioning of manual-volume dampers is specified in Division 23 Division 23 - Testing, Adjusting, and Balancing for HVAC.

3.3 CONNECTION OF FLEX DUCTS

- A. Secure all flexible ducts with 1/2" wide stainless-steel draw bands with worm gear assembly and hardened tightening screw, or secure with heavy-duty polymer straps by Panduit, Hellerman or Tyton. Polymer straps shall be covered by UL181 tape. After metal band or heavy-duty polymer strap is installed on the inner duct, the exterior vapor barrier shall then be secured with nylon "zip-strip" bands. Flexible duct support width shall be minimum 4" wide and shall extend at least 1/2 of the circumference of the flexible duct. Flexible ducts shall be installed in a fully extended condition free of sags and kinks, using only the minimum length required to make the connection. Ends of flex duct shall be secured with metal draw bands (nylon "zip-strips" are not acceptable). Installation, including attachment and support, shall be in accordance with the manufacturer's written instructions and with the latest edition of SMACNA Flexible Duct Installation Standards. Flexible duct runs shall be a maximum of 8', unless a longer length is specifically shown on the drawings.

END OF SECTION 233300

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SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Ceiling mounted ventilators.

1.2 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on 1,000-foot site elevations.
- B. Operating Limits: Classify according to AMCA 99.

1.3 SUBMITTALS

- A. Product data shall be submitted under the provisions of Division 23 - Common Requirements for HVAC Equipment. Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Fan speed controllers.
 - 7. Vibration isolators, if furnished by fan manufacturer.
- B. Operation and Maintenance Data: For power ventilators, submit operation and maintenance data under the provisions of Division 23 - Closeout Document Requirements for HVAC.

1.4 QUALITY ASSURANCE

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

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.6 COORDINATION

- A. Coordinate size and location of structural-steel support members.

PART 2 - PRODUCTS

2.1 CEILING MOUNTED VENTILATORS

- A. Cabinet-mounted centrifugal type complete with ½" acoustically lined steel cabinet, direct drive permanently lubricated motor and a single centrifugal blower and housing. Discharge arrangement shall be horizontal or vertical as indicated with a gravity operated backdraft damper mounted in the discharge opening. The motor shall have a plug-in cord set for easy

disconnect and removal for service. Provide in line adapter as required on drawings. Provide removable molded polymer or painted steel or aluminum grille. Where scheduled, provide unit mounted or field installed motion detector for fan start/stop control.

2.2 ROOF CURBS

- A. Refer to Division 23 - Hangers and Supports for HVAC Piping and Equipment.

2.3 TESTS

- A. Wheels shall be statically balanced before assembly and the assembled fans shall be dynamically balanced at the speeds at which they are scheduled to operate.

2.4 ACCESSORIES

- A. Provide the accessories noted or shown in the schedule. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification. Speed controllers shall be solid state type designed to reduce speed from 100% to 50%. Backdraft dampers shall be parallel blade type, either gravity or motorized as scheduled. Motion detectors shall be integral, or field mounted as scheduled, and shall be passive infrared type to automatically turn on the fan when a change in motion is sensed. Motion detectors shall have a viewing area of 180 degrees, and shall have an adjustable time delay shutoff of 30 seconds to 30 minutes.

2.5 FINISH

- A. All non-corrosion resistant ferrous metal fan parts shall be cleaned and painted with a heavy coat for primer finish and two coats of enamel paint.

2.6 SOURCE QUALITY CONTROL

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

2.7 MANUFACTURERS

- A. Fan capacities shall be as scheduled on the drawings and shall be manufactured by Twin City, Cook, Greenheck, Penn or Acme.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions and International Mechanical Code.
- B. Install power ventilators level and plumb.
- C. Install units with clearances for service and maintenance.
- D. Label units according to requirements specified in Division 23 - Identification for HVAC Piping and Equipment.
- E. Speed controllers for fans shall be field mounted and wired by Division 26. Exact location of speed controllers for fans shall be as shown on the mechanical drawings. If no specific location is shown on the mechanical drawings, the location shall be determined by the contractor, with the following requirements to be adhered to:
 - 1. Unless specifically shown otherwise, speed controllers shall not be mounted on wall below the ceiling and accessible by building occupants. Speed controllers are intended to be adjusted by the Test and Balance agent and left in the same position to maintain specified airflow rates.

END OF SECTION 233423

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

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

1.2 SUBMITTALS

- A. Product data shall be submitted under the provisions of Division 23 - Common Requirements for HVAC Equipment. For each product indicated, include the following:
1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static pressure drop, and noise ratings.
 2. Diffuser, Register, and Grille Schedule: Indicate grille designation (i.e., tag), model number, size, and accessories furnished. Do not indicate quantity in the submittal.

1.3 SOURCE QUALITY CONTROL

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The grilles, registers, and diffusers shall be manufactured by Carnes, Krueger, E. H. Price, Air Devices, Nailor-Hart, Kees, Air Louvers, Anemostat, Tuttle and Bailey, Titus/J & J or Metal*Aire.

