SECTION 237330 – CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 01 specifications sections, apply to this section.

1.2 WORK INCLUDED

A. The work under this Section shall include furnishing all materials, equipment and performing all operations necessary for the complete production, packaging, delivery, factory testing and assembling the air handling units.

B. The units shall consist of base, enclosures, access doors, insulation, piping, wiring systems, electrical components, and all components specified to be installed by the air handling unit manufacturer within the enclosures.

C. The unit(s) shall be factory fabricated to completion as an assembled unit and then separated into individual shipping sections only after the unit(s) are complete, tested and have been inspected by the Owner's representatives.

D. Sections shall be joined by bolting through gasketed field flanges which are pre-drilled with matching holes at both the base rail and continuously around the full perimeter (floor, walls, and roof) of the unit housing. Bolting shall be accomplished from the unit interior to provide a clean exterior appearance.

E. The unit base and structure shall be designed such that each section of the unit is self-supporting. The unit(s) shall be designed to operate properly when installed on the support structure provided as indicated. The installation of any additional support members beyond those indicated will be at the expense of the unit manufacturer.

F. The unit manufacturer shall ship the unit with blank-off plates suitably sealed to allow for field air leakage testing to occur.

1.3 REFERENCES

A. Design and fabrication shall be in accordance with the latest editions of the following codes, ordinances and standards, where applicable.

AMCA 203	Field performance measurements.

AMCA 300	Laboratory methods of testing fans for rating purposes. Test Code for Sound rating air moving devices.
ASHRAE 68-78	In-duct sound power measurements procedure for fans.
ANSI/AFBMA 9	Load ratings and fatigue life for ball bearings.
ARI	Air Conditioning and Refrigeration Institute.
SMACNA	HV AC Metal Duct Standards.
ASTM A386	Zinc coating (hot-dip) on assembled steel products.
ASTM A525	Steel sheet, zinc coated (galvanized) by hot-dip process.
ASTM B209	Aluminum - alloy sheet and plate.
ASTM B221	Aluminum alloy extruded bars, rod, wire, shapes, and tubes.
ASTM B251	General requirements for wrought seamless copper and copper-alloy tube.
ASTM E84	Test for surface burning characteristics of building materials.
OSHA	Occupational Safety and Health Administration.
ARI 410	Forced-circulation air cooling and air heating coils.
ASHRAE 33-78	Methods of testing forced circulation air cooling and heating coils.
NEC	National Electric Code.
NEMA	National Electrical Manufacturers Association.
UL	Underwriters Laboratory.

1.4 QUALITY ASSURANCE

A. All building heating and air conditioning systems shall meet the mandatory provisions for HVAC performance as documented in ASHRAE 90.1-2007 Section 6.4. The minimum system component efficiency requirements listed in ASHRAE 90.1-2007 Tables 6.8.1A-G must be met.

B. Fabrication: Conform to AMCA 99.

C. Air handling units: Product of manufacturer regularly engaged in production of custom built air handling units.

D. Ductwork and equipment installation shall be in accordance with the current editions of NFPA Air Conditioning and Ventilating System Code 90A and B.

E. Sound power level ratings: Comply with AMCA Standard 301 "Method of Calculating Fan Sound Power Ratings from Laboratory Test Data." Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating" Fans shall be licensed to bear the AMCA Seal for Air and Sound.

F. UL Compliance: Electrical components shall be UL listed and labeled.

G. NFPA Compliance: Provide air handling unit insulating materials having flame spread ratings not over 25 and smoke developed ratings no higher than 50; and complying with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" Manufacturer shall provide a copy of NFPA 90 test certificate as part of the submittal to indicate compliance.

H. NEMA Compliance: Motors and electrical accessories shall comply with NEMA Stan-dards.

I. Electrical Component Standard: Components and installation shall comply with NFPA 70"National Electric Code".

J. The air handling unit(s) shall be run tested as specified herein at the manufacturer's facility. A certified run test report shall be furnished prior to shipment.

K. ASHRAE 52.1-1992 and ASHRAE 52.2-1999.

L. Coil performance data shall be certified in accordance with ARI Standard 410 Coil Certification Program.

M. Qualify welding procedures and welding operators in accordance with American Welding Society (AWS) - Structural Welding Code.

N. Metal nameplates shall be provided on the units. All information contained on the nameplate shall be etched or burned into the surface to prevent fading. Information shall include:
1. Job name, sales order number, unit tagging, and service model number.
2. MCA, MOP, and maximum fuse/HACR circuit breaker size.
3. Voltage, frequency, phase, Hp, FLA, and inverter input current for all motors

O. Labels shall be provided on the units for unit rigging and coil piping and connection instructions. Labels shall be provided on fans indicating direction of rotation. Warning labels shall be provided on appropriate components indicating hazardous voltage. For each section which must be assembled to another, matching steel identification tags shall be welded at each mating joint to ensure correct assembly order.

P. Factory installed components shall be installed by the unit manufacturer in full accordance with the component manufacturer's installation procedures.

1.5 DEFINITIONS

A. Wall assemblies shall include all unit wall panels around the air tunnel perimeter, including all channels, fasteners, structural members and seams exposed to both the interior and exterior of the unit, and all removable wall access panels.

B. Door assemblies shall include interior and exterior unit door panels, door frames, and door channels, fasteners, exposed to both the interior and exterior of the unit.

C. Roof assemblies shall include exterior unit roof panels, interior unit ceiling panels, and all roof channels, fasteners, structural members and seams, exposed to both the interior and exterior of the unit.

1.6 ACTION SUBMITTALS

A. Product Data: For each air-handling unit, including components provided or furnished as part of the air-handling unit as a single submittal package, even where components are specified in related sections. Refer to related sections for component product data submittal requirements.
   1. Unit dimensions and required clearances.
   2. Unit components.
   3. Casing material, metal thickness, finishes, insulation, and accessories.
   4. Casing construction details.
   5. Weight loads and distributions by component section.
   6. Sound Date:
      a. Unweighted octave band air-handling unit sound power for inlets and outlets rated in accordance with AHRI Standard 260. Provide eight data points, the first for the octave centered at 63 Hz, and the eighth centered at 8,000 Hz.
      b. Unweighted casing radiated sound power over the same 8 octave bands in accordance with ISO 9614 Parts 1&2 and ANSI S12.12.
      c. Manufacturer shall not use sound estimates based on bare fan data (AMCA ratings), nor use calculations like the substitution method based on AHRI 260 tests of other air-handling unit products.
   7. Required clearances, field connection locations, wiring diagrams, shipping drawings, and curb drawings.
   8. Electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
   9. Static pressure profiles by component section.
   10. Panel deflection at +/- 10-inch wg, stated in terms of 'L/X' where 'L' is the casing panel length and 'X' is a constant provided by the AHU manufacturer.
   11. Casing leakage rate at +/- 10-inch wg, specified in terms of percentage of design airflow.

B. Air-handling unit plan, elevation and section views shall be provided in a scale no less than 1/4" = 1'-0".

1.7 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control reports.

C. Field quality-control reports.

1.8 CLOSEOUT SUBMITTALS

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

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: For each air-handling unit, provide:
      a. One set of filters at the start of testing, adjusting and balancing (TAB).
      b. One set of filters for final turnover to owner.
   2. Gaskets: One set(s) for each access door.
   3. Fan Belts: One set(s) for each air-handling unit fan.

1.10 DELIVERY, STORAGE AND HANDLING

A. Comply with ASHRAE 62.1, Section 7 - "Construction and Startup." Protect equipment from moisture by appropriate in-transit and on-site procedures.

B. Follow manufacturer's recommendations for handling, unloading and storage.

C. Protect, pack, and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions for application.

D. Protect, pack and secure controls devices, motor control devices and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.

E. Enclose and protect control panels, electronic devices, and variable frequency drives. Do not store equipment in wet or damp areas even when they are sealed and secured.

F. Seal openings to protect against damage during shipping, handling and storage.

G. Wrap indoor units with a tight sealing 8 mil shrink wrap membrane for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion during shipping. Wrapping membrane shall cover entire air-handling unit during shipping and storage. Cover equipment, regardless of size or shape.

H. Tarp outdoor units with a tight sealing membrane for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion during shipping. Tarp shall cover entire air-handling unit during shipping and storage. Cover equipment, regardless of size or shape.

I. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

J. The unit manufacturer shall ship the unit with blank-off plates suitably sealed to allow for field air leakage testing to occur.

1.11 SOURCE QUALITY ASSURANCE

A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.

B. AHRI 1060 Certification: Air-handling units that include air-to-air energy recovery devices shall be factory tested according to AHRI 1060 and shall be listed and labeled by AHRI.

C. AMCA 301 or AHRI 260: Air-handling unit fan sound ratings shall comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or AHRI 260, "Sound Rating of Ducted Air Moving and Conditioning Equipment."

