

SECTION 23 7323 - FACTORY FABRICATED CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Indoor and outdoor air handling units and components as scheduled and shown on drawings.
- B. Motor disconnects, motor starters, and variable frequency drives.
- C. Other required features.

1.2 RELATED DOCUMENTS

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

1.3 REFERENCES

- A. AMCA 99 – Standard Handbook
- B. AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes
- C. AMCA 500 – Test Methods for Louvers, Dampers, and Shutters
- D. AMCA 611-95 – Methods of Testing Airflow Measurement Stations for Rating
- E. ANSI/AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings
- F. ANSI/UL 900 – Test Performance of Air Filter Units
- G. AHRI 260 – Sound Rating of Ducted Air Moving and Conditioning Equipment
- H. AHRI 410 – Forced-Circulation Air Cooling and Air Heating Coils
- I. ANSI/AHRI 430 – Performance Rating of Central-Station Air Handling Units
- J. ASHRAE 52.1/52.2 – Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
- K. ASHRAE 62 – Ventilation for Acceptable Indoor Air Quality
- L. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
- M. ASTM-C 1338 – Standard Test Method for Determining Fungi Resistance of Insulation Material and Facings.
- N. NFPA 70 – National Electric Code (conductors, equipment and raceways)

- O. NFPA 90A – Installation of Air Conditioning and Ventilation Systems
- P. SMACNA – HVAC Duct Construction Standards
- Q. UL-181 – Mold Growth and Humidity Test
- R. UL-1995 – Standard for Safety for Heating and Cooling Equipment

1.4 QUALITY ASSURANCE

- A. Manufacturer shall have a minimum of 25 years of experience in designing, manufacturing, and servicing air-handling units.
- B. The design indicated on the schedules and shown on the drawings is based upon the products of the named manufacturer. Alternate equipment manufacturers are acceptable if equipment meets scheduled performance requirements and dimensional requirements.
- C. ARI Compliance:
  - 1. Comply with ARI 203/110 and ARI 303/110 for testing and rating energy efficiencies for RTUs.
  - 2. Comply with ARI 270 for testing and rating sound performance for RTUs.
- D. ASHRAE Compliance:
  - 1. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- E. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.
- G. UL Compliance: Comply with UL 1995.
- H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- I. Comply with FM Global requirements for fans and blowers, motors and VFD's, and for monitoring and diagnosis of vibration in rotating machinery.

1.5 COORDINATION

- A. If equipment is supplied by a manufacturer other than the one named, coordinate with the General Contractor and affected subcontractors to ensure the specified performance is met. This 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

B. The Mechanical Contractor shall be responsible for costs incurred by the General Contractor, Subcontractors, and Consulting Engineers to accommodate units furnished by a manufacturer other than manufacturer named as basis of design.

#### 1.6 RATINGS AND CERTIFICATIONS

- A. Air Handling Unit safety: ETL or UL 1995
- B. Air Handling Unit energy use: ASHRAE 90.1
- C. Fans: AMCA 210
- D. Air Coils: AHRI 410
- E. Air Handling Unit certification program: ANSI/AHRI 430
- F. Filter media: ANSI/UL 900 listed Class I or Class II
- G. Control wiring: NEC codes & ETL requirements
- H. Motors: Federally mandated Energy Policy Act (EPACT).
- I. Airflow Monitoring Stations: AMCA 611-95

#### 1.7 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design RTU supports to comply with project wind performance requirements, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1. Wind-Restraint Performance:

- a. **Basic Wind Speed: <Insert value>.**
- b. **Building Classification Category: [I] [II] [III] [IV].**
- c. **Minimum XX lb/sq. ft multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.**

#### 1.8 SUBMITTAL DOCUMENTATION REQUIRED

A. **[LEED Submittals:**

1. **Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.**
2. **Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."]**

- B. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - 1. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
  - 2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
  - 3. Wind-Restraint Details: Detail fabrication and attachment of wind restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
  
- C. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Structural members to which RTUs will be attached.
  - 2. Roof openings
  - 3. Roof curbs and flashing.
  
- D. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 23 0550 "Vibration Isolation."
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force 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.
  
- E. Furnish fan performance ratings and fan curves with specified operating point clearly plotted.
  
- F. Furnish drawings indicating unit dimensions, required clearances, field connection locations, wiring diagrams, shipping drawings, and curb drawings.
  
- G. Furnish performance report showing unit level performance data including: fan(s), motor(s), coil(s) and other functional components. Performance report shall also include unit casing performance.
  
- H. Furnish operation and maintenance data, including instructions for lubrication, filter replacement, motor and drive replacement, and condensate pan cleaning; spare parts lists, and wiring diagrams.
  
- I. Adjust and report performance ratings for the proper altitude of operation.
  
- J. Report air-handling unit performance ratings in accordance with ANSI/AHRI-430 (static pressure, airflow, fan speed, and fan brake horsepower).
  
- K. Report static pressure profiles by component section.
  
- L. Report coil ratings in accordance with AHRI-410 (capacities and pressure drops).
  
- M. Report unweighted octave band AHU 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. 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 AHU products. Provide data for inlets and outlets as scheduled. Report unweighted casing radiated sound power over the same 8 octave bands in accordance with ISO 9614 Parts 1&2 and ANSI S12.12.