2.2 GRILLES AND REGISTERS

- A. Side Wall Registers: Side wall registers and grilles shall be steel, stainless steel or aluminum construction, as indicated, double deflection type for supply and single deflection type for return, with indicated blade spacing and the front set of blades horizontal. Each blade on supply grilles/registers shall be individually, manually adjustable to provide for varying air flow patterns. Blades shall be airfoil shaped where indicated on the schedule on the drawings. Return grilles/registers shall have fixed blade setting. Supply registers and return registers shall match. Finishes shall be as indicated on the schedule. Provide a gasket between the flange and wall. Opposed blade volume dampers shall be aluminum or steel construction, operable through the front face of the register. Screw holes shall be countersunk with countersunk steel screws. Flange of grille shall be approximately 1-1/4 inches wide to cover duct and wall opening.
- B. Egg Crate Grilles and Registers: All aluminum extruded grille with aluminum opposed blade damper, where scheduled, 1" x 1" x 1" egg crate grid and baked enamel finish. Where specified, transfer grilles for air movement from room to above ceiling shall be 1/2" x 1/2" x 1/2" egg crate grid and baked enamel finish with 45-degree angled blades to prevent line of sight viewing above ceiling.

2.3 CEILING DIFFUSER OUTLETS

- A. Louver Face Diffusers: Louver face ceiling diffusers shall be of extruded aluminum or steel construction as scheduled, composed of a minimum of three square concentric cones. Finishes shall be as indicated on the schedule. Necks shall be square or round as indicated. Where round flex ducts are shown connected to square neck diffusers, provide insulated round to square neck sheet metal adapters. Where round flex ducts are shown connecting to a different diameter round neck size, provide round to round adapter. Diffusers shall have lay-in frame (outer cone $\pm$ 23-3/4" x 23-3/4") or flange frame as scheduled. Cone shall be adjustable where scheduled, allowing adjustment from horizontal to vertical. Back pan shall be factory insulated.

- B. Thermally Operated Diffusers - Thermafuser Type: Designed to vary the supply air volume between minimum and maximum flow rates within 1-1/2 degrees F of temperature setting. The temperature heating and cooling settings shall be field adjustable within an 8-degree F. range. Individual, thermally powered elements (2), shall vary the supply air volume (VAV) to maintain the room heating and cooling setpoints. A changeover element which will reverse the action from VAV cooling to VAV heating shall be included to change-over based on supply air temperature. Diffuser shall be manufactured by Acutherm or Rickard.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. See architectural reflected ceiling plan for location of ceiling grid. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.
- D. Provide round to square adapters at all round duct connections to square neck diffusers. For supply diffusers, adapter shall be insulated.
- E. Install items in accordance with manufacturer's instructions.

3.3 ADJUSTING

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

END OF SECTION 233713

SECTION 234100 - PARTICULATE AIR FILTRATION AND BI-POLAR IONIZATION UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications. This section also includes bi-polar ionization units designed to kill or inactivate mold, virus, bacteria, and to neutralize odors and create particle agglomeration for improved filter effectiveness.

1.2 SUBMITTALS

- A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; for each model indicated. Submit under the provisions of Division 23 - Common Requirements for HVAC Equipment, for the following:
 - 1. Medium Efficiency (MERV 8) Filters
 - 2. Bi-polar ionization units
- B. Operation and Maintenance Data: For each type of filter and rack, submit operation and maintenance data under the provisions of Division 23 - Closeout Document Requirements for HVAC.
- C. Submit product data for bi-polar ionization units published by the manufacturer, including dimensions, wiring diagrams, installation and operation manuals, material specifications, and data to confirm units comply with all aspects of specifications.

1.3 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Division 1 - Product Requirements.
- B. Comply with ASHRAE 52.1 and ASHRAE 52.2 as specified herein for method of testing and rating air-filter units.
- C. Comply with NFPA 90A and NFPA 90B.

1.4 EXTRA MATERIALS

- A. Furnish extra materials under the provisions of Division 23 - Closeout Document Requirements for HVAC.

PART 2 - PRODUCTS

2.1 MEDIUM EFFICIENCY MERV 8 30% FILTERS

- A. Filters shall be 1", 2" or 4" deep medium efficiency, pleated, disposable type, as noted in the specification for each product, or as noted on the drawings. Each filter shall consist of synthetic fiber media bonded to an electro-finish wire which itself is bonded to a heavy-duty fiberboard frame. The filter shall be listed by Underwriter's Laboratories as U.L. Class 2. The filter media shall be 100% synthetic continuous fiber. Filters shall have a minimum efficiency reporting value of MERV 8 when evaluated under the guidelines of ASHRAE 52.2-1999. When tested in accordance with the ASHRAE 52.1-92 standard, the media shall have an average dust spot efficiency of 25-30%. Efficiency on 1.0-micron size particles shall not be less than 40% using the laser particle counter. The filter media wire support shall be 24 ga. 1" x 1" electro-finish wire with a 96% open area. The welded wire backer shall be bonded to the media to prevent media movement. The pleated wire support shall allow total use of the filter media. The filter frame shall be heavy duty fiberboard, die cut for dimensional accuracy. The frame webbing shall be bonded to the filter pack, upstream and downstream, to ensure even pleat spacing. All ends of the filter shall be bonded to the inside of the frame to prevent air bypass. The filter shall be capable of withstanding 2.0" w.g. without failure of the media pack. The 2" deep filter shall have not less than 15 pleats per linear foot with an average effective media area of 4.6 square