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

E. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

F. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

1.12 COORDINATION

A. If equipment is supplied by a manufacturer other than the basis of design, coordinate with the General Contractor and affected subcontractors to ensure the specified performance is met. Coordination shall include (but is not limited to) the following:
   1. Structural supports for units.
   2. Size and location of concrete bases/housekeeping pads.
   3. Location of roof curbs, unit supports and roof penetrations.

4. Ductwork sizes and connection locations.
5. Piping size and connection/header locations.
6. Interference with existing or planned ductwork, piping and wiring.
7. Electrical power requirements and wire/conduit and over current protection sizes.
8. Trap height requirements.

1.13 WARRANTY

A. Manufacturer agrees to repair or replace components of air handling unit that fail in materials or workmanship within specified warranty period. This warrants that all products are free from defects in material and workmanship.
   1. Fives years from date of start up.

B. Warranty work shall be performed by manufacturer's factory-trained and factory-employed technician.

C. Warranty covers all parts except consumable items (belts, filters, fuses). Include factory-provided controls in the parts warranties.

D. Parts associated with routine maintenance, such as belts and air filters shall be excluded.

E. The manufacturer's factory-trained and factory-employed technician shall provide labor warranty for the unit's first operating year.

PART 2 - PRODUCTS

2.1 PRODUCT ACCEPTABILITY

A. Provide factory-fabricated and tested custom air handling unit as indicated, of sizes and capacities as scheduled, and as specified herein.

B. The details outlined on the drawings and in the following specification are considered necessary and important. Any deviation must be approved by the Engineer. The units have been designed to provide appropriate access for service and proper operating clearances, and the dimensions of the units must be strictly adhered to. Under sizing of the housings is unacceptable.

C. Units shall be steel sub-base structure, galvaneal or galvanized walls/roofs with aluminum interior skin, and at least 3-inch foam injected panel construction.

D. Air handling unit manufacturers must meet the specifications herein.

2.2 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide York/JCI or comparable product by one of the following:

1. Air Enterprises, Inc.
2. Buffalo Air Handling
3. Climate Craft
4. Energy Labs Inc.
5. JCI/York
6. Temtrol
7. Trane
8. TMI Climate Solutions
9. Carrier
10. AAON

2.3 MATERIAL

A. Steel: Galvanized in accordance with ASTM A386 or ASTM A525, G-90 hot dipped, or finished with baked-on enamel; thickness in accordance with USS gages.

B. Aluminum sheet and plate; 3003-H14 alloy, conforming to ASTM 8209.

C. Aluminum Extrusions: 6061-T6 or 6063-T52 alloy, conforming to ASTM B221.

2.4 PERFORMANCE REQUIREMENTS

A. AHUs shall meet the specified requirements indicated hereinafter for casing deflection, leakage, acoustics, and thermal performance.

B. Refer to the equipment schedules for the performance characteristics of all supply fans, coils, filters and related components required in the units.

C. Design data on the equipment schedules refer to conditions at job site elevation.

D. Design fan total static pressures to include all losses, internal and external to the unit, including an additional 0.50" WG allowance for MERV 8 filter loading and 1.0" WG for MERV 13 filter loading (added to internal static pressure).

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

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

G. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

H. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

I. Structural Performance:

1. Casing Panels: Self-supporting and capable of withstanding positive/negative 10-inch wg internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch of panel span.
2. Floor and Roof Panels: Self-supporting and capable of withstanding 300-lb static load at midspan, without exceeding a midpoint deflection of L/240.
3. Roof Panels: Self-supporting and capable of withstanding a static snow load of 30 lb/sq. ft., without exceeding a midpoint deflection of L/240.
4. When two or more air unit/air tunnels are stacked on top of each other, the structural integrity of the base unit(s) shall be sufficient to support the upper operating unit.
5. A 4" I-beam shall be installed along AHU ceiling above the fan array access plenum and leading towards an access door to use as a motor monorail for the removal/re-installation of the fan array casings/motors.

J. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 10 inch wg.

K. Thermal Performance: Condensation shall not form on the casing exterior at supply air temperature within the unit of 50°F and ambient conditions on the exterior of the unit of 81.2°F dry bulb and 76.4°F wet bulb. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing to the Engineer and Owner, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying units in the field should external condensate form on them.

2.5 GENERAL CONSTRUCTION REQUIREMENTS

A. Custom air handling units shall be factory assembled modules.

B. Design and assemble units to ensure that each enclosure is engineered to withstand +10.0" w.g. in all positive-pressure sections and -10.0" w.g. in all negative-pressure sections, or fan shut-off static pressure, whichever is greater. Leakage shall be no more than 1% of design air flow at +/- 10.0" w.g. and shall be calculated by totaling all leakage either in to or out of the unit.

C. Design and assemble units to ensure that each enclosure is engineered to not exceed L/250 deflection at +10.0" w.g. in all positive-pressure sections and -10.0" w.g. in all negative-pressure sections, where L is defined as the panel span.

D. Design and assemble units to require only external connection of electrical power, chilled water, drain piping, controls and ductwork.
1. For motor power connections, provide a wire non-fused disconnect switch on the exterior wall of the unit with conduit routed from the motor to the switch.
2. Unit power shall be a single point connection to an external mounted disconnect switch.
3. Extend piping for each coil 6-inches through panel casing. Terminate piping with either a flange or threaded connection at full size and cap. Provide internal unions for all piping to facilitate removal of coils etc. through access doors.

E. Furnish similar equipment, such as motors, coils, filters, and dampers from the same manufacturer.

F. Factory installs all internal components, conduits, electrical conductors, junction boxes, tubing and piping. All conduits shall be EMT and shall be properly supported and securely attached to units.

G. Removable panels shall be installed and located to facilitate fan and coil removal.

H. Openings shall be carefully cut and the exposed edges of the insulation protected by steel sleeves continuously welded in place.

I. All conduits penetrating the unit casing shall be sealed airtight. After wire is pulled, Nelson Flame Seal or equal sealant shall be used to maintain airtight casing. Air cannot be transferred into or out of the unit through conduits.

J. Any sheet metal screws placed in unit casing for mounting tubing, conduits, etc., shall be embedded in silicone caulking.

K. All air handling units shall be designed and constructed so that the fan, filters, coils, dampers and access doors are supported from the unit structure framework and not from the unit panels.

L. All casing seams and joints shall be caulked air and water tight with FDA and NFPA 90 approved caulk. Where extrusions intersect, they shall be continuously welded.

M. Piping sleeves shall be provided for all pipes, instrument lines and conduit passing through the casing. All annular spaces shall be sealed, insulation edges shall be sealed.

N. Casing fastening bolts, screws or rivets shall be Type 304 stainless steel or have a Ruspert® metal finish or equal. The Ruspert® metal surface processing technology shall consist of three layers: the 1st Layer; a metallic zinc layer, the 2nd layer; a high-grade anti-corrosion chemical conversion film, and a 3rd outer layer; baked ceramic surface coating. The fasteners' tensile and sheer strength shall exceed that which is required based on the operating and testing static pressure of the unit.

O. Junction boxes or connectors should be provided at ship break points for electrical and pneumatic connections and shall be properly tagged for reconnection.

2.6 FRAME AND/OR BASE

A. The unit shall be constructed on steel wide flanged or C-channel perimeter beams electrically welded. Roll-formed or fabricated structural members are not acceptable. Base shall be designed to support the dynamic load of the unit including 100 MPH wind loads and a snow load of 30 lbs per square ft and prevent any distortion or sagging of units housing, or internal components during lifting, shipping, unloading or operation.

B. Structural framework shall fully support the unit casing and all components during installation such that no section deflects more than L/1000 during rigging of that section, where L is defined as the distance between lifting lugs.

C. Provide additional structural steel cross channels and angles to adequately support and secure internal components of unit on no more than 2 foot centers in all directions.

D. The base/floor shall be constructed with adequate stiffening members to prevent oil canning and support a live load of 100 pounds per square foot.

E. Provide each section with a minimum of four lifting lugs attached to the structural components of the unit that are removable.

F. Bead blast all surfaces of base, and wipe clean all bare metal before painting.

G. Paint completed frame and/or base with epoxy primer 3-6 mils and one coat of polyurethane epoxy hi-gloss 3-4 mils.

H. Sealant shall be installed between panels at all joints, between panels and trim, and between panels and base channels to provide an airtight enclosure.

I. Sealant shall be non-sag, non-staining, permanently flexible, of highest quality and recommended by its manufacturer for the intended application.

2.7 FLOORING

A. The floor shall be fabricated such that each component section within the air tunnel (and each shipping section in other areas) is of pan type construction. The floor plate shall turn up on all sides of the unit and extend upward a minimum of 2" to contain any moisture on the interior of the unit. Sleeves and /or chases through the floor shall extend a minimum of 2" above the surface of the floor and be continuously welded to the floor to maintain a water-tight installation. No drive screws, bolts, or fasteners shall penetrate the unit floor assembly. Caulked and/or gasketed seams are not acceptable.