- N. Airflow measuring device performance shall be certified and rated in accordance with AMCA-611. Report data in accordance with AMCA-611. Provide AMCA Certified Rating Seal for Airflow Measurement Performance.
- O. Report panel deflection at **+/-10" [12"] w.g.**, stated in terms of 'L/X' where 'L' is the casing panel length and 'X' is a constant provided by the AHU manufacturer.
- P. Report casing leakage rate at **+/-10" [12"] w.g.**, specified in terms of percentage of design airflow.
- Q. Report weight loads and distributions by component section.
- R. Report product data for filter media, filter performance data, filter assembly, and filter frames.
- S. Report electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- T. Report motor electrical characteristics.
- U. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.
- V. List of items for project turnover to the University, when they received same, and University sign-off.
- W. Northwestern University Maintenance Requirement Forms, see Division 01.

#### 1.9 DELIVERY, STORAGE AND HANDLING

- A. Comply with ASHRAE 62, Section 5 (mold and corrosion resistant casings, filters upstream of wetted surfaces, and drain pan design).
- B. Comply with ASHRAE 62, Section 7 (practices to be followed during construction and startup). Protect equipment from moisture by appropriate in-transit and on-site procedures.
- C. Follow manufacturer's recommendations for handling, unloading and storage.
- D. 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.
- E. 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.
- F. Enclose and protect control panels, electronic or pneumatic devices, and variable frequency drives. Do not store equipment in wet or damp areas even when they are sealed and secured.

- G. Seal openings to protect against damage during shipping, handling and storage.
- H. Wrap indoor units with a tight sealing membrane. Wrapping membrane shall cover entire AHU during shipping and storage. Cover equipment, regardless of size or shape. Alternatively AHU must be tarped for shipment and storage.
- I. Wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion. Keep equipment clean and dry.
- J. Tarp outdoor units to protect against rain and road debris during shipping.
- K. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

1.10 EXTRA MATERIALS

- A. Provide one set of filters for balancing, and one additional set for final turnover to owner.
- B. Provide one extra set of belts, in addition to the factory-installed set.

1.11 WARRANTY

- A. Provide warranty for 5 years from date of turnover to the Owner at substantial completion, see Division 01. Warranty shall cover manufacturer defects. Warranty work shall be performed by manufacturer's factory-trained and factory- employed technician.
- B. Include factory-provided controls in the parts warranties.
- C. Parts associated with routine maintenance, such as belts and air filters shall be excluded.

1.12 SYSTEM STARTUP

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.
- B. Comply with manufacturer's start-up requirements to ensure safe and correct operation and integrity of warranty.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on schedule as **YORK Custom, div. of Johnson Controls Inc.** or comparable product by one of the following:
  - 1. Buffalo Air Handling.
  - 2. Gouvernaire Corp.
  - 3. HuntAir.
  - 4. TMI.

5. Trane Custom TCFS, div of Ingersoll Rand Inc.

## 2.2 GENERAL UNIT REQUIREMENTS

- A. Coils shall be arranged so that space between the coils is a minimum of 24".
- B. Fan compartments shall be arranged such that the space between the fan inlets and the housing is a minimum of one fan diameter.
- C. Arrangement of components shall be such that coil face velocity distribution shall not vary by more than 20% from the average coil velocity.
- D. Coil assemblies shall have provisions to facilitate total or partial removal from coil bank. Removal panels shall be provided on both sides of the unit.
- E. Multiple coil banks shall have coils independently supported.
- F. Outdoor and return air mixing sections shall be arranged to minimize stratification.

## 2.3 UNIT CASINGS

### A. Unit Casing Performance

1. Leakage shall be no more than 1/2% of rated unit CFM at +/- 10" static pressure. Manufacturer shall perform a factory leakage test on at least one unit. Customer shall select which unit to test. Perform test at 10" static pressure. If unit fails at the factory, manufacturer shall seal and retest unit until it meets specified performance.
2. Deflection shall be no more than L/240 of panel length at +/- 10" static pressure. Manufacturer shall perform a factory deflection test on at least one unit. Customer shall select which unit to test. Measure deflection on the largest wall panel. Perform test at 10" static pressure. If unit fails, manufacturer shall add structural support required to achieve specified performance.
3. Thermal performance:

- a. Unit wall shall not sweat with interior air temperature of XX°F and exterior air at XX/XX db/wb*
- b. R-value of wall shall be R-13[R19] [R25] at the center of panel.*

- B. 4" foam injected thermal break (thermal breaks in cooling coil sections and downstream from same) in walls: Construct walls with interior and exterior sheet metal surfaces, welded internal post structure, and 4' of injected foam insulation. Foam board or fiberglass insulation is not acceptable.