feet per square foot of filter face area. The 4" deep filter shall have not less than 11 pleats per linear foot with an average effective media area of 7.0 square feet per square foot of filter face area. Media thickness shall be minimum 0.15 inches. Dust holding capacity when evaluated using ASHRAE test dust shall be at least 170 grams. The initial resistance at 500 fpm shall not exceed 0.30" w.g. Filter shall be Camfil-Farr model Aeropleat IV + or equal by approved manufacturer listed herein.

- B. Manufacturers: Filters shall be manufactured by American Air Filter, Camfil-Farr, Airguard, Flanders, Continental, Purolator or EcoAir.

2.2 NEEDLEPOINT TYPE BI-POLAR IONIZATION UNITS (COMPACT TYPE)

- A. Needlepoint type compact type ionizer designed to produce positive and negative ions to kill mold, bacteria, viruses, and neutralize odors. Tube type bi-polar ionization units shall not be allowed. Technologies that do not address gas disassociation such as UV lights, powered particulate filters and/or polarized media filters shall not be considered. Uni-polar ion generators shall not be acceptable. "Plasma" particulate filters shall not be acceptable. The bipolar ionization system shall operate in such a manner that equal amounts of positive and negative ions are produced. Single pole ion devices shall not be acceptable. Bipolar ionization tubes manufactured of glass and steel mesh shall not be acceptable due to replacement requirements, maintenance, performance output reduction over time and corrosion. Ionization output from each electrode shall be a minimum of 160 million positive and negative ions. Manufacturer shall demonstrate that no voltage potential exists due to exposed electrical components in the duct system or plenum. Ion generators shall be installed in a convenient location for visual inspection, removal, and servicing. All plasma ion generators shall include internal short circuit protection, overload protection, and automatic fault reset. Needlepoint type units shall be designed for mounting within HVAC equipment, as scheduled on the drawings. Interior mounted units shall include integral mounting tabs or magnet. Housing materials of unit shall be ABS plastic or 18-gauge powder coated steel, with carbon or stainless-steel ionization needles. Unit shall accept 24 VAC. Units shall have LED indicating operating status. Units shall be powered from the 24 VAC transformer integral with HVAC equipment. Power consumption shall be maximum 18 watts up to 2400 cfm during operating cycle. Unit shall not require airflow to operate properly, but units shall be wired to only operate when airflow is present. Units shall be suitable for -20° to 160°F temperature range, and 0-99% non-condensing humidity range. Unit shall be UL 867 approved. Unit shall be equipped with dry contact output capable of connection to BAS for monitoring a fault condition. Monitoring of the fault condition dry contact is not included in the scope of this project. Contact rating shall be 5 amp at 120V maximum. Unit shall be UL-2998 certified for no ozone. Bi-polar ionization unit shall be manufactured by Plasma Air International, Aerisa, Phenomenal Air, Global Plasma Solutions or Bioclimatic.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install filter and filter frames according to manufacturer's written instructions.
- B. Position each filter unit with clearance for normal service and maintenance. Provide adequate clearance for filter access door opening.
- C. Install filters in position to prevent passage of unfiltered air. Provide filter blanks as required to prevent bypass of unfiltered air between filters.
- D. All filter racks and filter housings, whether integral with HVAC equipment or manufactured by filter manufacturer, shall be provided with a neoprene gasket seal on filters with MERV 8 or greater rating. Contractor shall field install gasketing if not provided by HVAC manufacturer. Urethane gasket shall not be allowed.

- E. Contractor shall refer to the drawings and equipment specification sections for product type of filter for each piece of equipment. If no product type is indicated, contractor shall provide filter media efficiency and standard thickness as required by the manufacturer, and filter shall be, as a minimum, medium efficiency 20% filters.
- F. Bi-Polar Ionization Installation and Start-Up: Bi-polar units shall be installed inside equipment as shown on the drawings. Install in accordance with bi-polar ionization unit manufacturer's installation instructions. For units mounted inside equipment, contractor shall not mount units in a location that will interfere with the supply fan's performance. Contractor shall verify operation for each bi-polar ionization unit. For compact type, contractor shall verify LED is illuminated after supply fan is energized, and verify power is cut off when fan is de-energized. Provide a start-up form showing all the above specified requirements have been performed. Provide form signed by Owner as shown below:

BI-POLAR IONIZATION UNIT START UP FORM		
Tag	Equipment Served	Unit is Powered/LED Illuminated When Fan Is Energized/De-energized
Equipment listed below is an example		
BPIU-1	RTAC-1	Yes
BPIU-2	RTAC-2	Yes
Owner Representative's Signature:		
Date Verified:		

- G. Air Filters: During construction, filter shall be pleated type as specified. Immediately prior to occupancy by Owner, Contractor shall remove pleated filters and furnish and install new clean pleated filters at all equipment.