B. Floor deflection shall not exceed L/250 under a point load of 200 pounds, where L is defined as the floor span.

C. Under-floor shall be insulated with at least 3" of sprayed-on urethane foam or fiberglass (minimum R-value of 18.0) and covered with a 0.04" aluminum sub-floor properly sealed to act as a vapor barrier. Insulation shall completely fill the panel cavity in all directions so that no voids exist. Base assemblies shall comply with NFPA 90A.

D. Each section shall be provided with a floor drain. The drains shall be factory piped to the unit base rail exterior and capped.

E. Floor drains shall be provided in each section and as indicated on the drawings. Drains shall be a minimum of 1 ½", recessed into the floor and provided with a removable protective grill

mounted flush with the floor. Each drain shall be factory piped to the unit exterior with 1 ½" insulated copper pipe and capped.

2.8 DRAIN PANS

A. Full-length drain pans shall be provided for each bank of cooling coils. The pans shall be fully welded 16-gauge Type 304 stainless steel.

B. Where cooling coils are stacked, intermediate drain pans shall be provided. These pans shall be manufactured of 16-gauge Type 304 stainless steel and provided with 1" downspouts of Type 304 stainless steel or Type K copper, draining to the lowest drain pan. Intermediate drain pans shall be sloped towards the drain outlet.

C. Drain pans shall be of the IAQ type and pitched in two directions toward the condensate outlet. The outlet shall be a 1 1/2" minimum Type 304-stainless steel N.P.T nipple extended through the side of the unit base. All pans shall be installed to be completely self-draining. Traps for condensate drains shall be provided and installed by contractor, and shall be sized to assure drainage at the maximum design positive or negative pressure differential.

D. The primary pan shall extend 24" minimum downstream of the assembly. Intermediate pans shall extend 10" downstream of the coil assembly. Any coil support member located inside a primary drain pan shall be of the same material as the drain pan.

E. The primary drain pan shall be a minimum of 3" deep. Intermediate drain pans shall be a minimum of 1" deep.

F. Primary and secondary pans shall extend 1" beyond headers and U-bends on each side of coils.

G. Drain pans meeting the requirements stated above shall be provided at the interior of each inlet louver.

H. All drain pans shall have a rigid safety grate walk bridge stretched across the unit width. Safety grates shall be min 85% open area and support a minimum 400-pound load. Safety grates shall be made of Type IWA welded rod with a cross flow pattern of 1.5" x 4". Grating shall be aluminum construction for units with aluminum floors. The walk bridge and support system shall be suspended above the drain pan (not in contact with the drain pan bottom) and shall be easily removable for drain pan cleaning.

2.9 PANEL CONNECTIONS

A. Units shall have formed panel or post and panel construction with galvaneal or galvanized panels with aluminum interior liner. Panels shall be connected to each other or to structural members with self tapping screws. All seams shall be caulked with an industrial sealant. Formed metal reinforcing for wall to floor connections, wall to roof connections and corners shall be utilized.

2.10 WALLS AND ROOF DECK

A. Unit casing shall be double wall insulated sandwich panel construction, including the roof assembly. Outer wall shall be 20 gauge galvanized steel. Inner walls shall be 0.032" solid aluminum sheets. Insulation for all wall types shall be 4-inch polyisocyanurate foam for walls and roof, having a "U" factor of not less than 0.04 and conforming to NFPA 90A requirements.

B. A full thermal break shall be provided throughout the entire wall assembly. Wall assemblies shall include all unit wall panels around the air tunnel perimeter, all channels exposed to both the interior and exterior of the unit, and all removable wall access panels.

C. Provide at least 3-inch foam injected insulation with a minimum R-value of 18 throughout all unit wall and roof assemblies. Insulation shall prevent wicking of moisture. Insulation shall completely fill the panel cavity in all directions so that no voids exist and settling of insulation is prevented. Wall and roof assemblies shall comply with NFPA 90A.

D. Removable wall access panels shall be provided in coil and fan sections for service removal of components. Removable access panels shall be provided for removal of the total energy heat wheels.

2.11 ACCESS DOORS

A. Access doors shall be provided in each section. Minimum size shall be 24" wide x 66" high or as high as casing permits. Doors shall be wide enough to remove motors and all other replaceable unit components. Door frames shall be of welded, mitered extruded aluminum with a full thermal break and welded at the corners. Door shall be made of insulated sandwich panel construction matching the unit casing construction and thickness. Doors shall be manufactured by custom manufacturer or provided by AJ, APEX or Cesco.

B. Doors shall have perimeter airtight double sealing replaceable gasketing. Door sealing gaskets shall be Ventlock No. 380, 3/4 inch wide x 1/8 inch thick sponge rubber.

C. Door hinges or door frames shall be the adjustable type. Door handles shall be designed for minimized leakage and to provide a full thermal break. Ventlok handles are not acceptable. Handles shall fasten against the door frame with a roller cam to eliminate wear of the door frame. All door handles shall be operable from both the unit exterior and interior. Door hinges and frames shall be stainless steel.

D. All doors shall be installed to open against the higher air pressure.

E. Door test ports shall be provided by the AHU Manufacturer as indicated on the schedule and drawings. Test ports shall be designed to allow the test and balance contractor to validate pressure losses using a hand held instrument. Test ports shall have a removable cover that completely seals the door penetration when testing and balancing is not being conducted.

F. All access doors shall be provided with 12" x 12" viewports of double thickness insulated wire reinforced glass.

2.12 ACCESS PANELS

A. Removable access panels, located at each coil, fan and where indicated on the drawings shall be provided to facilitate removal of each coil and fan. The panels shall be constructed the same as an access door except that each panel shall be bolted in place on 4" centers.

B. Access panels should facilitate cleaning of coil tubes from exterior of unit without shutting fans down when removable header coils are specified.

2.13 SHIPPING SPLITS

A. Shipping splits shall be provided as indicated on the drawings or as required. Heavy-gage gussets shall be provided in the corners of each split on the unit interior to minimize the opportunity for racking of the section during shipping and rigging. Structural members shall be provided at the base of the unit exterior to enable "macro" pull together of each shipping split. Structural members shall also be provided on the unit interior across the floor and ceiling of each split to enable "micro" alignment and pull together of the complete perimeter using bolts provided by the AHU manufacturer.

2.14 UNIT PAINT

A. External surfaces of all unit casings shall be prepared and painted resulting in a minimum 1.5 mil thick coating when dry. Paint shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 500 consecutive hours. Paint shall be custom color per the project architect.

2.15 FANS

A. Approved manufacturers: York (JCI), Trane, Twin City and New York Blower. Fans shall be tested, rated and certified in accordance with ANSI/AMCA Standard 210 for air delivery and shall bear the AMCA seal. The fan balancing process, including vibration limits, shall be performed in accordance with ANSI/AMCA Standard 204.

B. Fans shall be un-housed, Single Width-Single Inlet [SWSI] plenum type with high-efficient AF blades. Fans shall be 12-Blade direct drive plenum type. Fan wheels shall be aluminum. Fans shall be furnished with inlet collars. The HP characteristic of all fans shall be non-overloading.

C. Fans, in conjunction with AHU construction and components, shall be selected to provide acoustical characteristics as described herein.

D. Each fan shall be provided with a fan airflow measurement system to measure fan airflow directly or to measure differential pressure that can be used to calculate fan airflow. The accuracy of the devices shall be no worse than +/-5% when operating within stable fan operating conditions. Devices shall not affect the submitted fan performance and acoustical levels. Devices that obstruct the fan inlet or outlet shall not be acceptable. Devices shall be

connected to transducers with selectable 4-20 mA or 2-10 VDC output. Signal shall be proportional to air velocity.

E. The total fan assembly after installation shall be checked for balance for 10-100% of design speed of the air handling unit. Fans are to be statically and dynamically balanced to American National Standard Institute (ANSI) balancing tolerance of Grade G6.3 or as per AMCA Standard 204-96 - Balance Quality & Vibration Level for Fans.

2.16 FAN ACCESSORIES

A. Unit fans shall be provided with separate variable frequency fan drives. Fans in array may be served be one variable frequency fan drive. Drives shall be provided as a part of the unit. Variable frequency drives on the project shall be of the same manufacturer, fully coordinated with motor controller, and as specified in Division 23 Section "Variable Frequency Drives (VFDs)". After the air handling unit is installed, the VFD shall be field commissioned by a factory trained and employed service technician.