### 1. Interior Liner:

- a. Galvanized Steel, G90 shall be 22 ga [20 ga, 18 ga].*
- b. Stainless Steel, 304 shall be 20 ga [18 ga, 16 ga].*
- c. Stainless Steel, 316L shall be 22 ga.
- d. Pre-painted galvanized steel shall be 18 ga [16 ga].*
- e. Aluminum, 3003 shall be 0.05" thick (0.05" thickness is equivalent to 16 ga. Aluminum).
- f. For fan sections, liner to be perforated with stand-offs for insulation liner and minimum 1 mil Tedlar liner*

2. Exterior surface
  - a. **Galvanized Steel, G90 shall be 20 ga [18 ga, 16 ga, 14 ga].**
  - b. **Stainless Steel, 304 shall be 20 ga [18 ga, 16 ga].**
  - c. Stainless Steel, 316L shall be 16 ga.
  - d. **Pre-painted galvanized steel shall be 18 ga [16 ga].**
  - e. Aluminum, 3003 shall be 0.04" thick, textured (0.04" thickness is equivalent to 18 ga. Aluminum).
3. Internal Post Structure: Formed galvanized 16 ga steel C-channel. Structure shall be fully welded. Post spacing shall be designed to provide L/240 wall deflection at +/- 10"
4. w.g. Maximum post spacing shall be 24" on centers.
5. Fasteners
  - a. Exterior Fasteners
    - 1) For outdoor units, units with stainless steel or aluminum exterior walls use self-tapping series 400 stainless steel sheet metal screws to fasten exterior sheet metal walls to post frame structure on 18" centers
    - 2) For indoor units use self-tapping rust inhibited sheet metal screws to fasten exterior sheet metal walls to post frame structure on 18" centers.
  - b. Interior Fasteners
    - 1) For Galvanized interior liner: use self-tapping rust inhibited sheet metal screws to fasten interior and exterior sheet metal walls to post frame structure on 27" centers.
    - 2) For Stainless steel or aluminum interior liner: use self-tapping series 400 stainless steel sheet metal screws to fasten exterior sheet metal walls to post frame structure on 27" centers
6. Casing Joints: Joints shall be mechanically fastened. Fasteners shall not extend from the outside to the inside of the unit. Use angle to fasten and seal walls at corners, floors, and roofs.
7. Sealing: Seal joints with polyurethane water resistant sealant, no additional coating.
8. **Mill finish for galvanized steel casings: Immediately after cleaning and pre-treating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of polyurethane prime coat and polyester thermosetting topcoat. Coating shall pass ASTM B-117 1,000 hour salt spray test. Color shall be manufacturer's standard champagne.**
9. **Factory applied high build (3 to 5 mils) alkyd enamel. Coating shall pass ASTM B-117 500 hour salt spray test. Color shall be manufacturer's standard champagne, or Architect shall specify color.**
10. **Factory applied single coat industrial 2-part epoxy shall be 3 – 4 mils and pass ASTM B- 117 3,500 hours salt spray test. Color shall be manufacturer's standard champagne, or Architect shall specify color.**
11. **Factory applied double coat industrial 2-part epoxy shall be 6 – 8 mils and pass ASTM B- 117 3,500 hours salt spray test. Color shall be manufacturer's standard champagne, or Architect shall specify color.**
12. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2013.

C. Roofs

1. Construction of the roof shall be identical to the wall construction specified.
2. Unit roof for outdoor units are to be sloped a minimum pitch of ¼" per foot.
3. The roof shall overhang all side and end panels to prevent precipitation drainage from streaming down the unit wall panels. Gutter systems are not acceptable.
4. Roofs less than 12' wide shall be sloped to the non-door side of the unit; roofs 12' wide and wider shall be peaked in the center and sloped to both sides of the unit.
5. Roof construction shall accommodate a minimum snow-load of 30 lb/ft<sup>2</sup>.
6. Roof shall be designed to hold a 300lb load for service and maintenance.
7. The roofing system shall consist of a white (or custom color) 100% acrylic elastomeric coating with "Mildewcide". Coating shall be a minimum 20 mils thick. Coating shall meet the following requirements:
  - a. CRRC Solar Index Rating of 112 per ASTM E1980-01
  - b. CRRC Initial Solar Reflectance of 0.89; 0.81 after 3 years
  - c. CRRC Initial Thermal Emittance of 0.89; 0.87 after 3 years
  - d. Fungi Resistance per ASTM G21 of zero growth
8. Outdoor roofs supplied with non-sloped roofs or standing seam roof systems are not acceptable.
9. For all outdoor roof duct connections provide a minimum 1.5" duct flange.

D. Casing Insulation and Adhesive:

1. Materials: ASTM C 1071, [**Type I**] [**Type II**].
2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the cooling-coil section.
  - a. Liner Adhesive: Comply with ASTM C 916, Type I.
  - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
  - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service-air velocity.
3. Location and Application: Encased between outside and inside casing.

E. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall, 4-inch insulated panels of same material type and thickness as unit casing.
2. Inspection and Access Panels:
  - a. Fasteners: Attached to unit casing with tek screws with EPDM washers on maximum 9-inch centers.
  - b. Gasket: ¾" wide x 1/8" thick PVC gasket applied around entire perimeters of panel frames [**and the access opening**].
  - c. Construction: Factory shall provide double sided tape where liner is attached to internal supports.
3. Access Doors:

- a. Frames: Type 6063-T6 aluminum extrusion, **[with thermal break for "no through metal" construction]**, welded at the corners and attached to the unit casing with **[plated, stainless steel]** hardware.
  - b. Hinges: A full height stainless-steel piano hinge with minimum two roller cam latches per door, operable from inside and outside. Rotating knife-edge or "paw" latches are not acceptable. **[Provide galvanized, Z-type safety latch for all outward opening access doors opening with unit pressure.]**
  - c. Handles: Glass fiber reinforced, UV rated, padlockable, nylon polyamide as manufactured by Allegis Corporation.
  - d. Gasket: EPDM-sponge, applied around entire perimeters of panel frames. [Provide one set of spare door gaskets for each access door.]
  - e. Viewports: Provide **[8"x8", 12"x12"]**, **[single pane, thermal pane]** viewing window centered in each access door with wire-reinforced safety glass.
  - f. Test Ports: Ventlok No. 699 instrument test holes installed in door locations as required to measure pressure drops across unit.
  - g. Rain Lip: Provide rain lip of same material type as unit casing attached with tek screws above all access doors.
  - h. Interlock Switch: Provide Nema 3R, plunger type interlock switch mounted on doors as noted on submittal drawing.
- F. Service Vestibule (recommended on outdoor units with at least six (6) ft. of interior clearance): Air handling unit(s) shall be provided with a service vestibule equivalent to the unit casing, having a minimum thermal conductivity R of 12 /hr-ft<sup>2</sup>-°F/BTU.
1. Service vestibule shall be a minimum six (6) ft. wide by full height and length of the unit.
  2. Service vestibule floor construction shall be the same as the unit floor.
  3. Selected access doors are provided as indicated in door section of this specification.
  4. Selected lighting and outlets provided as indicated in the electrical section of this specification (if selected). Lights shall provide a minimum of 10 foot-candles of illumination per OSHA 1926.56(a) standards for mechanical equipment rooms.
  5. ***Vestibule shall be provided with [208/240V 1-3Phase, 5KW or 480V 3Phase, 5KW] electric heater with integral thermostat set to maintain a minimum of 50 deg F. (if selected).***
  6. ***Vestibule shall be provided with hot water unit heater with wall mounted thermostat set to maintain a minimum of 50 deg F. (if selected).***
  7. Provide ventilation for removing heat of motor starters or other devices located within the vestibule.
- G. Pipe-Chase:
1. Air handling unit(s) shall be provided with an external pipe-chase consisting of casing equivalent to the unit casing, having a minimum thermal conductivity R of 12 hr-ft<sup>2</sup>-°F/BTU.
    - a. Pipe-chase shall be **[24"]****[36"]****[48"]** to provide sufficient space for coil connections to be installed without interference.
    - b. [Loose-shipped pipe-chase enclosures shall be provided with lifting lugs for field installation (if any loose shipped).]
    - c. Pipe-chase shall be provided with **[18"]****[24"]****[30"]** doors. Doors shall be the same construction as the main unit doors. Door quantities shall match contract drawings.
    - d. Pipe chase floor construction shall be the same as that of the unit.

2. Air handling unit(s) shall be provided with a recessed pipe chase consisting of casing equivalent to the unit casing, having a minimum thermal conductivity R of 12 hr-ft<sup>2</sup>-°F/BTU. Pipe chase shall be flush with the unit exterior.
  - a. Pipe-chase shall be [24"][36"][48"] to provide sufficient space for coil connections to be installed without interference.
  - b. [Optional: Internal pipe chase shall be furnished with an additional [24"][36"][48"] external pipe chase extension.]
  - c. Pipe-chase shall be provided with [18"][24"][30"] doors. Doors shall be the same construction as the main unit doors. Door quantities shall match contract drawings.
  - d. Pipe chase floor construction shall be the same as that of the unit.

## H. Floors:

1. Floor shall be 10 ga. hot rolled steel [stitch welded, caulked and sealed] [full seam welded] to the base.
  - 1) ***[Floor shall be 18 ga [10 ga., 12 ga., 14 ga., 16 ga.] G90 galvanized steel stitch welded, caulked and sealed to the base.]***
  - 2) ***[Floor shall be [12 ga., 16 ga.], Type [304, 316L] stainless steel [stitch welded, caulked and sealed] [full seam welded] to the base.]***
  - 3) ***[Floor shall be [0.125-in, 0.100-in] aluminum diamond plate [stitch welded, caulked and sealed] [full seam welded] to the base.]***
  - 4) ***[Floor shall be [0.125-in, 14 ga.] hot rolled steel diamond plate [stitch welded, caulked and sealed] [full seam welded] to the base.]***
  - 5) ***[Floor shall be 0.125-in, Type 304 stainless steel diamond plate [stitch welded, caulked and sealed] [full seam welded] to the base.]***
  - 6) ***Floor shall be insulated with [2-inch, 3-inch, 4-inch] polyurethane spray foam insulation.***
2. Floor shall be thermally isolated from welded base frame members (perimeter and internal supports). Construction without thermally isolated floor and walls shall not be acceptable.
  - 1) Floor shall have upturned lip with fully welded seams, and be capable of holding 2-inch of water. Penetrations through the floor shall not exist. Construction allowing screws or bolts to penetrate floor shall not be allowed. All floor openings shall have a fully welded 2" upturned lip.
  - 2) Each section shall be equipped with drain connection to facilitate washdown and maintenance. Drain connection shall be extended through the base and have a removable cap installed.
  - 3) All internal equipment shall be provided with a minimum 2-inch high base to raise equipment and components off the unit floor for housekeeping.
- b. Floor Paint:
  - 1) ***[Factory applied high build (3 to 5 mils) alkyd enamel. Coating shall pass ASTM B-117 500 hour salt spray test. Color shall be manufacturer's standard champagne or as specified by Architect.]***
  - 2) ***[Factory applied single coat industrial 2-part epoxy shall be 3 – 4 mils and pass ASTM B-117 3,500 hours salt spray test. Color shall be manufacturer's standard champagne.]***

