

## CUSTOM AHU MASTER SPECIFICATIONS

### **237323 – Custom Central Station Air Handling Units**

#### **PART 1 – GENERAL**

##### **1.01 DESCRIPTION:**

- A. This section of the work includes the design, fabrication, testing, cleaning and packaging, shipment, final assembly and installation of custom built-up air handling units by the unit manufacturer in complete accordance with the following specification.
- B. The details outlined and component manufacturers named in this specification may not be deviated from in the air handling unit manufacturer's preparation of the bid, even where techniques are required which are not considered standard by the manufacturer. The construction as described in this specification is considered essential, and any deviation from this specification must be specifically identified and bid as a Voluntary Alternate (add or deduct), but only after complying with the specification defined as the Base Bid.

##### **1.02 QUALITY ASSURANCE:**

- A. All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified or as denoted on the drawings and schedule.
- B. Equipment furnished under this specification shall be in accordance with the following industry, association and government codes and standards, as applicable to their design, fabrication, assembly and testing.
  - 1. AMCA 99 Standards
  - 2. ARI 430 Central Station Air Handling Units
  - 3. NFPA 70 National Electric Code
  - 4. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating System
- C. Fans shall be rated in accordance with AMCA Standard 210 for performance and AMCA Standard 301 for sound and shall bear the AMCA seal. Motor shall meet requirements of NEMA, IEEE, ANSI, and NEC standard. Coils shall be rated in accordance with ARI Standard 410 and bear the ARI seal.
- D. Equipment within unit shall be UL listed where applicable.

##### **1.03 SUBMITTALS:**

- A. WITH THE QUOTATION: Provide the following detailed information on the equipment proposed. Unit manufacturer shall itemize all deviations from the specified requirements. If not so indicated, unit manufacturer will be required to furnish at no cost to the owner:
  - 1. Information requested in the RFQ, including equipment data sheets, schedules and sketches.
  - 2. Equipment drawings showing dimensions, weights (shipping & operating), configuration, major component locations, access door locations, duct connection sizes and locations, and shipping split locations.
  - 3. Materials of construction for housing and major components.



- B. AFTER PURCHASE: Make submittals in accordance with requirements of conditions of purchase. Submittals shall show Buyer's purchase order number, equipment number and project number. Information shall include, as applicable, but not be limited to the following:
1. Information submitted with quotation, revised and expanded as required; including airborne and transmitted sound power levels by octave band for unit.
  2. Fan manufacturer and performance curves with the operating points clearly indicated. Motor sizes and types.
  3. Coil selections with sizes rows, fin spacing, face velocity, air & fluid temperatures, flow rates, air & fluid pressure drops, and connection sizes.
  4. Proposed filters indicating size, efficiency, and pressure drop.
  5. (If applicable) Electrical data, wiring diagrams, and accessory panel layouts. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
  6. (If applicable) Factory testing procedures for review and acceptance.
- C. AFTER RECEIPT OF APPROVED DRAWINGS: Submit manuals with detailed description of installation, operation, and maintenance, including the following:
1. All approved "Certified for Construction" drawings.
  2. Written recommendations for field storage, both indoors and outdoors.
  3. Installation requirements including assembly instructions, lifting requirements and adjustments.
  4. Manufacturer's literature describing each piece of equipment including operation instructions with step by step preparation of starting, shutdown, and draining and maintenance instructions including lubrication.

**1.04 PRODUCT CLEANING, DELIVERY, STORAGE, AND HANDLING:**

- A. Thoroughly clean equipment, components and subassemblies of water, dirt, debris, weld splatter, grease, oil and other foreign matter prior to shipment.
- B. Unit to be prepped and completely sealed for protection during shipment.
1. Seal all openings in unit casings with gasketed, thin gauge sheet metal closure sheets.
  2. Seal closures, caps and plugs dust-tight and moisture-tight.
  3. Protect pipe flanges with plywood coverings; protect pipe threads with plastic end caps or plugs.
  4. Protect machined surfaces with suitable, easily removable rust preventive.
  5. Provide full charge of proper lubricant for grease lubricated bearings.
  6. Provide desiccant bags or vapor phase inhibitors where required to keep components dry.
- C. **(optional – add \$)** Ship all air handlers with complete protection from rain and dirt. Air handlers shipped on open trailers shall be protected with a minimum of two (2) layers of heavy mill shrink wrap plastic. Covering units with tarpaulins will not be acceptable since tarpaulins may damage the unit surface.
- D. Units delivered with scratched, dented, or dirty surfaces or damage of any type shall be restored to "as new" condition as directed by the Architect/Engineer/Owner at no cost to Owner.
- E. If equipment is to be stored before use, shipping protection provided by the unit manufacturer shall remain on the unit until the unit is installed. Manufacturer shall submit written recommendations for field storage.