2.17 HEATING AND COOLING COILS

A. Heating Coils
1. Heat shall be provided from electric-resistance air coils in the pre-heat position to protect the cooling coils from freezing.
2. Electric heater elements shall be constructed of heavy-duty nickel chromium elements internally wired. Electric heater package shall have automatically reset high limit control operating through heating element contactors. All heaters shall be individually fused from the factory, where required, and shall meet all NEC and CEC requirements.
3. Electric heat modules shall be U.L. listed or CSA certified.
4. Silicon controlled rectifiers (SCR's) must be provided to ensure full-modulation of heater.
5. Electric heat shall be controlled by the DDC panel which monitors outdoor air and determines heat stages by calculating the delta T provided by each stage and determines how many should be activated.

B. Cooling Coils
1. Cooling shall be provided from chilled water cooling coils.
2. All coils shall be certified in accordance with A.R.I. Standard 410 or ASHRAE Standard 33-78 and shall be manufactured by Temptrol, York (JCI), Trane, Heatcraft or Aerofin.
3. U-bends shall be formed copper with high temperature silver-brazed joints. Coils over 72" in length shall have a center tube support. Coils over 96" in length shall have two tube supports.
4. Connections to coils shall have thread protectors (caps or plugs).
5. Each coil shall be independently supported by a coil support assembly consisting of a drain pan with integral stainless steel supports mounted on horizontal stainless steel channels and designed such that any coil in a bank can be slid horizontally out of the casing normal to the direction of airflow through the access panel without disturbing the other coils in the bank. When coils are staggered, provisions shall be provided to easily slide the coils furthest from the access panel through the access panel.

6. Water velocities shall not exceed 8 feet per second or exceed the water pressure drop scheduled.
7. Cooling coils shall be constructed with 5/8" O.D. seamless copper tube with a minimum 0.025" wall thickness. U-bends shall have a minimum 0.035" wall thickness.
8. Cooling coils shall have minimum 16 gauge #304 stainless steel casings and stainless steel intermediate tube supports.
9. Coils shall be of the continuous plate fin type with 0.0075" thick aluminum fins. Fin spacing shall not exceed 10 fins per inch.
10. Headers shall be 0.049" thick copper pipe with brazed joints. Headers shall be provided with plugged drain and vent openings at the highest and lowest points in the coil.
11. Coil connections shall be schedule 40 red brass pipe with threaded connections, the connections shall be factory piped through the casing wall with a minimum extension beyond the casing exterior of 2.5 times the pipe O.D., internal unions shall be provided.
12. Safing for the cooling coils shall be 16-gauge Type 304 stainless steel.
13. Coils shall be suitable for operation at 200 PSIG and 220 F and shall have been tested with minimum air pressure of 300 PSIG while coil is under water.

2.18 FILTERS AND FILTER FRAMES

A. Filter elements and cartridges shall be as scheduled on the drawings and of the type specified in Division 23 Section "Particulate Air Filtration".

B. Filter holding frames shall be of heavy duty construction designed for industrial applications. Holding frames applied in both low efficiency pre-filter applications and high efficiency final filter applications shall be upstream accessible only. Holding frames shall be constructed from no less than eighteen (18) gauge galvanized steel. Filter racks over forty-eight (48) inches in height and seventy-two (72) inches in width shall require steel reinforcement at the midpoint. The filter racks with dirty filters shall have maximum defection not to exceed 1/200th of rack dimension in either direction.

C. Racks shall be equipped with polyurethane foam gaskets, fasteners, and filter centering dimples. The in-line depth shall not be less than 2.75 inches in order to effect adequate bearing surface for built-up filter banks. Filter fasteners shall be capable of being installed without the requirement of tools, nuts or bolts. The holding frame shall be designed to accommodate standard size filters with the application of the appropriate type fastener. Holding frame assemblies shall be sized to accommodate the filters scheduled on the drawings.

D. All filters shall be the same size, in either 24"x24" or 12"x24".

E. Air Filter Gauges
1. Air filter gauges shall be provided for each bank of filters and mounted flush with unit casing.
2. Each gauge shall be a diaphragm actuated, dial type gauge with zero adjustment, 3-way vent valves, static pressure tips, integral compression fittings on both valves and tips, and aluminum surface mounting bracket with screws. Gauge shall be Dwyer Instruments, Inc., Series 2000 Magnehelic differential pressure gauge.
3. Gauges shall have a range of 0 to 1.0" for pre-filter banks, 0 to 2.0" for ASHRAE cartridge filter banks, and 0 to 3.0" for two stage banks.

2.19 DAMPERS

A. Aluminum Low Leakage Dampers
   1. Frame shall be 5" x 1" x 6063T5 extruded aluminum hat channel with .125" minimum wall thickness.
   2. Blades shall be maximum 6" wide 6063T5 heavy gauge extruded aluminum, airfoil shape, parallel blade, as detailed on the drawings.
   3. Assembly shall use extruded vinyl blade edge seals and flexible metal compressible jamb seals. Shafts shall be square or hexagonal. Round shafts are unacceptable.
   4. When tested in accordance with AMCA Standard 500, leakage rate through a 48" x 48" damper shall not exceed 6.2 CFM/sq. ft. @ 4" W.G. pressure differential.
   5. Dampers shall be Ruskin CD-50 or equal.

B. Fan Isolation/Smoke Dampers
   1. Frame shall be 10" x 2" x 12 gauge mill finish galvanized steel channel.
   2. Blades shall be airfoil shaped, 7-3/4" wide, .080" thick, 6063T5 extruded aluminum, parallel blade, as detailed on the drawings.
   3. Blade edge seals shall be silicon rubber and jamb seals shall be stainless steel, flexible metal compression type.
   4. The leakage rating under UL555S shall be Leakage Class I (4.0 CFM/sq. ft. @ 4" W.G.) and a minimum of Class II at 8" W.G. A 48" wide damper shall be structurally suitable to withstand a pressure differential of 12" W.G.
   5. Dampers shall be Ruskin SD-102 or equal, with electric actuators.

C. Smoke Dampers
   1. Smoke dampers that do not serve as fan isolation dampers shall be Ruskin SD-50 or equal.
   2. Frame shall be 5" x 1" x 6063T5 extruded aluminum hat channel with .125" minimum wall thickness.
   3. Blades shall be maximum 6" wide 6063T5 heavy gauge extruded aluminum, airfoil shape, parallel blade, as detailed on the drawings.
   4. Dampers shall have silicon rubber blade edge seals and flexible aluminum compression type jamb seals.
   5. The leakage rating under UL555S shall be Leakage Class I. W.G. pressure differential.
   6. Dampers shall be furnished with electric actuators.

D. Damper Operators
   1. Damper actuators (except for smoke dampers) shall be furnished and installed by the controls contractor.

2.20 AIRFLOW MEASURING STATIONS

A. Fan Inlet Airflow Measuring Devices
   1. Fan inlet airflow measuring devices shall be by the fan manufacturer as part of the fan assembly. The probes shall contain multiple total and static pressure sensors at concentric area centers along the exterior surface of the probe and internally connected to their respective averaging manifolds.

2. Sensors shall not protrude beyond the surface of the probe, nor be adversely affected by particle contamination normally present in building system airflows.
3. The fan inlet airflow traverse probes (two per inlet) shall have dual end support brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings. Probes for fan inlets 20" in diameter and larger shall be extruded aluminum with hard anodized finish. Probes for smaller fan inlets shall be 300 series stainless steel.
4. The fan inlet airflow traverse probes shall not induce a measurable pressure drop, nor shall the sound level within the system be amplified by its presence in the fan inlet bell. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 3% of actual flow over a fan operating range of 6 to 1 capacity turndown.

B. Transmitters
1. Electronic flow transmitters shall be capable of receiving signals of total and static pressure from the airflow measuring device, of amplifying, extracting the square root, and scaling to produce a 4-20 maDC or 0-5 VDC output signal linear and scaled to air volume or velocity. Flow transmitters shall be of the industrial process control type. Commercial grade transmitters are not acceptable.
2. Transmitters shall include an adjustable (every 1 to 24 hours on 1 hour intervals) automatic zeroing circuit and be capable of maintaining linear output signals on applications requiring 10 to 1 velocity (100 to 1 pressure) turndown. The transmitter shall include an integral multi-line digital LED display for configuration and calibration, and to display one transmitter output during normal operating mode. Input pushbuttons shall provide means to perform transmitter configuration, parameter setting, zero and span calibration, and display formatting and scaling via the on-board microprocessor. Transmitters shall be Air Monitor Veltron II in NEMA 1 enclosure and enclosed terminal strip, in compliance with the following criteria:

Reference Accuracy:	± 0.25% of natural span (including non-linearity, hysteresis, and non-repeatability)
Zeroing:	Automatic, within 0.1% of operating span
Spans:	Factory custom spanned down to 40% of natural spans. Natural span ranges from 0 to 400 FPM to 0 to 12665 FPM.
Temperature Stability:	0.015% of full span/F. No zero effect.
Power Supply:	24 VAC, 20 to 40 VDC, selectable. Optional 120 V AC
Overpressure Limit:	25 psig

2.21 ENERGY RECOVERY WHEELS

A. Unit shall be provided with one factory-installed total energy recovery wheel, with size and performance as scheduled on the drawings, manufactured by Thermotech, Semco, NovelAire or Innergy Tech.