- 3) ***[Factory applied double coat industrial 2-part epoxy shall be 6 – 8 mils and pass ASTM B-117 3,500 hours salt spray test. Color shall be manufacturer's standard champagne.]***

c. Subfloors:

- 1) ***[Subfloor shall be 0.05" Aluminum screwed to the base channel.]***  
 2) ***[Subfloor shall be [16 ga., 20 ga., 22 ga.] G90 Galvanized Steel screwed to the base channel.]***  
 3) ***[Subfloor shall be 20 ga. Type 304 Stainless Steel screwed to the base channel.]***

d. Floor Drains:

- 1) Factory shall provide 1-1/4" floor drain in segments where noted on the unit drawing.  
 2) Floor drain piping shall be **[Schedule 40 black steel, 304 stainless steel]** extended from the floor drain and terminated with a 1-1/4" MPT threaded connection to the exterior through the unit base.

e. Floor Openings:

- 1) Factory shall provide c-channel support around perimeter of all floor openings.  
 2) Factory shall provide **[galvanized steel, 304 stainless steel]** flattened expanded metal safety screen attached with screws over all floor openings.  
 3) Factory shall provide **[galvanized steel, 304 stainless steel, aluminum]** walk on grate attached with screws over all floor openings.

i. Baseraills:

1. ***[Type ASTM A36 welded structural steel c-channel, [6-inch, 8-inch, 10-inch, 12-inch] height, with cross supports spaced at regular intervals and removable lifting lugs. Factory shall provide curb angle welded to the base for outdoor curb mounted units.] [Type 6061 T6 welded structural aluminum, [6-inch, 8-inch, 10-inch, 12-inch] height, with cross supports spaced at regular intervals and removable lifting lugs.]***  
 2. ***[Factory applied high build (3 to 5 mils) alkyd enamel. Coating shall pass ASTM B-117 500 hour salt spray test. Color shall be manufacturer's standard champagne or as specified by Architect.]***  
 3. ***[Factory applied single coat industrial 2-part epoxy shall be 3 – 4 mils and pass ASTM B- 117 3,500 hours salt spray test. Color shall be manufacturer's standard champagne.] [Factory applied double coat industrial 2-part epoxy shall be 6 – 8 mils and pass ASTM B-117 3,500 hours salt spray test. Color shall be manufacturer's standard champagne.]***

- J. Fan Removal Beams: For any units with fans 4'-0" or higher, fan removal beams/devices shall be included in unit.

2.4 FAN ARRAYS (Also Refer to Section 23 3400 "Fans"):

- A. Fan Arrays: Fan arrays shall consist of multiple direct-drive, arrangement 4, modular plenum fans selected to provide the scheduled airflow at the scheduled total static pressure. Fans

shall be statically and dynamically balanced and designed for continuous operation at maximum- rated fan speed and motor horsepower. Fans shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise beyond the peak efficiency to ensure quiet and stable operation. Fans shall have a non-overloading design with self-limiting horsepower characteristics and shall reach a peak in the normal selection area. All fans shall be capable of operating over the minimum pressure class limits as specified in AMCA's Standard 2408-69.

B. Internal Vibration Isolation: Refer to Section 23 0550.

C. Fan Options

1. Back-Draft Dampers: Each fan shall have an individual industrial grade low leak back-draft damper. Frame shall be minimum 9" deep x 2" (229 x 51) flanged 12 (2.8) gage galvanized steel channel. The blades shall be maximum 7" (178) wide, minimum .080 (2) thick, 6063T5 extruded aluminum airfoil shaped with integral structural reinforcing tube running full length of each blade. Damper blades shall be equipped with silicone rubber seals mechanically locked into extruded blade slots. Adhesive type seals are not acceptable. Adhesive type seals are not acceptable. Dampers shall be equipped with vinyl jamb seals for low leakage application. Wind stop type seals are not acceptable. Axles shall be minimum 3/4" (19) diameter with machined edge to provide positive locking connection to blades. Full round axles are not acceptable. Bearings shall be ball style pressed into frame. Linkage shall be minimum 3/16" thick 3/4" (5 x 19) bar located on face of blade in airstream. Submittal must include leakage, pressure drop, and maximum pressure data based on AMCA Publication 500 testing.
2. Airflow Measuring: Each fan shall include an Airflow Measuring System (AFMS) consisting of a piezometer ring mounted in the throat and a static pressure tap mounted on the face of the inlet cone. **[A differential pressure transducer [and an analog display] shall be provided. Transducer shall have a field configurable 0-5 VDC or 0-10 VDC output, as well as a 4-20 mA output. Transducer shall have a standard accuracy of ±1% FS.]** AFMS shall not obstruct the airflow in any way and shall have no effect on fan airflow performance, static pressure, or sound power levels.

## 2.5 MOTORS

- A. All fan motors shall comply with NEMA and IEEE for temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 0513 "Motors."