- F. Provide non-corrosive nameplate permanently attached to the equipment containing the following information:
1. Manufacturer's project/serial number
  2. Plant name and location
  3. Customer equipment number
  4. Date of manufacture

**1.05 WARRANTY:**

- A. All equipment, materials, and workmanship shall be warranted for (12) months from startup or (18) months from shipment, whichever period expires first. During the warranty period, the manufacturer shall repair or replace, at no additional cost to the Owner, any equipment, material, or workmanship in which defects may develop.
- B. Warranty is for parts only; labor to remove or reinstall parts is the responsibility of others.
- C. **(optional – add \$)** The manufacturer to provide full one year parts and labor warranty after owner acceptance. The warranty labor to be performed by a factory authorized technician; technician shall be capable of responding in a 2 hour period, 24 hours a day, 7 days per week. Warranty work may be required after hours to accommodate owner requirements.

**PART 2 - PRODUCTS**

**2.01 MANUFACTURERS:**

- A. Provide air handling units as manufactured by: Air Enterprises, **(add others; consult AE for preferences)**
- B. Alternate pricing based on pre-approved manufacturers will be considered if the following performance requirements and construction techniques are adhered to in all respects. Any substitutions shall be approved by the Architect/Engineer/Owner in writing ten (10) days prior to bid.
- C. The unit manufacturer shall have been manufacturing custom built-up air handling units for a minimum of 20 years.

**2.02 CUSTOM BUILT-UP AIR HANDLING UNITS:**

- A. Custom built-up units shall be of the configuration, capacity and style as indicated on the drawings and Equipment Schedule and as specified herein. Through properly designed access; ease of maintenance, removability of components, and unit serviceability shall be assured.
- B. The units shall be constructed for **(select)** indoor / outdoor installation. **(If outdoor chosen) Outdoor units to be provided with weatherproofing (roofing, gutturing, etc.) as defined herein.**
- C. The units shall consist of: **(develop appropriate listing)** intake sections for return and outside air, mixing section with dampers for outside air, return air and exhaust air, pre-filter section, final filter section, heating coil section, cooling coil section, humidifier section, supply and return fan sections, diffuser section, and discharge section.
- D. **(optional)** Units shall be provided with a complete lighting system with switches and receptacles, damper operators furnished and installed on all dampers, and motor wiring to safety disconnect switches.
- E. Unit shall employ aluminum material (panels, bases, supports, safing, etc.) to reduce overall unit weight and minimize facility maintenance requirements.



- F. Provide safing between internal components and unit casing to prevent air bypass. Safing material shall match unit interior. All seams or voids between safing, components and unit casing shall be caulked and sealed airtight.
- G. Provide hygienic unit design with interior suitable for washing down. The use of support members framed within the unit casing which will allow for trapping of debris between the supports and casing will not be allowed. Unit insulation must be completely encapsulated.
- H. The unit is to be shipped factory assembled in one complete section, when possible. If necessary to ship the unit in sections, due to rigging or shipping constraints, the unit is to be designed to minimize the number of sections. **(optional) The unit manufacturer shall field erect the units in place at the jobsite.**
- I. The unit sizes shown on drawings are established based on unit performance, structural, and access requirements and are not to be altered. **(optional) Maximum allowable section size to be h'-h" H x w'-w" W x d'-d" L & xx,xxx lbs.**