END OF SECTION 234100

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SECTION 238119 - SELF-CONTAINED AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes packaged air-conditioning units (e.g., rooftop air conditioning units (RTAC)) with refrigerant compressors and controls, intended for outdoor installations, with integral air-cooled condensers.

1.2 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, color samples where specified, and accessories for each type of product indicated. Provide data in submittals that each unit is run tested as described herein. Product data shall be submitted under the provisions of Division 23 - Common Requirements for HVAC Equipment.
- B. Operation and Maintenance Data: For self-contained air-conditioning units, submit operation and maintenance data under provisions of Division 23 - Closeout Document Requirements for HVAC.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- C. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- D. Run Testing: Each unit shall be 100% run tested at the factory. Each RTAC unit shall be run tested for cooling. Each RTAC unit shall be run tested for heating. Refrigerant suction and discharge pressures shall be checked to insure proper performance. All safety devices shall be checked. Each electrical component shall have the amperage and voltage checked to insure acceptability.

1.4 COORDINATION

- A. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations specified in Division 23 - Hangers and Supports for HVAC Piping and Equipment.
- B. Verify that roof is ready to receive work and opening dimensions are as indicated on shop drawings or illustrated by the manufacturer. Verify additional structural framing is installed between building structural members to support entire perimeter of roof curb.
- C. Verify unit is provided with metal engraved nameplate indicating unit model and serial number and all technical data. Obtain and attach such nameplate from unit manufacturer if unit is not so equipped. Verify that proper gas and power supply matching unit nameplate is available.

1.5 WARRANTY

- A. See Division 23 - Closeout Document Requirements for HVAC for warranty information.

1.6 EXTRA MATERIALS

- A. See Division 23 - Closeout Document Requirements for HVAC for the supply and transfer of extra materials to the Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Unit shall be manufactured by Trane, Carrier, Daikin or Aeon.

2.2 MANUFACTURED UNITS

- A. Provide roof-mounted units having gas heating or reverse cycle heat pump heating with auxiliary electric heating coil (as scheduled), and electric refrigeration. Unit shall be self-contained, packaged, factory assembled and pre-wired, consisting of cabinet and frame, supply fan, outdoor air damper (as scheduled), dehumidification circuit (as scheduled), heat exchanger and burner controls for gas fired units, air filters, refrigerant cooling coil and compressor, condenser coil, condenser fan and automatic temperature controls. Unit shall be designed for single point electric power connection. Unit shall be rated and certified in accordance with ARI-210/240/360 (for cooling performance) and ARI-270 (for sound) and bear the ARI seal. Unit shall be UL-465 designed and certified to ANSI Z21.47 and NFPA 90A.

2.3 CASING

- A. Cabinet: Galvanized steel with baked enamel finish, and hinged access panels with quick 1/4 turn fasteners. Unit's surface shall be tested 500 hours in a salt spray test in compliance with ASTM B117. Structural members shall be minimum 18 gauge (1.20 mm), with access doors or removable panels of minimum 20 gauge. Top cover shall be one piece or where seams exist, shall be double hemmed and gasket sealed to prevent water leakage. Hinged access panels shall provide access to filters, heating section, fan section, evaporator coil and units controls. Down flow units shall have a raised 1-1/8" (minimum) high lip around supply and return openings for water integrity. Roof cabinet shall be sloped to ensure water runoff.
- B. Insulation: Minimum 1/2 inch thick neoprene coated glass fiber on surfaces where conditioned air is handled and foil faced in the furnace compartment. Protect edges from erosion.

2.4 SUPPLY FAN

- A. Forward curved centrifugal type, resiliently mounted with adjustable variable pitch motor pulley or multi-speed direct drive. Motor shall be permanently lubricated, thermally protected and vibration isolated from unit. Motor shall be 1750 rpm maximum and shall meet EPA requirements for motor efficiency. See also Division 23 - Common Requirements for HVAC Equipment for motor efficiency. Fan shall be statically and dynamically balanced. Evaporator fan shaft bearings shall have average life of 200,000 hours. Fan shafts shall be solid hot roll steel.
- B. Fans shall be two-speed or staged as required to meet current Department of Energy requirements. Where manufacturers utilize variable frequency drives for controlling fan speed or fan staging, manufacturer shall furnish an operator interface to allow changing operating parameters for the VFD(s) and check fault codes. Operator interface may be permanent type inherent in the VFD or a remote keypad kit. Remote keypad kit shall consist of a handheld keypad, with LCD display, and CAT 5 data cable. Manufacturer may furnish only one remote keypad kit when that kit will be compatible with all rooftop air conditioners specified for the building. Provide appropriate number of kits to allow Owner to interface with all rooftop air conditioners provided on this project.