## 2.6 COILS AND COIL DRAIN PANS

- A. For coils, refer to Section 23 8216 "Coils" and meet requirements below

1. Cooling coil maximum face velocities at maximum design airflow to be 350 fpm.
2. Provide cooling coil drain pans that are sufficient to contain coil condensate. Drain pan shall be 16 ga. 304 Stainless steel **[16 ga. G-90 Steel][316L Stainless Steel]** construction and extend a minimum of 6 **[12] [18]** inches downstream of leaving face of the coil to allow for condensate pan access and maintenance and meet requirements for ASHRAE 62-2007. IAQ drain pan must slope in 3 directions and have single 304 Stainless steel 1.5 **[2]** inch connection for trapping at jobsite. Pans to be insulated double wall.

3. Provide a minimum of 24 inches clearance between preheat and cooling coil banks and provide access door as shown on drawings.
4. Locate access doors near coils connections to provide minimum clearance of 2 inches for field installed external piping insulation. Space shall allow a minimum of 90 degrees of door swing.
5. Provide coil segment casing that meets or exceeds casing thermal performance of the unit. Provide coil pull panel that are easily removable with no special tools. Coils shall be removable from the side of the AHU. **[For units with multiple stacked coils, provide a G-90 steel [304 stainless steel] [316L Stainless Steel] stacking rack to allow individual coils to be removed from side of AHU without disturbing any other coils].**

## 2.7 AIR FILTRATION

- A. Refer to Section 23 4114 "Filters".
- B. General Requirements for Air Filtration Section:
  1. Provide filter segments with filters and frames as scheduled, and per Section 23 4114 "Filters."
- C. Filter Gages:
  1. **[3-1/2-inch- (90-mm-)] [2-inch- (50-mm-)]** diameter, diaphragm-actuated dial in metal case.
  2. Vent valves.
  3. Black figures on white background.
  4. Front recalibration adjustment.
  5. **[2] [3] percent of full-scale accuracy.**
  6. **Range: [0- to 0.5-inch wg (0 to 125 Pa)] [0- to 1.0-inch wg (0 to 250 Pa)] [0- to 2.0-inch wg (0 to 500 Pa)] [0- to 3.0-inch wg (0 to 750 Pa)] [0- to 4.0-inch wg (0 to 1000 Pa)].**
  7. **Accessories: Static-pressure tips with integral compression fittings, 1/4-inch (6-mm) [aluminum] [plastic] tubing, and 2- or 3-way vent valves.**

## 2.8 DAMPERS

- A. **Refer to Section XX XXXX if smoke dampers required, Section XX XXXX if isolation dampers required, and Division 25 if control dampers required.**

## 2.9 HUMIDIFIERS

- A. Refer to Section 23 8413 "Humidification Equipment."

## 2.10 SOUND ATTENUATORS

- A. If the required sound attenuation can be provided with integral fan housing attenuators, that is acceptable, but if not, see below.
- B. Sound attenuator (silencer) segments shall be provided as shown on drawings and as scheduled. Silencers shall be rectangular, 24" **[36", 60"]** long sound attenuators as indicated on drawings and equipment schedule.

- C. Outer casings of rectangular silencers shall be made of 22 gauge type #G-90 lock-former- quality galvanized steel **[304 stainless steel]**.
- D. Interior partitions for rectangular silencers shall be not less than 26 gauge type #G-90 galvanized lock-former-quality perforated steel **[304 stainless steel]**.
- E. Filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin- and moisture-proof. **[Filler material shall be totally encapsulated and sealed with polymeric film of an appropriate thickness. The encapsulated fill material shall be separated from the interior perforated baffles by means of a noncombustible, erosion resistant, factory-installed, acoustic stand-off. It shall not be acceptable to omit the acoustic stand-off and try to compensate for its absence by means of corrugated baffles. (Hospital grade)]**
- F. Combustion ratings for the silencer acoustic fill shall be not greater than the following when tested to ASTM E 84, NFPA Standard 255, or UL No. 723:
  - 1. Flamespread Classification 20
  - 2. Smoke Development Rating 20

#### 2.11 AIR BLENDERS

- A. Multiple-blade, air-mixer assembly shall mix air to prevent stratification.
- B. Air blenders shall be of the rotary turbulating design consisting of radially extending blades. Units shall be completely fixed devices, with no moving parts.
- C. Static air mixers material shall be .080" or .125" thick aluminum  **[.095" 304 Stainless Steel]**. Static air mixers shall be welded.
- D. When multiple air blenders are used, they shall impart a counter rotational mixing of the airstreams relative to each other. Simple mixing devices that do not produce expanding discharge with counter rotational mixing will not be acceptable.
- E. The air blenders shall be installed such that the blender shall be capable of providing a minimum mixing effectiveness of 75% and  $\pm 6$  °F standard deviation when mixing 50% OA with 50% RAS at 50 °F inlet temperature differential, and minimum mixing effectiveness of 80% and  $\pm 5$  °F standard deviation when mixing 30% OA with 70% RAS at 50 °F inlet temperature differential.