### **2.03 UNIT BASE:**

- A. The unit shall be constructed on an all-aluminum or stainless steel structural base. The base shall be designed to distribute loads properly to a suitable mounting surface and be braced to support internal components without sagging, pulsating or oil canning.
- B. The unit base shall be provided with sloped sumps in areas as indicated on the drawings. Sumps to be welded and guaranteed waterproof to serve as a drain pan to prevent building water damage from the unit. Sump to be double-sloped (min. ¼" per foot) towards units drains to positively remove condensate from the unit.
- C. The base floor shall be minimum 3/16" thick aluminum plate welded at all joints and to structural members. Floor material shall have **(select) smooth / safety-tread** surface. The base floor shall be designed for a minimum live load of 100 pounds per square foot throughout the unit. The base floor is to be supported with adequate stiffening members to prevent oil canning. Caulking, gaskets and mechanical fasteners to guarantee seals and water tightness of joints will not be acceptable.
- D. The perimeter support members shall be a minimum of 6" structural member properly sized to support all major components and the housing during rigging, handling and operation of the unit.
- E. The underneath side of the base pan and base perimeter shall be insulated with minimum 2" thick 1.5-pcf high density polyisocyanurate foam insulation to form a vapor barrier. **(optional – outdoor units)** Vapor barrier is then protected by a 0.040" thick aluminum sheet attached to the bottom of the base.
- F. Each section of the unit base shall contain a minimum 1" NPT drain to facilitate system washdown, maintenance and condensate removal. Areas in the base where potential standing water cannot be removed through drains or weep holes are not acceptable. Clean out drains shall be provided with removable caps of non-corrosive material.
- G. All equipment within air handling unit shall be provided with a minimum 2" high base to raise equipment off unit floor for housekeeping. Equipment mounted directly on unit floor is unacceptable.
- H. Supply air openings to be framed with 2" high water dam continuously welded to the pan to allow proper duct connections and to prevent moisture from entering the openings. Framed openings shall be provided with removable aluminum or 304 stainless steel grating designed and fabricated for a live load of 100 pounds per square foot. Galvanized or painted steel grating will not be accepted.



- I. All unit base service openings shall be framed with a minimum 2" high water dam continuously welded to the floor. All pipe and electric conduit chases with openings to building or elements shall be covered with thin gage aluminum or 304 stainless steel. Penetrations by contractors shall be sealed by the respective contractor.
- J. Fastening to floor plate or joining of unit sections to be accomplished by bolting through gasketed joints above the floor line or continuously welding. Fasteners which penetrate base floor plate are not acceptable.
- K. Unit to be provided with properly located permanent lifting plates or removable lifting lugs for each section to adequately allow rigging of the unit sections in place.
- L. **(optional – as applicable)** Base plates shall be provided for attachment to the perimeter members for securing the unit to the floor to prevent movement created by seismic conditions. Base plates and bolt patterns shall be provided in such a manner that the forces are evenly distributed over the base of the unit.

#### **2.04 UNIT CASING**

- A. Air handling unit casing shall be built up from the unit base with panels. The unit manufacturer shall be the manufacturer of the panel system. Panels shall be load bearing and capable of forming the enclosure without additional structural members. Panels shall be joined together with independent joining member and fastened with closed end aluminum rivets or stainless steel fasteners. Plated fasteners will not be accepted.
- B. **(optional)** Panel joints and seams shall be sealed with FDA approved sealant. Other sealing methods or materials must be approved by the Architect/Engineer/Owner in writing before application.
- C. All panels shall be double wall all-aluminum construction with minimum 0.040" exterior and interior skin thicknesses. Interior finish to be smooth, mill finish; exterior finish to be a low-reflective textured mill finish. Each panel shall contain an integral frame or be properly supported by a structural framing system. Panel shall have continuous tight seal at the interior and exterior skins completely encapsulating the insulation.
- D. The minimum panel thickness shall be 2-1/2" thick with 3-pcf high density **(select)** fiber / polyisocyanurate foam insulation. The panel R value shall be a minimum of 12 or greater.
- E. Thickness of the panel skin, core density, rib structural frame spacing shall be regulated to eliminate panel pulsation and restrict the maximum deflection to 1/200 of any span at design load of 1-1/2 times the design positive or negative pressure plus snow and wind loading.
- F. Casing system shall be guaranteed to assure the owner that system capacity, performance, and cleanliness standards specified are not compromised. Leakage to be guaranteed at no more than 1/2% of the design volume at 1-1/2 times the design operating pressure or 30 CFM, whichever is greater.
- G. All casing walls shall be of panel construction, including but not limited to the fan discharge walls, mixing section walls and divider wall to the access corridor.
- H. **(optional)** Panel system shall incorporate an integral thermal break system downstream of cooling coil such that there is no through metal path between the interior and exterior surface of the unit casing at all locations. The thermal break shall consist of a minimum 1/2" structural epoxy bridge. Adhesive tapes or gaskets do not constitute an acceptable thermal break. Criteria to evaluate requirement for thermal break system shall be based upon scheduled unit performance and ambient conditions anticipated around the units.
- I. Any equipment flashing, internal partitions or other attachments to the casing shall be made in such a way as to ensure a permanent leak-tight connection. Attachments that are bolted, screwed, or