2.5 AIR FILTERS

- A. Filter frame and filter media shall be one inch thick for units 5 tons and less, and two inches thick for units above 5 tons.
- B. Filter shall be pleated type.

2.6 BURNER (FOR GAS FIRED UNITS ONLY)

- A. Gas Burner: Aluminized steel or stainless steel forced or induced draft type burner with adjustable combustion air supply, pressure regulator, two stage (high-low) gas valves (10 tons or larger), manual shut-off; direct intermittent spark ignition, flame sensing device, and automatic 100 percent shut-off pilot. Tubular heat exchanger with turbulators shall be minimum 20-gauge steel coated with nominal 1.2 mill aluminum-silicon alloy or 22-gauge stainless steel. Drum and tube heat exchanger shall be minimum 18-gauge steel.

- B. Gas Burner Safety Controls: Energize spark ignition, 90 second limit time for establishment of flame, sensor prevent opening of main gas valve until pilot flame is proven, stop gas flow on ignition failure, energize induced draft blower motor, and after air flow proven and slight delay, allow gas valve to open after sensor detects flame. On call for heat, combustion blower shall purge heat exchanger before ignition. Main gas valve will not be allowed to open unless combustion blower is operating.
- C. High Limit Control: Temperature sensor (limit switch) with fixed stop at maximum permissible setting, deenergize burner on excessive bonnet temperature and energize burner when temperature drops to lower safe value.
- D. Supply Fan Control: Temperature sensor sensing bonnet temperatures and independent of burner controls, or adjustable time delay relays with switch for continuous fan operation.
- E. Gas Source: Unit shall be designed for use with natural gas. A factory installed gas pressure regulator shall be furnished integral with this equipment to regulate the incoming gas pressure to the manifold pressure recommended by the manufacturer. This regulator shall be capable of, and the equipment shall function properly, over an inlet pressure range of 5" w.c. (minimum) to 14" w.c. (maximum).

2.7 EVAPORATOR COIL

- A. Provide copper tube, aluminum fin coil assembly with sloped corrosion resistant drain pan and threaded connection. Provide trap and discharge as shown on drawings. Coil shall be factory leak tested at 150 psig and pressure tested to 450 psig. Down flow units shall have a raised 1-1/8" (minimum) high lip around supply and return openings for water integrity.

2.8 COMPRESSOR

- A. Provide hermetic scroll compressors, 3500 RPM maximum, resiliently mounted with positive lubrication via an oil pump, crankcase heater, high and low pressure safety controls on the refrigerant circuit, motor overload protection, high and low voltage protection, over temperature protection, suction and discharge service valves and gage ports and filter drier. Compressors shall be vibration isolated.
- B. Five-minute timed off circuit shall delay compressor start and prevent short cycling.
- C. Provide step capacity control by cycling compressors or cycling unloading. Provide minimum of two steps of capacity control for units eight tons or larger, and where scheduled on drawings.

2.9 CONDENSER

- A. Provide copper tube, aluminum fin coil assembly or aluminum microchannel type coil assembly. Provide louvered coil guards to protect condenser coils from damage. Wire type shall not be acceptable. Copper tube type coils shall be factory leak tested at 150 psig and pressure tested at 600 psig.
- B. Provide direct drive propeller fans, permanently lubricated, resiliently mounted with fan guard, statically and dynamically balanced with motor overload protection, wired to operate with compressor. Fan shafts shall be solid hot rolled steel.

2.10 CONTROLS

- A. General: Unit shall be controlled as specified in Division 23 - Instrumentation and Control for HVAC. Unit shall be provided with internal controls for connection to a standard thermostat, or shall be provided with a field installed or factory installed DDC controller as specified in Division 23 - Instrumentation and Control for HVAC. Appropriate control points include, but are not limited to:
 - 1. Fan On/Off
 - 2. Heat (stages as specified)
 - 3. Cooling (stages as specified)
 - 4. Outdoor Air Damper Open/Close or Economizer enable/disable (as applicable)
 - 5. Reversing Valve (as applicable)

- 6. Humidity Sensor (as applicable)
- B. All units shall include a 24-volt transformer sized adequately for internal controls. All required contactors and starters shall be factory installed.
- C. Economizer Exhaust Fan Control: Where economizer exhaust fans are scheduled, provide factory installed controls to start economizer exhaust fan(s) to prevent building over-pressurization.