B. The wheel shall be an integral part of the AHU and shall be sized per the ventilation requirement of the units. Additional outside air units, or other field assembled and ducted energy recovery devices, are not acceptable.

C. The energy recovery wheel shall be certified to ANSI/ARI Standard 1060 and bear the ARI 1060 label. Performance characteristics of the energy wheel shall be provided as defined by ARI 1060 definitions. The energy wheel shall be a total energy wheel, with the sensible and latent effectiveness reported and within 5% of each other. The calculated total net effectiveness of the recovery wheel shall not be less than 70% when the specified ventilation flow rate equals the exhaust flow rate. The energy wheel's EATR shall be less than the value indicated in the schedule and drawings. The amount of outside air transferred to the exhaust air shall also be reported to ensure proper fan and damper sizing. Wheel face velocity shall not exceed 900 fpm and pressure drops shall be less than 1.15" w.g.

D. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belts. The energy wheel media shall be constructed of corrugated synthetic fibrous media, with a desiccant intimately bound and uniformly and permanently dispersed throughout the matrix structure of the media. Face flatness of the wheel shall be maximized (+/- 0.032 in) in order to minimize wear on inner seal surfaces and to minimize cross leakage. Rotor shall be constructed of alternating layers of flat and corrugated media. Wheel layers should be uniform in construction forming uniform aperture sizes for air flow. Wheel construction shall be fluted or formed honeycomb geometry so as to eliminate internal wheel bypass. Wheel layers that can be separated or spread apart by air flow are unacceptable due to the possibility of channeling and performance degradation. Energy recovery cassettes shall be UL-recognized components certified for mechanical, electrical and fire safety in accordance with UL Standard 1812.

E. The desiccant material shall be a molecular sieve, and specifically a 4A or smaller molecular sieve to minimize cross contamination. The media shall not be subject to corrosion in marine or coastal environments. The adsorbent shall be integrally bound into the media or impregnated into the media without the use of binders or adhesives. The adsorbent shall not be coated, bonded, or synthesized onto the media and not susceptible to erosion, abrasion, or delamination. The adsorbent shall be selected for its high affinity for water vapor and shall not dissolve or deliquesce in the presence of water or high humidity.

F. All diameter and perimeter contact brush seals shall be provided as part of the cassette assembly. Perimeter seals shall be self-adjusting and diameter seals shall be adjustable. Seals shall be factory set and easily adjustable.

G. Wheel drive motor shall be provided mounted in the cassette frame and factory wired to the fan starter or VFD for a single-point power connection. Motor locations shall be as indicated on the schedule and drawings. Wheel drive motor shall be thermally protected and UL Component Recognized. Drive belts shall not require belt tensioners. Wheel motors shall be of the voltage, phase, frequency, and Hp indicated on the schedule and drawings. Wheels shall have flanged or pillow block bearings which support the rotating shaft of the wheel. Outboard bearings shall be provided with grease fittings for periodic lubrication. L-10 bearing life shall be greater than 400,000 hours at design conditions.

H. Access doors shall be provided for the removal of wheel segments. Doors shall be located to allow access to the entire upstream and downstream face of each wheel. Adequate space and access shall be provided for energy wheel motor, bearing and belt removal.

I. Energy recovery wheels shall be designed with variable effectiveness control, to vary the wheel's recovery capacity. Variable effective control shall be done by an internal bypass damper (provided by the AHU Manufacturer) or variable frequency speed control. The wheel's variable effectiveness control shall have the ability to modulate the total energy recovery ability down to at least 40% of the initial recovery capacity.

J. Variable Effectiveness Control
   1. An AC variable frequency drive shall be provided to maintain supply air temperature by varying wheel speed. The variable frequency drive shall include a door mounted manual speed potentiometer, start-stop, an automatic/manual switch, and a digital display of drive output frequency, output amps, and drive fault. The variable frequency drive system shall provide an 80:1 turndown (20 rpm to 1/4 rpm).
   2. The solid-state controller shall accept input signals from four linearized thermistor sensors and provide a 4-20 mA signal to the AC variable frequency drive. The proportional temperature sensor in the supply air stream shall vary wheel speed to maintain the supply air temperature set point. The differential summer/winter changeover sensors in the outdoor and return air streams shall override the supply air sensor and index wheel to maximum speed for cooling whenever outdoor air temperature exceeds return air temperature operation.
   3. The modulating frost prevention sensor in the exhaust air stream shall override the supply air sensor to prevent frost build-up.
   4. Control of energy wheels shall be incorporated and an integral part of the AHU control systems and shall be as described under the AHU control specifications. Secondary independent wheel controllers are not acceptable.
   5. Frost prevention shall be achieved by exhaust air bypass or variable frequency speed control. Frost set point temperatures based on the scheduled design air conditions shall be provided by the AHU Manufacturer. Winter design supply and exhaust air conditions leaving the energy wheel shall be provided by the AHU Manufacturer and shall include any de-rate in performance due to frost prevention measures.
   6. A magnetic rotation sensor shall transmit a pulse to the rotation detector at each wheel revolution. If no pulse is transmitted within five (5) minutes, "Alarm" light on rotation detector shall be energized. The rotation detector shall include N.O. and N.C. contacts for remote indication of wheel stoppage.

2.22 VARIABLE FREQUENCY DRIVES

A. VFDs shall be factory mounted on AHU as indicated on the drawings. After mounting and wiring of VFDs on the AHUs, trained factory personnel shall ensure proper operation of each VFD through a thorough factory test. Testing shall include a Hypot test of unit wiring to insure that no weaknesses exist in wiring or motor. Each VFD shall be energized and the fan run to ensure the VFD will operate throughout the usable range of the drive and that the fan rotation is correct.

2.23 CONTROLS

A. Controls shall be field provided and installed.

2.24 ELECTRICAL

A. General
1. All electrical wiring shall be in conformance with the N.E.C.
2. All wiring shall be 600 volt rated type M1W/TTHN stranded copper, enclosed in 3/4-inch diameter or larger, EMT galvanized conduit. Connections to all fans shall be made with a minimum 3-foot length of 3/4-inch diameter or larger FMC. All junction boxes shall be U.L. approved and gasketed.
3. All wiring shall be routed above access doors and panels and shall be not less than 12" above the unit interior floor.
4. On units that ship in sections, wiring harnesses shall be provided for facilitate field reconnection at section breaks.
5. All permanent and temporary conduit termination points shall be sealed to prevent moisture from entering the conduit.
6. All control and instrument wiring shall be identified with a unique wire number. These numbers shall agree with the numbers shown on the supplier's wiring diagrams. Control circuit wiring shall be permanently identified with W. H. Brady Company wire markers applied within 1" of each terminal and splice.
    a. Power Wiring
        1) Unit shall be completely factory wired and shall be arranged to accept the single point connections indicated below. Unit manufacturer shall furnish, install and wire junction boxes for each connection.
            a) 3-phase 480-volt power connection
        2) AHU manufacturer shall provide wiring from variable frequency drives to unit mounted motor junction boxes.
        3) AHU manufacturer shall provide integral GFCI receptacle with weatherproof cover.
        4) Receptacle/lighting circuit shall remain functional when main disconnect is in "OFF" position.
    b. Lighting Systems
        1) Each unit shall have factory installed and wired lighting fixture in each compartment, placed for optimum viewing without obstructing service access.
        2) Lights shall be wired through light switches with pilot lights at each section access door to a central lighting junction box and factory connected via transformer in AHU controller. Lights in separate air handling unit sections shall be independently switched.
        3) All switches shall be mounted forty-eight (48) inch from the supporting floor surface.
        4) Lighting fixtures shall be provided in each air handling compartment.

2.25 EQUIPMENT IDENTIFICATION

A. Mechanical and electrical equipment within the unit shall be identified in accordance with the designations indicated on the drawings using engraved laminated black and white phenolic legend plates. Letters shall be 3/4" high black on surrounding white and mounted using non-ferrous screws.