welded to or through the casing creating air bypass, air leakage or rust propagation areas are not acceptable.

- J. All ductwork penetrations through unit enclosure shall be provided with framed openings of size and arrangement as indicated on drawing. **(optional) Openings to be provided with flanged duct connections of same material as casing interior extending a minimum of 4" from surface of unit casing.**
- K. Pipe and conduit penetrations through the unit casings shall be provided by the unit manufacturer and be properly sealed prior to leaving the factory. Penetrations sealed by simply caulking around extension are not acceptable.
- L. Provide minimum 24" wide access doors for access to all internal components. Access doors shall be installed to open against the greatest pressure relative to air pressure on each side of access door.
  - 1. Access doors shall be of the same construction as panels described above.
  - 2. The access doors shall incorporate two continuous separate gasket seals around the entire periphery of the door. Gasket material shall be UV-resistant, closed cell neoprene; gaskets shall be attached by adhesive and not mechanically held in place. Single gasket seals will not be accepted.
  - 3. Each access door shall contain a thermopane safety glass window (min. 10" square).
  - 4. **(optional) Provide 1" dia. test ports with screwed caps on casing upstream and downstream of all coils and filters for pressure and temperature measurement.**
  - 5. Each access door shall be mounted with a corrosion-resistant continuous piano hinge and shall have a least two (2) non-corrosive handles operable from either side.
- M. Removable access panels shall be provided as indicated on the drawings for service and maintenance. Access panels shall be of the same construction as panels described above. Removable access panels shall be designed and constructed such that removal and replacement may be accomplished without disturbing adjacent panels. Airtight integrity must be maintained.

## **2.05 ROOF SYSTEM (use for outdoor units)**

- A. Unit roofs for outdoor units are to be sloped a minimum of 1/4" per foot to assure positive run-off. Roof to **(select) peak in center and drain off to both sides / on door side and drain away from door side.**
- B. The entire roofing system shall be a polymer membrane permanently bonded to the unit roof. Membrane to be minimum 0.045" thick. Standing seam roofing system will not be acceptable.
- C. Unit shall be provided with a non-corrosive rain gutter system with downspouts to guide unit roof water run-off to the building roof. Units incorporating roof systems without controlled water run-off accommodations are not acceptable.

## **2.06 OUTSIDE AIR SECTION**

- A. Outside air shall be admitted and exhaust air shall be discharged through storm-proof, extruded aluminum or stainless steel louvers, minimum 3-1/2" deep with aluminum or stainless steel birdscreen and aluminum or stainless steel weather hoods. Weatherhood exterior to match the finish of the unit casing.  
**(optional) Outside air shall be admitted through drainable blade stationary fog-type louver. Louver shall be certified storm-proof, extruded aluminum, with aluminum birdscreen. Louver to be Cesco Products, Type ASL6.**
- B. Louver shall have AMCA certified air performance and water penetration ratings.



- C. **(optional)** Louver to be provided with a low-leakage outside air damper. Dampers shall be as specified below and shall be furnished and installed by the unit manufacturer.
- D. Outside air intake shall be sized for a maximum of 450 fpm. Exhaust air discharge shall be sized for a maximum of 750 fpm.

## **2.07 MIXING SECTION**

- A. Complete with framed openings with low-leakage outside and return air dampers. Dampers shall be as specified below and shall be furnished and installed by the unit manufacturer.
- B. Mixing section shall be designed for controlled mixing in that the proximity, relation, and air velocity for each respective damper shall be such that volume swings and stratification will be eliminated.
- C. Outside air damper banks incorporating minimum outside air to be provided with an independent damper with independent control for minimum outside air. Minimum outside air provided by controlling outside air damper bank to a minimum position will not be acceptable.