2.11 INTAKE AND RELIEF REQUIREMENTS

- A. Intake Hood and Damper Arrangement: Intake hoods shall be waterproof and have a bird screen. For units with economizers, outside and return air damper shall be powered to open or closed position. For units without economizers, outside air damper shall be manually adjustable fixed type, unless a motorized two position damper is scheduled on the drawings.

2.12 PERFORMANCE

- A. Scheduled performance is based on ARI 210 test conditions except as indicated otherwise. Sound Rating Numbers are in accordance with ARI 270.

2.13 DEHUMIDIFICATION PACKAGE

- A. Rooftop air conditioners shall be provided, where scheduled, with controls and components to allow the unit to run in a dehumidification mode. These controls include a controller that will accept a space humidistat input. When humidity rises above setpoint, factory installed controls will energize the compressor, and hot gas solenoid valve will open to reheat air after passing through the evaporator coil. Controls also include all relays and programming to allow proper operation of the dehumidification sequence. Components include DX heating coil in the reheat position, hot gas piping and solenoid valve, thermal expansion valve, crankcase heater, and froststat. This dehumidification package is designed to allow dehumidification at mild ambient temperature conditions where sensible load is low but latent load is high.

2.14 CONVENIENCE OUTLET

- A. Provide, where scheduled, factory installed powered convenience outlet. Outlet shall be GFCI (ground fault circuit interrupting) 120-volt 2 plug type. Outlet shall be powered type, meaning that the outlet is designed to be wired to a factory installed step down transformer.

2.15 ROOF CURBS

- A. Roof Curbs: All units shall be provided with a roof curb designed to mate with the unit and to provide for complete weathertight installation. Roof curb construction shall comply with the requirements of Division 23 section "Hangers and Supports for HVAC Piping and Equipment". If equipment manufacturer provides roof curbs, and if factory insulation of curb is not provided, manufacturer shall notify contractor so that insulation contractor can include field insulation of curbs in their submittal data.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb on factory furnished roof curb.
- B. Anchor units to structure.
- C. Install in accordance with manufacturer's instructions.
- D. Mount units on manufactured roof mounting curb (vibration isolating type where scheduled) providing gasketed watertight enclosure to protect ductwork and utility services (electrical power, and control routed inside curb), constructed in accordance with Division 23 - Hangers and Supports for HVAC Piping and Equipment. Install roof mounting curb with top level. See architectural drawings for roof slope. Refer to Division 23 - Instrumentation and Control for HVAC for complete control requirements. Gas piping connection shall be outside of casing, unless otherwise noted on the drawings.

- E. Seal all spaces between duct penetrations and roof slab with required thickness of closed cell neoprene flexible seal to minimize sound transmission to building.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install gas and condensate piping adjacent to unit to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service and Start Up: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Provide startup report from representative to document start-up has been performed in accordance with Division 23 - Closeout Document Requirements for HVAC.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Refer to Division 1 - Demonstration and Training.

END OF SECTION 238119

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SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes ductless split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting.

1.2 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics. Submit under the provisions of Division 23 - Common Requirements for HVAC Equipment.
- B. Field quality-control test reports.
- C. Operation and Maintenance Data: For ductless split-system air-conditioning units, submit in operation and maintenance data in accordance with Division 23 - Closeout Document Requirements for HVAC.

1.3 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Refer to Division 1 - Product Requirements.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

1.4 COORDINATION

- A. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations specified in Division 23 - Hangers and Supports for HVAC Piping and Equipment.

1.5 WARRANTY

- A. See Division 23 - Closeout Document Requirements for HVAC for warranty information.

PART 2 - PRODUCTS

2.1 DUCTLESS WALL MOUNTED FAN COIL UNIT

- A. General: Furnish and install slim silhouette, wall mounted fan coil unit of the ductless, split type designed for air-to-air heat pump application.
- B. Casing: Cabinet discharge and inlet grilles shall be high-impact polystyrene. Cabinet shall be fully insulated for thermal and acoustic performance.
- C. Fans: Fans shall be tangential direct-drive blower type with air intake at the upper front face of the unit and discharge at the bottom front. Automatic motor-driven horizontal air sweep shall be provided. Air sweep operation shall be user selectable. Vertical direction may be manually adjusted and horizontal air sweep may be manually set.
- D. Motor: Motors shall be open drip proof, permanently lubricated ball bearing with inherent overload protection. Fan motors shall be three-speed.