PART 3 - EXECUTION

3.1 FACTORY INSPECTION AND TESTING

A. Prior to shipment to the project, each unit shall be inspected, tested, and, in the judgment of the project consultant, determined to be in compliance with the specifications. Any deviations found shall be corrected. The Owner and/or Owner's representative(s) may, at their option, inspect the equipment and witness the testing for the air handling units. The cost of travel and accommodations for five persons shall be at the unit manufacturer's expense. The unit manufacturer shall provide notification two weeks prior to the date the unit(s) will be ready for inspection and testing. Test results shall be submitted to the Architect and included in the O&M Manual. The following tests shall be performed:

1. Air Leakage Test
    a. The unit housing shall be factory tested for leakage at 10" W.G. differential pressure, positive or negative depending on unit configuration. Leakage shall be calculated by totaling all leakage in or out of the unit.
    b. SMACNA HVAC Duct Leakage Manual. Leakage rate shall not exceed 0.5% of design airflow. Testing shall be done on the assembled unit, with openings sealed as required to isolate the positive and negative pressure sides of the unit.
    c. Submit for review and approval 10 days prior to the performance of the of the testing either flow meter calibration data or certification signifying that the manufacturer of the meter is incompliance with the ASME Requirements for Flow Meters per section 5.3 of the SMACNA HVAC Duct Leakage Manual.
    d. A minimum of 10 working days prior to the air leakage test, the air handling unit manufacturer shall submit copies of the Air Leakage Test Form, provided as part of this specification, properly filled out, for each unit to be tested, and submitted for the engineers review and approval. The factory testing shall not occur without the engineer's approval of the test form. After successful completion of the test, two (2) copies of the complete report shall be submitted to the engineer for final acceptance.
    e. If the specified leak rate is not attained, the unit manufacturer shall modify the unit in any and every manner required to achieve the required results except that the modifications shall not compromise the unit construction, performance, or any other elements of the unit deemed important to the design consultant. After the modifications are complete, the manufacturer shall retest the unit at their expense, in the presence of the owner or its representatives. All costs involved in bringing the consultants back to the factory, including payment of the consultant's hourly fee will be borne by the unit manufacturer.
2. Fan Vibration Test
    a. All fan assemblies shall have a dynamic balance performed after the unit is complete. An IRD or PMC analyzer shall be used to measure velocity. The final reading shall not exceed 0.1 inch per second vertically or horizontally at the bearing caps nor exceed 0.09 inches per second in the axial direction. The exact level of vibration shall be recorded operation and maintenance manual as proof of the factory dynamic balance.
3. Panel Deflection Test

a. A panel deflection test shall be performed. The testing shall be performed with a dial indicator accurate to plus or minus 0.001". The cabinet panel deflection shall not exceed 1/250 of the panel span at the casing leakage test pressures.

3.2 SUPERVISION OF INSTALLATION

A. After the mechanical contractor has received the units on site, the AHU service company shall inspect the units for proper storage, check for damage, and complete initial inspection report to be submitted to the engineer. The installing contractor shall coordinate this site visit with the AHU service company.

B. The manufacturer's factory trained and authorized technician shall supervise the work performed by the installing contractor during the rigging and assembly of the unit. All tools and labor shall be provided by the installing contractor.

C. Once the contractor has set the units in place, the AHU service company shall provide on site installation specific instructions to the contractor regarding piping, electrical, ductwork, and field control wiring connections to the unit. The AHU service company representative shall approve any and all field penetrations to the units, if required. Upon completion of this inspection, the AHU manufacturer representative shall complete an inspection report to be submitted to the engineer. The mechanical contractor shall coordinate this site visit with the AHU service company.

D. The Mechanical Contractor shall verify that the following items have been completed prior to scheduling the AHU Manufacturer's final inspection and start up. In addition to items listed below, please complete manufacturer's AHU Pre Start-Up Checklist and submit a copy to engineer a minimum of two weeks prior to scheduled start-up:
1. All spring-isolated components have had their shipping restraints removed and the components have been leveled.
2. All water piping connections have been completed and hydrostatically tested and all waterflow rates have been set in accordance with the capacities scheduled on the Drawings.
3. All ductwork connections have been completed and all ductwork has been pressure tested for its intended service.
4. All power wiring, including motor starters and disconnects, serving the unit has been completed.
5. Power is available to the unit and within unit manufacturers tolerances.
6. All automatic temperature and safety controls have been completed.
7. All dampers are fully operational.
8. All shipping materials have been removed.
9. All (clean) filter media has been installed in the units.
10. Remove all foreign loose material in ductwork leading to and from the unit and in the unit itself.
11. Condensate drains have been connected and trapped properly.
12. All internal demount wiring has been completed.
13. There is free movement of rotating components and this has been confirmed by hand rotation.
14. Individual Fan hub screws have been checked for tightness.

15. Bearing set screws have been checked for tightness.

3.3 SYSTEM CHECK TEST AND START-UP

A. Upon completion of AHU installation, the AHU manufacturer shall perform a final inspection to verify proper installation of the Air Handling Units and perform factory start up. The automatic temperature control contractor shall be scheduled to be at the job site at the same time of the AHU start up. Upon completion of this inspection and start up, the AHU manufacturer representative shall complete the inspection report/start up log to be submitted to the engineer

1. Record date, time, and person(s) performing service.
2. Lubricate all moving parts.
3. Verify all electrical power connections.
4. Conduct start up inspection per the AHU Manufacturer's recommendations.
5. Disengage all shipping fasteners on vibration isolation equipment.
6. Check safety guards to insure they are properly secured.
7. Secure all access doors to the multiple fan array section , the unit and the ductwork.
8. All devices adjusted/set at appropriate design (high pressure switch, float switch, damper end switches, etc.)
9. Inspect Filter Support for tightness
10. Inspect for proper installation of filters
11. Inspect water valves check operation
12. Inspect control wiring to dampers
13. Inspect Freezestat wiring
14. With Power De-Energized
    a. Check for any loose connections
    b. Check circuit breaker disconnect mechanisms/mechanical interlocks operate properly
    c. Check VFD size and rating (voltage and horsepower)
    d. Check and set motor start protectors (MSP) for correct size and setting (temperature, amperage).
    e. Check fan rotation and spin wheel to verify that rotation is free and does not rub or bind.
    f. Visually check dampers for trouble free rotation
15. With Power Energized
    a. Connect proper input line voltage power to line side of panel
    b. Energize incoming power circuit
    c. Check for proper line voltage
    d. Check voltage between all neutral terminations and NEMA rates panel ground
    e. Check internal power supplies for proper voltage output(s) and adjust as required
    f. Test and verify proper operation of all GFCI devices
    g. Test and verify proper operation of all lights and light switches
    h. Check operation of NEMA rated cabinet cooling fan, adjust thermostat as specified
    i. Check and record all voltage readings
    j. Energize motor start protectors (MSP) one at a time to ensure correct motor rotation.
    k. Record voltage and amperage of fan motor
    l. Check fan for excessive vibration.

m. Physically check each fan at start up and shut down to insure no abnormal or problem conditions exist.
n. Ensure that CFM monitoring system is functioning
o. Open and Close dampers and record trouble free operation.
p. Check entering and leaving air temperatures (dry bulb and wet bulb) and simultaneously record entering and leaving chilled water temperatures and flow, and outside air temperature .

3.4 USER TRAINING

A. The Manufacturer's Representative shall instruct the Owner's operating personnel in the operation and service of the air handling units. This instruction shall occur at the air handling unit installation site. Instruction services shall include a minimum of 24 hours of instruction to be coordinated with the Owners Engineering services office to provide instruction to all required personnel on each work shift.

3.5 CONTRACTOR COMMISSIONING

A. After final assembly is complete, each unit shall be inspected and tested in the field, by the installing contractor, and shall be determined to be in compliance with the specifications. Any deviations found shall be corrected. The Owner and/or Owner's representative(s) may inspect the equipment and witness the inspection and testing. The installing contractor shall provide notification one week prior to the date the unit(s) will be ready for inspection and testing.

B. The following tests shall be performed by the manufacturer's field service technician:
1. Air Leakage Test
a. The unit housing shall be tested for leakage at 10" W.G. differential pressure, positive and/or negative depending on unit configuration.
b. The manufacturer of the air-handling unit shall suitably seal all factory penetrations in the casing sections to be air leak tested prior to shipment. This includes, but is not limited to, all factory supply/return/exhaust/outside air openings, pipe sleeves, pipe and electrical chases, floor drains, condensate drain lines, etc. The unit manufacturer shall provide appropriately sized and sealed connections (minimum 2" collar) at each casing section and the installing contractor shall suitable seal all non-factory penetrations made to the air-handling unit casing in the field.
c. The leakage test shall be conducted in accordance with the procedure outlined in the SMACNA HVAC Duct Leakage Manual. Leakage rate shall not exceed 1% of design air-flow. Testing shall be done on the assembled unit, with all openings sealed, as required to isolate the positive and negative pressure sides of the unit.
d. Contractor shall submit for review and approval, 10 days prior to the performance of the testing, either flow meter calibration data or certification signifying that the manufacturer of the meter is in compliance with the ASME Requirements for Flow Meters per section 5.3 of the SMACNA HVAC Duct Leakage Manual.
e. The Air Leakage Test Form, provided as part of this specification, shall be properly filled out and submitted to the engineer, for each unit to be tested, 10 working days in advance of the performance of the testing for the engineers review

and approval. The field testing shall not occur without the Engineers approval of the Test Form. After successful completion of the test, two (2) copies of the complete report shall be submitted to the engineer for final acceptance.

f. If the leakage rate exceeds that specified, the installing contractor shall make the necessary modifications to the unit and retest the unit at his own expense until the specified leak rate is delivered.

g. The unit manufacturer shall provide, a test fan, full freight allowed to the project site, of sufficient capacity to provide the necessary CFM at the required positive and/or negative static pressure and test instrumentation. The installing contractor shall provide, temporary high pressure duct material between the test fan and the unit(s) to be tested, all field labor, which includes but is not limited to: off loading and rigging of the test equipment into position, installation, prior to the test, and removal, after the test, of the unit connection fittings and temporary duct material, providing a 460 volt/3 phase temporary electric circuit sized to power the test fan within 6 feet of the test fan and a 115 volt/1 phase temporary electric service at each unit to be tested, labor and materials required to re-turn the test equipment (freight collect) to the air handling unit manufacturer and all other items required to perform successful testing.