## **2.08 DAMPERS**

- A. Dampers shall be low leakage, opposed blade design capable of withstanding 8" wg differential pressure at 2,000 fpm approach velocity. Leakage rate not to exceed 6 CFM per ft.<sup>2</sup> at 4" wg differential pressure and 2,000 fpm approach velocity.
- B. Damper frames shall be made of extruded aluminum. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures. Dampers shall be provided with stainless steel blade end seals and flexible synthetic blade edge seals.
- C. **(optional)** Damper actuators to be mounted by unit manufacturer. Damper actuator to be Johnson Controls - model D3153 or equal. Actuators for dampers with modulating control to be provided with pilot positioners.
- D. Acceptable dampers: Arrow 'AFD-20', Ruskin 'CD-50', TAMCO 1500, Greenheck.

## **2.09 SUPPLY & RETURN FAN SECTIONS:**

- A. Provide fans, motors and drives of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications.
- B. **(housed fans)** Fan sections shall be complete with DWDI, arrangement 3, centrifugal fans as per the following:
  1. Fan housing shall be heavy gauge construction with spun inlet cones. Housings shall be suitably braced to prevent vibration or pulsation. Scroll housing shall be connected to sideplates with a high quality air tight seal; seam shall be continuously welded as required for application. Bearing supports shall be rigid and shall provide a firm foundation for the shaft and bearings. Bearings supported from the fan housing will not be acceptable.
  2. Fan wheels shall be non-overloading, airfoil type. Impellers shall be statically and dynamically balanced to a level of G6.3 (per ANSI 2-19) or better. Hubs shall be straight bored, keyed and set screwed to the shaft. Shafts are to be solid steel sized for first critical speed of at least 1.25 times the maximum speed for the class for class I and II fans and 1.42 times the maximum speed for class for class III and IV fans.
  3. Bearings are to be heavy duty, grease lubricated, anti-friction, self-aligning, pillow block type and selected for minimum average bearing life (AFBMA L-50) in excess of 200,000 hours at the maximum class RPM. All bearings shall be equipped with regreasable Zerk fittings and lubrication lines extended to accessible location on fan housing for easy access for lubrication.



4. Fan shall be provided with heavy gauge wire inlet screens, housing access door, and scroll drain as required. In the event inlet vanes are provided, fan will not require inlet screens.
  5. Fan shall be cleaned, prime coated and provided with two coats of enamel final coat.
  6. Each fan shall be test run at their operating speed or at the maximum RPM for the particular fan's construction class prior to shipment. The fans are to be balanced and records maintained of the readings in the axial, vertical, and horizontal direction on each of the fan's bearings. Final peak velocity measurements shall not exceed 0.1 in/sec.
  7. Acceptable fan manufacturers: Twin City Fan, Greenheck, Cook, New York Blower
- C. **(plenum fans)** Fan sections shall be complete with SWSI, arrangement, **(select) 3 (belt-drive) / 4 (direct-drive)**, plenum fans as per the following:
1. Fan unit shall be formed by welding heavy gauge steel inlet plate with spun inlet cones to steel angle frame. **(Arr. 3 only) Bearing supports shall be rigid and shall provide a firm foundation for the shaft and bearings. Bearings supported from the fan housing will not be acceptable.** A square formed lip shall surround the unit, suitable for attachment of flex connector.
  2. Fan wheels shall be non-overloading, airfoil type. Impellers shall be statically and dynamically balanced to a level of G6.3 (per ANSI 2-19) or better. Hubs shall be straight bored, keyed and set screwed to the shaft. Shafts are to be solid steel sized for first critical speed of at least 1.25 times the maximum speed for the class for class I and II fans and 1.42 times the maximum speed for class for class III and IV fans.
  3. Bearings are to be heavy duty, grease lubricated, anti-friction, self-aligning, pillow block type and selected for minimum average bearing life (AFBMA L-50) in excess of 200,000 hours at the maximum class RPM. All bearings shall be equipped with regreasable Zerk fittings and lubrication lines extended to accessible location on fan housing for easy access for lubrication.
  4. Fan shall be provided with wire mesh protective wheel enclosure and heavy gauge wire inlet screen. In the event inlet vanes are provided, fan will not require inlet screens.
  5. Fan shall be cleaned, prime coated and provided with two coats of enamel final coat.
  6. Each fan shall be test run at their operating speed or at the maximum RPM for the particular fan's construction class prior to shipment. The fans are to be balanced and records maintained of the readings in the axial, vertical, and horizontal direction on each of the fan's bearings. Final peak velocity measurements shall not exceed 0.1 in/sec.
  7. Acceptable fan manufacturers: Twin City Fan, Greenheck, Cook, New York Blower
- D. Motors shall be 1750 RPM, 460V/3ph/60Hz as per the following:
1. Motor shall be premium efficient, **(select) ODP / TEFC** enclosure.
  2. Motor shall be of HP as listed on schedule and be selected for a minimum of 10% over calculated BHP. The motor service factor shall be a minimum of 1.15. **(Substitute for arr. 4 direct-drive) Motor shall be of HP listed on schedule; selected to provide adequate torque throughout entire range of fan operation and not exceed nameplate HP when fan operates at synchronous motor speed.**
  3. Motor shall be designed for continuous duty operation, NEMA Design B with class F insulation.
  4. The motor shall be suitable for operating with variable frequency drives without undue noise, vibration or deterioration of reliability and life.
  5. Motors shall be "Inverter Ready" per NEMA Std. MG1 part 31.4.4.2 and labeled as such.