- E. Coil: Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins will be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a drain connection for hose attachment to remove condensate. Condensate pan shall have internal trap and auxiliary drip pan under coil header.
- F. Filters: Unit shall have filter track with factory-supplied cleanable filters.
- G. Controls: Controls shall consist of a microprocessor based control system which shall control space temperature, determine optimum fan speed, and run self diagnostics. The temperature control range shall be from 64°F to 84°F. The unit shall have the following functions as a minimum:
 - 1. An automatic restart after power failure at the same operating conditions as at failure.
 - 2. A timer function to provide a minimum 15-hour timer cycle for system Auto. Start/Stop.
 - 3. Temperature sensing controls shall sense return air temperature. Indoor air high discharge temperature shutdown shall be provided.
 - 4. Evaporator coil freeze protection.
 - 5. Wired remote control to enter set points and operating conditions (required accessory).
 - 6. Filter status indication after 250 hours of indoor fan operation.
 - 7. Test mode button to run self-diagnostics and aid in trouble shooting.
 - 8. Auto. Stop features shall have integral setback control.
 - 9. Automatic air sweep control provides on or off activation of air sweep louvers.
 - 10. Dehumidification mode provides increased latent removal capability by modulating fan speed and set point temperature.
 - 11. Fan only operation provides room air circulation when no cooling is required.
 - 12. Diagnostics provides continuous checks of unit operation and warn of possible malfunctions. Error messages shall be displayed at the unit and at the remote controller.
 - 13. A 35-foot indoor to outdoor thermistor connection cable shall be provided with the fan coil unit.
 - 14. Fan speed control shall be user-selectable; high, medium, low, or microprocessor automatic operation during all operating modes.
 - 15. A time delay shall prevent compressor restart in less than three minutes.
 - 16. Condenser high temperature protection shall be provided to detect excessive condenser discharge temperatures.
- H. Wired remote controller shall allow control of fan coils. The remote shall provide two-way communication capability of system inputs and outputs. The liquid crystal display (LCD) shall provide continuous status of the system operating conditions. The kit shall include 15 feet of interconnecting cable and can be located inside the conditioned space.
- I. Manufacturers: The ductless wall mounted fan coil units shall be manufactured by L.G., Mitsubishi, Samsung, Trane, Daikin or Carrier.

2.2 DUCTLESS HEAT PUMP

- A. General: Furnish and install factory assembled air cooled condensing units (heat pump) of the size and capacity as indicated on the drawings.
- B. Cabinet:
 - 1. Unit shall be constructed of galvanized steel, bonderized and coated with a baked enamel finish.
 - 2. Unit access panels shall be removable with minimal screws and shall provide full access to the compressor, fan, and control components.
 - 3. Compressor compartment shall be isolated and have an acoustic lining to ensure quiet operation.
- C. Fans:
 - 1. Condenser fans shall be direct-drive propeller type, shall discharge air horizontally, and shall blow air through the condenser coil.

2. Condenser fan motors shall be totally enclosed, single phase motors with class B insulation and permanently lubricated sleeve bearings. Motor shall be protected by internal thermal overload protection.
 3. Shaft shall have inherent corrosion resistance.
 4. Fan blades shall be corrosion resistant and shall be statically and dynamically balanced.
 5. Condenser fan openings shall be equipped with PVC coated protection grille over fan and coil.
- D. Compressor:
1. Compressor shall be DC rotary compressor with variable speed inverter drive technology.
 2. Compressor shall be equipped with oil system, operating oil charge, and motor. Internal overloads shall protect the compressor from over temperature and overcurrent. Scroll compressors shall also have high discharge gas temperature protection if required.
 3. Motor shall be NEMA rated class F, suitable for operation in a refrigerant atmosphere.
 4. Compressor assembly shall be installed on rubber vibration isolators and shall have internal spring isolation.
- E. Condenser Coil: Coil shall be constructed of aluminum fins mechanically bonded to internally enhanced, seamless copper tubes which are cleaned, dehydrated and sealed. Refrigerant flow from condenser shall be controlled by a linear expansion valve (LEV) metering device. LEV shall be controlled by a microprocessor controlled step controller.
- F. Controls and Safeties: Operating controls and safeties shall be factory selected, assembled and tested. The minimum control function shall include:
1. Controls:
 - a. Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
 - b. Automatic restart on power failure.
 - c. Three-pole contactors on three phase units.
 - d. Safety lockout if any condensing unit safety is open.
 - e. A time delay control sequence is also provided standard through the fan coil board on wall mounted and ceiling suspended fan coil units.
 - f. High and low pressure switches.
 - g. Automatic condenser fan motor protection.
 - h. Start capacitor and relay (single phase units without scroll compressors).
 2. Safeties:
 - a. High condensing temperature protection (when matched with wall mounted or ceiling suspended fan coils).
 - b. System diagnostics (when used with wall mounted or ceiling suspended fan coils).
 - c. Compressor motor current and temperature overload protection.
 - d. High pressure relief.
 - e. Condenser fan failure protection.
- G. Options: Listed is a description of possible options. See Schedule on plans for individual options specified with each unit.
1. Low Ambient Kit: Control shall regulate fan motor cycles in response to saturated condensing pressure of the unit. The control shall be capable of maintaining a condensing temperature of 100°F +/- 10°F with outdoor temperatures to -20°F. Installation of kit shall not require changing the condenser fan motor.
 2. Compressor Cycle Delay (when matched to in-ceiling cassette): Compressor shall be prevented from restarting for a minimum of five minutes after shutdown.
 3. Winter Start Control: Unit shall be equipped with winter start control, which shall permit start-up for cooling operation under low-load conditions and at low-ambient temperatures by bypassing the low-pressure switch for a three-minute delay period.
 4. Note: Winter start control shall be required when unit is equipped with low-ambient kit.