3.6 INSTALLATION

A. General
   1. Contractor to install air handling units where indicated on the drawings in full accordance with equipment manufacturer's installation instructions and as follows:
   2. Access: Provide access space around units for service as indicated on the drawings, but in no case less than recommended by the equipment manufacturer.
   3. Electrical: Install electrical devices furnished by unit manufacturer but not specified to be factory-mounted. Verify that electrical wiring installation is complete and in accordance with manufacturer's submittal and installation requirements of Division 26 sections.
   4. Piping: Provide piping, valves, accessories, gauges, and supports as indicated on the drawings. Trap unit drain pans according to manufacturer's recommendations and extend condensate line to nearest drain. For indoor units, provide a concrete pad of adequate height to allow for proper installation of condensate drain trap above the finished floor.
   5. Duct Connections: Provide ductwork, accessories, and flexible connections as required.

3.7 FINAL CLEANING

A. Prior to acceptance by the owner, the contractor shall thoroughly clean the outside and particularly the inside of each air handling unit. Industrial grade cleaners can be used to remove construction dust. Any sheet metal mil finish or grease can be removed with Freon TF solvent fluorocarbon. All proposed cleaning materials shall have contents identified and approved prior to use.

AIR LEAKAGE TEST FORM

The items below are to be submitted to the engineer 10 working days in advance of the performance of the AHU (installed on site) leak testing for engineer's review and approval. Testing is not to occur prior to engineer's approval.

Project Name:
Date of Test:
Unit Manufacturers Name:
Unit Project Tag:
Unit Model Number:
Unit Serial Number:

Positive Pressure Test
Total design CFM to be used for basis of positive pressure leakage determination:
The positive pressure at which the casing will be tested:
Maximum allowable CFM leakage - positive (ex. 60,000 design CFM @ 1% leakage = 600 CFM):

Negative Pressure Test
Total design CFM to be used for basis of negative pressure leakage determination:
The negative pressure at which the casing will be tested:
Maximum allowable CFM leakage - negative: (ex. 60,000 design CFM @ 1% leakage = 600 CFM):

The largest casing volume to be tested during positive or negative pressure test:
The CFM output of the test fan at the maximum design test pressure:
Submit copy of fan curve for the test blower for engineers review and approval.
Estimated time to achieve test pressure (casing volume tested 1 fan CFM - max leakage CFM):

Flow orifice Manufacturer:
Flow orifice Model Number:
Flow orifice Serial Number:
Flow orifice calibration Date:
Diameter of flow orifice (D2):
Duct Connection Size (D1):
Ratio D21 D1:
Orifice coefficient (K from Table 5-1):
Flow Equation (equation #1)

The delta P across the flow orifice, which relates to the maximum allowable CFM leakage positive:
The delta P across the flow orifice, which relates to the maximum allowable CFM leakage negative:

This form must be accompanied with either flow meter calibration data or certification signifying that the manufacturer of the flow meter is in compliance with the ASME Requirements for Flow Meters per section 5.3 of the SMACNA HVAC Duct Leakage Manual.

Readings taken during Field Testing

	Positive Pressure	Negative Pressure
Pressure		
The casing pressure reading taken during the test:		
The delta P reading taken across the flow orifice:		
The calculated casing CFM leakage:		
The casing tested leak rate (%):		

Testing Performed By:	Name	Company	Signature
Testing witnessed By:	Name	Company	Signature
Test Results:	Passed	Failed - Must Retest	Per Signature:

END OF SECTION 237330

SECTION 230550 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFDs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. Related Requirements:
   1. Section 230513 "Common Motor Requirements for HVAC Equipment."

1.3 DEFINITIONS

A. BAS: Building Automation System.

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. LCD: Liquid-crystal display.

F. LED: Light-emitting diode.

G. OCPD: Overcurrent protective device.

H. PID: Control action, proportional plus integral plus derivative.

I. RFI: Radio-frequency interference.

J. VFD: Variable-frequency drive.

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFD indicated.
   1. Include dimensions and finishes for VFDs.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFD indicated.
1. Include mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Variable frequency drives shall be included in the development of the Coordination and Installation Drawings, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Required working clearances and required area above and around VFDs.
2. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements.
3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.

B. Product Certificates: For each VFD from manufacturer.

C. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

D. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
b. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
c. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
d. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.7 DELIVERY, STORAGE, AND HANDLING

A. VFDs should be delivered, stored and handled in a manner that protects them from damage, moisture, dirt and intrusion of foreign materials.

B. Store VFDs indoors in clean, dry space with uniform temperature to prevent condensation. Maximum ambient temperature for storage shall be -40 to 120 degrees Fahrenheit.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Inc.
   2. Danfoss Inc.
   3. Yaskawa Electric America, Inc.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFDs:
   1. VFDs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

B. Application: Variable torque.

C. VFD Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
   1. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
   2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage (not applicable to fan arrays).
   1. For fan arrays, output rating shall match fan array motor selection.

F. Unit Operating Requirements:
   1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFD input voltage rating.
   2. Input AC Voltage Unbalance: Not exceeding 5 percent.
   3. Input Frequency Tolerance: Plus or minus 3 percent of VFD frequency rating.
   4. Minimum Efficiency: 96 percent at 60 Hz, full load.
   5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
   6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
   7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F. Operating up to 122 degF shall be possible with 10 percent de-rating if required.
   8. Humidity Rating: Less than 95 percent (noncondensing).
   9. Altitude Rating: Not exceeding 3300 feet.
   10. Vibration Withstand: Comply with NEMA ICS 61800-2.
   11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
   12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
   13. Output Carrier Frequency: Selectable; 0.5 to 12 kHz.
   14. Stop Modes: Programmable; includes fast, free-wheel, and dc coast or ramp to stop.

G. Isolated Control Interface: Allows VFDs to follow remote-control signal over a minimum 4:1 speed range.
   1. Signal: Electrical.

H. Internal Adjustability Capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.
   3. Acceleration: 0.1 to 999.9 seconds.
   4. Deceleration: 0.1 to 999.9 seconds.
   5. Current Limit: 30 to minimum of 110 percent of maximum rating.

I. Self-Protection and Reliability Features:
   1. Surge Suppression: Factory installed as an integral part of the VFD, complying with UL 1449 SPD, Type 1 or Type 2.
   2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
   3. Under- and overvoltage trips.
   4. Inverter overcurrent trips.
   5. VFD and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFDs and motor thermal characteristics, and for providing VFD overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
   6. Critical frequency rejection, with three selectable, adjustable deadbands.
   7. Instantaneous line-to-line and line-to-ground overcurrent trips.
   8. Loss-of-phase protection (drive and bypass mode).
   9. Short-circuit protection.

10. Motor-overtemperature fault.

J. Automatic Reset/Restart: Attempt five restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

K. Bidirectional Autospeed Search: Capable of starting VFD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

L. Integral Input Disconnecting Means and OCPD:
1. VFDs Without a Bypass System:
a. NEMA KS 1, fusible switch with pad-lockable, door-mounted handle mechanism.
b. Disconnect Rating: Not less than 115 percent of VFD input current rating.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFDs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFDs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.
1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 CONTROLS AND INDICATION

A. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
a. Control Authority: Supports at least four conditions: Off, local manual control at VFD, local automatic control at VFD, and automatic control through a remote source.

B. Historical Logging Information and Displays:
1. Real-time clock with current time and date and battery backup.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last three faults with time and date stamp for each.

C. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFD door and connected to display VFD parameters including, but not limited to:
1. Output frequency (Hz).