6. Provide stainless steel nameplate indicating the following:
  - a) NEMA efficiency index nominal efficient (MB1-12.53BO).
  - b) AFBMA bearing numbers.
  - c) Lubrication instructions.
7. Acceptable motor manufactures: Baldor, Marathon Electric, TECO - Westinghouse
- E. The entire fan assembly shall be provided with a minimum of 18" clearance on all unattached sides for proper service access. Fan inlets to be provided with a minimum clearance distance equal to 75% of the wheel diameter.
- F. The unit manufacturer shall provide flexible connection between fan and fan wall. Fan assembly shall be provided with thrust arrestors as required to prevent damage to the flex connection. Flex connection material shall be flame retardant fabric suitable for intended use meeting the requirements of NFPA 90A.
- G. The fan and motor shall be factory-mounted on a **(select) spring / inertia** type vibration base. The base shall be mounted on **(select) stable free standing spring / adjustable, seismically restrained (seismic zone 4)** isolators with 3" maximum deflection rating. Spring efficiency to be not less than 98%. **(optional when using inertia base) The inertia base shall have additional mass equal to two times the fan weight. Mass to be provided by concrete installed by the general contractor during unit installation at the jobsite.**
- H. **(Arr. 3 fans only)** Motor shall be mounted on an adjustable motor base affixed to the fan vibration base. The motor base shall control belt tension in order to minimize belt servicing and extend belt life. The motor base shall be permanently aligned type so belts can be changed without having to realign the motor and V-belt drive. The motor base shall be mounted parallel to belt pull for maximum bearing life.
- I. **(Arr. 3 fans only)** The V-belt drive shall be the constant speed type provided with a minimum of two (2) drive belts. Drives with two (2) belts shall have a minimum service factor of 2.0; all other drives shall have a service factor of 1.5. **(optional) The unit manufacturer shall provide one (1) set of additional sheaves as required to balance the unit for the system. Installation of any additional sheaves shall be the responsibility of the balancing contractor.**
- J. **(Arr. 3 fans only)** V-belt drive shall be enclosed in a perforated metal belt guard. The belt guard is to be a two-piece design split along shaft centerlines; fastened with two quick disconnect clasps so that access to the belts can be made without the use of any tools. Designs resulting in loose hardware will not be accepted. Beltguard shall have framed holes at the fan & motor shaft with cover plates to allow for tachometer measurements.
- K. **(Optional)** Fan section to be provided with structural I-beam assembly posted from the unit floor for mounting trolley to assist in motor removal; trolley assembly by others. Beam assembly to be steel construction; cleaned, prime coated and provided with two coats of enamel final coat.
- L. **(Optional - dual fan arrangements)** Each fan shall have an isolation damper to isolate one of the fans off-line for servicing while the second fan continues to operate. Damper shall be per the following:
  1. Dampers to be installed with the damper blades positioned vertically. Dampers shall be low leakage, opposed blade design capable of with standing 8" wg differential pressure at 2,000 fpm approach velocity. Leakage rate not to exceed 6 CFM per ft.<sup>2</sup> at 4" wg differential pressure and 2,000 fpm approach.
  2. Damper frames shall be made of extruded aluminum. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures. Dampers shall be provided with stainless steel blade end seals and extruded silicone blade edge seals.