5. Crankcase Heater: Unit shall be equipped with a clamp-on compressor oil sump heater. Heater shall be used in all long-line applications.
- H. Manufacturers: The ductless condensing units (heat pumps) shall be manufactured by L.G., Mitsubishi, Samsung, Trane, Daikin or Carrier.

2.3 REFRIGERANT CIRCUIT

- A. Provide each unit with refrigerant circuit, factory supplied and internally piped.
- B. Provide the following for each refrigerant circuit:
 1. Piping and specialties in accordance with Division 23 - Refrigerant Piping.
 2. Provide reversing valve (for heat pump) and filter dryer (as required by manufacturer). Provide factory installed external liquid and suction line service valves with service gauge port for checking pressure.
 3. Provide linear expansion valve (LEV) refrigerant metering control as required for proper operation. LEV shall be controlled by a microprocessor controlled step motor.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install roof-mounting compressor-condenser components on equipment supports specified in Division 23 - Hangers and Supports for HVAC Piping and Equipment. Anchor units to supports.
- C. Install and connect refrigerant tubing to component's fittings. Install tubing to allow access to unit.

3.2 DFCU INSTALLATION

- A. Provide insulated condensate piping trap on DFCU(s) not specified with integral condensate pump.
- B. Install unit and associated piping, conduits, etc. so that all access panels are completely removable and unit can be easily serviced. Clearance shall be provided to allow for easy removal of unit filters.
- C. Make connection to thermostat and program with start/stop times and set points as directed by Owner.

3.3 DHP INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Coordinate installation of controls with Division 23 - Instrumentation and Control for HVAC.
- C. Install units level, anchored as specified in Division 23 - Hangers and Supports for HVAC Piping and Equipment.
- D. Provide connection to refrigeration piping system and evaporators.

3.4 MANUFACTURER'S AND CONTRACTOR'S FIELD SERVICES

- A. Supply initial charge of refrigerant and oil for each refrigerant circuit. Installing Contractor shall replace any refrigerant and oil lost during the first year of system operation.

END OF SECTION 238126

SECTION 238240 - ELECTRIC HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes heaters with integral fans and electric heating elements.

1.2 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories. Product data for each type of equipment shall be submitted under the provisions of Division 23 - Common Requirements for HVAC Equipment.
- B. Field quality-control test reports.
- C. Operation and Maintenance Data: For electric heaters, submit operation and maintenance data under provisions of Division 23 - Closeout Document Requirements for HVAC.

1.3 QUALITY ASSURANCE

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

1.4 WARRANTY

- A. See Division 23 - Closeout Document Requirements for HVAC for warranty information.

PART 2 - PRODUCTS

2.1 ELECTRIC WALL HEATERS

- A. General: Furnish and install surface or recessed mounted, heavy-duty architectural electric wall heaters as indicated on the drawings. Each unit shall be completely factory assembled consisting of a cabinet, electric heating element, fan and controls as specified below. All heaters shall be UL listed and meet the requirements of the National Electrical Code.
- B. Cabinet: The wall housing shall be fabricated from 20 gauge galvanized steel and the architecturally styled front grille fabricated from 16 gauge steel with closely spaced down flow discharge bars. Finish shall be baked enamel paint and the front grille shall be attached with partially concealed screws. All units shall be recessed mounted into concrete block wall which has been cut only to sufficient depth for insertion of the unit, unless indicated otherwise.
- C. Heating Element: Electric heating element shall be copper clad steel sheath type with aluminum fins. Fan motor shall be totally enclosed and permanently lubricated, with the statically and dynamically balanced aluminum propeller fan direct connected to the motor shaft.
- D. Controls: Operating and safety controls for each heater shall include thermostat, automatic reset thermal overload protector, contactors, fan delay switch to energize fan motor only after element is heated, thermal limit switch and double pole disconnect switch complying with NEC requirements. The built-in comfort thermostat shall have an adjustable range between 55 degrees and 85 degrees F with manually set "no heat" position. Thermostat shall be tamper-resistant, requiring the use of a long blade screwdriver to accomplish adjustment through the front grille.
- E. Manufacturers: Electric wall heaters shall be of the capacities indicated on the drawings and shall be manufactured by Q-Mark, Redd-i, Indeeco, Electromode, Erincraft, Chromalox, Markel, Raywall or Berko.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive wall and ceiling heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

- B. Examine roughing-in for electrical connections to verify actual locations before wall and ceiling heater installation. Verify proper power supply is available.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall boxes in finished wall assembly.
- B. Install heaters to comply with NFPA 90A.

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.

3.4 ADJUSTING

- A. Adjust initial temperature set points.

END OF SECTION 238240