2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

D. Control Signal Interfaces:
   1. Electric Input Signal Interface:
      a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
      b. A minimum of six multifunction programmable digital inputs.
   2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS system for HVAC or other control systems:
      a. 0- to 10-V dc.
      b. 4- to 20-mA dc.
      c. Fixed frequencies using digital inputs.
   3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:
      a. Output frequency (Hz).
      b. Output current (load).
      c. DC-link voltage (V dc).
      d. Motor torque (percent).
      e. Motor speed (rpm).
      f. Set point frequency (Hz).
   4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
      a. Motor running.
      b. Set point speed reached.
      c. Fault and warning indication (overtemperature or overcurrent).
      d. PID high- or low-speed limits reached.

E. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
   1. Number of Loops: Two.

F. Interface with BAS System for HVAC: Factory-installed hardware and software shall interface with BAS system for HVAC to monitor, control, display, and record data for use in processing reports. VFD settings shall be retained within VFD's nonvolatile memory.
   1. Hardwired Points:
      a. Monitoring: On-off status.
      b. Control: On-off operation.
   2. Communication Interface: The standard protocols shall be Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet. Communication shall interface with BAS system for remotely control and monitor from an operator workstation. Control

features and monitoring points displayed locally at control panel shall be available through the BAS system and mapped to graphical user interfaces.

2.5 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations. Provide minimum 5 percent impedance AC line reactor or DC bus chokes of equivalent impedance.

B. Output Filtering: For separation between motor and VFD of greater than 100 feet, provide dV/dT filters.

C. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for the First Environment restricted level (Category C2).

2.6 OPTIONAL FEATURES

A. Multiple-Motor Capability: VFD suitable for variable-speed service to multiple motors. Overload protection shuts down VFD and motors served by it, and generates fault indications when overload protection activates.
   1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.

B. Damper control circuit with end-of-travel feedback capability.

C. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station or smoke-control fan controller, this password-protected input:
   1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
   2. VFDs Without a Bypass System: Forces VFD to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
      a. Final speed setting to be determined during commissioning, testing, and balancing of the ventilation system.
   3. Causes display of override mode on the VFD display.
   4. Reset VFD to normal operation on removal of override signal automatically.

D. Communication Port: RJ-45 port.

2.7 ENCLOSURES

A. VFD Enclosures: NEMA 250, to comply with environmental conditions at installed location.
   1. Dry and Clean Indoor Locations: Type 1.
   2. Mechanical Rooms and Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12:

3. Outdoor Locations: Type 4X.
4. Wash-Down Areas: Type 4X, stainless steel.
5. Other Wet or Damp Indoor Locations: Type 4.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFD as "Plenum Rated."

2.8 ACCESSORIES

A. Phase-Failure: Solid-state sensing circuit with isolated output contacts for hard-wired connections.

B. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

C. Programming Tools: To support the drive's life cycle from startup and monitoring, to backup, and performance tuning.

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFDs according to manufacturers' standard procedures and in accordance with ISO 9001, latest revision.
1. Test each VFD while connected to a full motor load that is comparable to that for which the VFD is rated, at rated drive amperes at 105 degrees Fahrenheit in a temperature chamber.
2. Verification of Performance: Rate VFDs according to operation of functions and features specified.

B. VFDs will be considered defective if they do not pass tests and inspections.

C. Test and inspection reports shall be available upon request.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks.

B. Roof-Mounting Controllers: Install VFD on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

C. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Comply with NECA 1.

F. Controllers shall be located so that door can be fully opened without interference.

3.3 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each VFD with engraved nameplate.
   3. Label each enclosure-mounted control and pilot device.

3.4 FIELD QUALITY CONTROL

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

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Inspect VFD, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
   3. Test continuity of each circuit.
   4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect before starting the motor(s).
   5. Test each motor for proper phase rotation.
   6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   8. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFDs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.

3.6 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges.

E. Set field-adjustable pressure switches.

F. All field adjustments shall be recorded and kept in cabinet with drawings.

3.7 STORAGE AND PROTECTION

A. Replace VFDs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION

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

END OF SECTION 230550

SECTION 234100 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Pleated panel filters.
   2. Rigid cell box filters.
   3. Front- and rear-access filter frames.
   4. Side-service housings.
   5. Filter gages.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
   1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
   2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
   3. Include diagram for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: For each filter bank, provide:

a. One complete set of filters at the start of testing, adjusting and balancing (TAB).
b. One complete set of filters for final turnover to owner.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
3. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Comply with NFPA 90A and NFPA 90B.

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

2.2 PLEATED PANEL FILTERS (TYPE A)

A. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr 30/30 or comparable product by one of the following:
1. 3M
2. AAF International
3. Airguard
4. Camfil Farr
5. Flanders Corporation
6. Koch Filter Corporation
7. Purafil, Inc.

B. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

C. Filter Unit Class: UL 900, Class 2.

D. Media: Cotton and synthetic fibers coated with nonflammable adhesive.

1. Media shall be coated with an antimicrobial agent.
2. Separators shall be bonded to the media to maintain pleat configuration.
3. Welded-wire grid shall be on downstream side to maintain pleat.
4. Media shall be bonded to frame to prevent air bypass.
5. Support members on upstream and downstream sides to maintain pleat spacing.

E. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.

F. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

G. Capacities and Characteristics:
1. Capacities, efficiencies, and size of filter units shall be as scheduled on the drawings.
2. Maximum or Rated Face Velocity: 450 fpm.
3. Efficiency: 90 percent on particles 20 micrometers and larger at 500 fpm.
4. MERV Rating: 8 when tested according to ASHRAE 52.2.
5. Recommended Final Resistance: 1.0" inches wg at 500 fpm.

2.3 RIGID CELL BOX FILTERS (TYPE B)

A. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr Riga-Flo or comparable product by one of the following:
1. 3M
2. AAF International
3. Airguard
4. Camfil Farr
5. Flanders Corporation
6. Koch Filter Corporation
7. Purafil, Inc.

B. Description: Factory-fabricated, self-supported, extended-surface, high efficiency media box filter with media perpendicular to airflow, and with holding frames.

C. Filter Unit Class: UL 900, Class 2.

D. Media: Microfine glass media in a uniform high loft blanket.
1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Media shall be coated with an antimicrobial agent.
3. The media blanket shall be formed into uniform tapered radial pleats and bonded to a stiffened backing that is bonded to the downstream side of the media to preclude media oscillation.
4. The media shall be mechanically and chemically bonded within the frame to prevent air bypass.

E. Filter-Media Frame: Corrosion resistant galvanized steel sealed or bonded to the media.

F. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

G. Capacities and Characteristics:
1. Capacities, efficiencies, and size of filter units shall be as scheduled on the drawings.
2. Maximum or Rated Face Velocity: 450 fpm.

3. MERV Rating: 13 when tested according to ASHRAE 52.2.
4. Recommended Final Resistance: 1.5" inches wg at 500 fpm.

2.4 FRONT- AND REAR-ACCESS FILTER FRAMES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr Type 8 or comparable product by one of the following:
1. 3M
2. AAF International
3. Airguard
4. Camfil Farr
5. Flanders Corporation
6. Koch Filter Corporation
7. Purafil, Inc.

B. Framing System: Galvanized-steel framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

C. Prefilters: Incorporate a separate track with spring clips, removable from front.

D. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.

E. The frame shall include filter-centering dimples on each frame wall to facilitate ease of filter installation and assure filter centering against filter sealing flange.

2.5 SIDE-SERVICE HOUSINGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr Type 3P Glide/Pack or comparable product by one of the following:
1. 3M
2. AAF International
3. Airguard
4. Camfil Farr
5. Flanders Corporation
6. Koch Filter Corporation
7. Purafil, Inc.

B. Description: Factory-assembled, side-service housings, constructed of galvanized steel, with flanges to connect to duct or casing system.

C. Prefilters: Where indicated to be installed with prefilters, frame shall incorporate the capability of two stages of filtration with integral tracks to accommodate 2-inch- deep, disposable prefilters.

D. Access Doors: Hinged, with continuous gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.

E. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

F. The frame shall include filter-centering dimples on each frame wall to facilitate ease of filter installation and assure filter centering against filter sealing flange.

G. Accessories:
   1. Filter removal rod.

2.6 FILTER GAGES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. AirGuard; Clarcor Air Filtration Products, Inc.
   2. Dwyer Instruments, Inc.

B. Magnehelic diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
   1. Diameter: 4-1/2 inches.
   2. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg or Less: 0- to 0.5-inch wg.
   3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg or Less: 0- to 1.0-inch wg.
   4. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg or Less: 0- to 2.0-inch wg.
   5. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg or Less: 0- to 3.0-inch wg.
   6. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg or Less: 0- to 4.0-inch wg.

C. Accessories: Two 1/8" NPT plugs for duplicate pressure taps, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gage for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling-unit installations.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Test for leakage of unfiltered air while system is operating.

B. Air filter will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 234100