#### 2.12 SUPPLY FAN DISCHARGE AIR SOUND ATTENUATION BARRIER

- A. Unit shall include a discharge air sound attenuation barrier. The passive sound attenuator barrier shall be mounted on the downstream side of the supply fan and shall block line of sight between the fan and the unit discharge opening. End panel sound attenuator shall be used with top, bottom and side discharge openings

#### 2.13 TESTING

- A. **[Perform factory test on a fully assembled unit with sections joined per manufacturer's installation instructions. Use of additional material (tape, sealant, caulk) shall be**

*minimized to only that required to simulate permanent jobsite conditions not otherwise duplicable in the factory.]*

- B. [Factory performance to be witnessed by owner's representative. Owner's representative shall select one unit, at time of release, to be tested. Manufacturer shall notify contractor and/or owner 14 days prior to test for witnessing. (Travel expenses are not part of this contract). A written report shall be provided showing the test results and the test methods used.]**
- C. [Factory Panel Deflection Test: The unit manufacturer shall provide a factory deflection test on one unit. Casing panel deflection shall not exceed  $L/240$  at  $\pm 10$ " w.g. (or as required by AHRI 1350.) 'L' is defined as the panel span length and 'L/X' is the deflection at panel midpoint. Measurements shall be taken along the vertical seam of the largest panel on the side.]**
- D. [Factory Leak Testing: The unit manufacturer shall provide a factory leak test on one unit across the cabinet exterior walls. Casing leakage shall not exceed 0.5% of design CFM at  $\pm 10$ " w.g. (or as required by AHRI 1350.)] Sections that will be negative pressure shall be tested under negative pressure and sections that will be positive pressure shall be tested under positive pressure.**
- E. [Factory Sound Pressure Testing: The unit manufacturer shall test one unit for sound power of AHU discharge and/or return openings using sound pressure measurements. All sound pressure level measurements shall be made with a Type 1, Precision Sound Level Meter that complies with both ANSI S1.4 & ANSI S1.4A. Sound meter's octave band filters shall conform to ANSI1.11 and be calibrated with handheld acoustical calibrator immediately before each measurement session. Sound pressure readings shall be reviewed and converted to sound power level by a professional engineer (acoustical engineer) using established ANSI S12.34 and ISO 3744 methods. Testing per AHRI 260 or AMCA 300 will be considered acceptable alternative methods. All other test methods must be approved by Engineer prior to bid.]**
- F. [Factory Sound Power Testing: The unit manufacturer shall test one unit for sound power of AHU discharge and/or return openings using sound intensity measurements. All sound intensity level measurements shall be made with a Type 1-D analyzer meeting the requirements of ANSI S1.11 for octave and 1/3 octave band filters. Analyzer shall be periodically calibrated with reference sound source as specified in Section 5.8 of ANSI S12.12. Sound Intensity measurements shall be performed by professional engineer (acoustical engineer) using methods based on AHRI Standard 230. Testing per AHRI 260 or AMCA 300 will be considered acceptable alternative methods. All other test methods must be approved by Engineer prior to bid.]**
- G. Should a unit fail a test, the unit shall be treated with a permanent remedy at manufacturer's expense until test is successfully passed.**
- H. Unit(s) shall be tested at the extreme winter and summer ambient and airway conditions stated in the design and performance data sheets.**

## 2.14 LIGHTS AND OUTLETS

- A. Lights

1. Vapor Resistant Pendant: Factory shall provide vapor resistant pendant, marine type light fixture with clear globe, metal guard, and **[100W incandescent, 23W compact fluorescent]** bulb in segments and quantity as noted on drawings.
2. Fluorescent Twin Tube: Factory shall provide 48" fluorescent light fixture with corrosion resistant housing, acrylic diffuser and twin 32W, T8 lamps and rated for installation in damp environment.
3. Provide low temperature ballasts for fixtures in low temperature locations. Ballasts to be electronic.
4. Factory shall wire all light fixtures to a common 120v switch located on the supply fan segment.
5. Factory shall wire each light fixture to a separate 120v switch located near the access door of the segment with the light fixture.

## B. Outlets

1. Factory shall provide a 15A GFI duplex outlet mounted in a weatherproof enclosure in segments and quantity as indicated on the drawings.

## 2.15 LOUVERS AND HOODS

## A. Louvers

1. Provide 16 ga., galvanized steel, stationary type, drainable blade louver with downspouts in the jamb and mullions and 1/4" sq. galvanized mesh birdscreen. Blades shall be housed inside a 16 ga. galvanized steel frame flush mounted to the unit exterior. Louver to be pre-painted with baked enamel finish in a manufacturer's standard color as selected by the Architect.

## B. Weather Hood

1. Provide weather hood of same material type and thickness as unit exterior skin with 1/4" **[1/2"]** sq. galvanized mesh birdscreen.

2.16 **OTHER UNIT FEATURES/REQUIREMENTS:**

- A. **Provide galvanized steel safety step assemblies with railing(s) from roof up to service corridor entry door(s).**
- B. **Provide gutters over unit exterior doors with downspouts extending to below doors.**
- C. **For all exterior and interior doors, provide sleeves and seals.**
- D. **Provide gasketed and capped test ports for all sections of the unit.**
- E. **Provide all required framing, safing, supports, etc., for all components to be installed in the unit, including (but not limited to): Fans, dampers. coils, piping, humidifier grids, attenuators, heat exchangers, etc.**
- F. **Fixed or telescoping fan motor removal beams.**
- G. **Moisture eliminators.**
- H. **Washdown construction with capped drains**

- I. Stainless steel coil raising structures inside unit if required for proper cooling coil drain trapping and/or steam condensate trapping/drainage.***
- J. Humidifier control valves, strainers and valves shall be outside the airstream.***
- K. Do not locate humidifiers upstream of fan sections. The preferred location for humidifier sections are downstream of the fans.***
- L. Humidifiers shall be located 18" downstream of heating coils and a minimum of 3' upstream of cooling coils.***

### PART 3 - EXECUTION

#### 3.1 INSTALLATION

- A. Install equipment per industry standards, applicable codes, and manufacturer's instructions.
- B. Do not use AHUs for temporary heating, cooling or ventilation prior to complete inspection and startup performed per this specification.
- C. Install AHUs on a concrete pad, roof curb, or structural steel base, as shown on drawings.
- D. Install AHUs with manufacturer's recommended clearances for access, coil pull, and fan removal.
- E. Provide one complete set of filters for testing, balancing, and commissioning. Provide second complete set of filters at time of transfer to owner.
- F. Install AHU plumb and level. Connect piping and ductwork according to manufacturer's instructions.
- G. Install pipe chases per manufacturer's instructions.
- H. Insulate plumbing associated with drain pan drains and connections.
- I. Install insulation on all staggered coil piping connections, both internal and external to the unit.

#### 3.2 FIELD QUALITY CONTROL

- A. Store per AHU manufacturer's written recommendations. Store AHUs indoors in a warm, clean, dry place where units will be protected from weather, construction traffic, dirt, dust, water and moisture. If units will be stored for more than 6 months, follow manufacturer's instruction for long-term storage.
- B. Rig and lift units according manufacturer's instructions.

### 3.3 AHU INSPECTION

- A. Hire manufacturer's factory-trained and factory-employed service technician to perform an inspection of unit and installation prior to startup. Technician shall inspect and verify the following as a minimum:
1. Damage of any kind
  2. Level installation of unit
  3. Proper reassembly and sealing of unit segments at shipping splits.
  4. Tight seal around perimeter of unit at the roof curb
  5. Installation of shipped-loose parts, including filters, air hoods, bird screens and mist eliminators.
  6. Completion and tightness of electrical, ductwork and piping
  7. Tight seals around wiring, conduit and piping penetrations through AHU casing.
  8. Supply of electricity from the building's permanent source
  9. Integrity of condensate trap for positive or negative pressure operation
  10. Condensate traps charged with water
  11. Removal of shipping bolts and shipping restraints
  12. Sealing of pipe chase floor(s) at penetration locations.
  13. Tightness and full motion range of damper linkages (operate manually)
  14. Complete installation of control system including end devices and wiring
  15. Cleanliness of AHU interior and connecting ductwork
  16. Proper service and access clearances
  17. Proper installation of filters
  18. Filter gauge set to zero
- B. Resolve any non-compliant items prior to unit start-up.

### 3.4 INSPECTION AND ADJUSTMENT: AHU FAN ASSEMBLIES

- A. Hire the manufacturer's factory-trained and factory-employed service technician perform an inspection of the AHU fan assemblies subsequent to general AHU inspection and prior to startup. Technician shall inspect and verify the following as a minimum:
1. Fan isolation base and thrust restraint alignment
  2. Tight set screws on pulleys, bearings and fan
  3. Tight fan bearing bolts
  4. Tight fan and motor sheaves
  5. Tight motor base and mounting bolts
  6. Blower wheel tight and aligned to fan shaft
  7. Sheave alignment and belt tension
  8. Fan discharge alignment with discharge opening
  9. Fan bearing lubrication
  10. Free rotation of moving components (rotate manually)

### 3.5 STARTUP SERVICE and OWNER TRAINING

- A. Manufacturer's factory-trained and factory-employed service technician shall startup AHUs. Technician shall perform the following steps as a minimum:
1. Energize the unit disconnect switch
  2. Verify correct voltage, phases and cycles
  3. Energize fan motor briefly ("bump") and verify correct direction of rotation.

4. Re-check damper operation; verify that unit cannot and will not operate with all dampers in the closed position.
  5. Energize fan motors and verify that motor FLA is within manufacturer's tolerance of nameplate FLA for each phase.
- B. Provide a minimum of 16 hours (but more if required based on actual project conditions and complexity, coordinate with University and HVAC Shop) of training for owner's personnel by manufacturer's factory-trained and factory-employed service technician. Training shall include AHU controls, motor starters, VFD's, and AHU's. Training shall be videoed and DVD's of same given to the University.
- C. Training shall include startup and shutdown procedures as well as regular operation and maintenance requirements.
- D. If AHU is provided with a factory-mounted variable frequency drive (VFD), hire the VFD manufacturer's factory-trained and factory-employed service technician to inspect, test, adjust, program and start the VFD. Ensure that critical resonant frequencies are programmed as 'skip frequencies' in the VFD controller.
- E. Submit a startup report summarizing any problems found and remedies performed.

### 3.6 FIELD PERFORMANCE VERIFICATION

- A. Leakage: Pressurize casing to maximum operating static pressure and measure leakage. If leakage exceeds 1% of design airflow, seal leakage points with a permanent solution. Repeat test. If the AHU still does not pass, contact the manufacturer to seal unit.
- B. Submit a field test report with testing data recorded. Include description of corrective actions taken.

### 3.7 CLEANING

- A. Clean unit interior prior to operating. Remove tools, debris, dust and dirt.
- B. Clean exterior prior to transfer to owner.

### 3.8 DOCUMENTATION

- A. Provide Installation Instruction Manual, & Startup checklist in the supply fan section of each unit.
- B. Provide six copies of Spare Parts Manual for owner's project system manual.

**END OF SECTION 23 7323**