3. Dampers shall be provided with two sets of linkage; one set concealed in the side frame of the damper and one set mounted from the blades on the face of the damper. Dampers are to be driven from an extended drive rod.
  4. **(optional) Damper actuators to be mounted by unit manufacturer. Damper actuator to be Johnson Controls – D-3240 series or equal.**
  5. Acceptable dampers: Arrow 'AFD-20', Ruskin 'CD-50', TAMCO 1500.
- M. All features, as outlined above shall be provided in order to reduce fan system maintenance downtime and minimize equipment service.

**2.10 (optional) AIR FLOW MEASUREMENT**

- A. Provide as indicated on the accompanying plans, airflow measurement provision **(optional) and transmitters** for the purpose of continuously monitoring unit airflow volume.
- B. The airflow measurement system shall consist of a piezometric flow ring incorporated into the inlet of the fans. Ring shall consist of a minimum of four orifice ports strategically located in the throat of the fan inlet; orifice taps to be piped with tubing in a continuous ring. Tubing to be extended to accessible location for connection to flow transmitter.
- C. Piezometric ring to be provided integral with the fan construction.

**2.11 (optional) (select) DIFFUSING SCREEN / EVASE DIFFUSER SECTIONS**

**DIFFUSING SCREEN**

- A. Provide air diffusing screen downstream of supply fan to disperse air evenly across the downstream components. Free area of total diffusing screen area shall be equal to twice the area of the fan discharge.
- B. Diffusing screen shall be minimum 1/8" thick aluminum material, 1/2" holes on 11/16" centers, mounted on aluminum vertical angles extending the full height of the unit section. Screen shall be rigidly bolted into place to prevent undue vibration and noise.
- C. Diffusing screen shall be located not less than 12" from the fan discharge wall. Minimum clearance of 24" is required downstream of screen to adequately service final filters.

Or **EVASE**

- A. Provide air diffusing evase downstream of supply fan to disperse air evenly across the downstream components and provide regain of velocity pressure at fan discharge.
- B. Evase sides to provide total expansion angle at 15 °; top and bottom of evase expansion angle to be total 30 °. Evase length shall not be less than 75% of the fan wheel diameter for optimum regain.
- C. Evase shall be minimum 16 ga galvanized steel material with edges sealed for maximum strength and minimum leakage. Evase shall be rigidly braced to prevent undue vibration and noise.
- D. Evase to be mounted with leaving edge fixed to the fan discharge wall. Flexible connection to be provided between the fan and the evase.

**2.12 FILTER SECTIONS:**

- A. Provide all prefilters and final filters of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Filters to be selected for a maximum face velocity of **500** fpm.



- B. Filters shall have nominal rating of 500 fpm. Each cell shall be 24" x 24", or 12" x 24". Initial pressure drop shall not exceed that indicated. Media shall be approved and listed as Underwriters Laboratories Class 2 when tested according to UL Standard 900 and as described below:
1. Prefilters: 2" thick **MERV 7** efficiency (per ASHRAE Test Standard 52.2-2007), and **MERV 12** (per ASHRAE Test Standard 52.2-2007), rigid disposable filters.
  2. Final Filters: 12" rigid type, **MERV 15** (per ASHRAE Test Standard 52.2-2007), rigid disposable filters.
  3. HEPA Filters: **99.97% (when tested with 0.3 micron thermally generated particulates) high capacity HEPA filters tested and certified.**
- C. Filters shall be upstream removable. Side access is not acceptable. Pre-filter sections shall be complete with holding frames capable of holding prefilters with high efficiency filters. Prefilters shall be capable of being removed and installed without affecting seal of the high efficiency filter.
- D. Filter frames upstream of cooling coils or humidifiers shall be galvanized steel construction; stainless steel or aluminum construction required for locations downstream of cooling coils or humidifiers. Frames to be provided with closed cell neoprene gasketing and all associated clips required to hold filter cells.
- E. Filter holding frames shall be installed and individually sealed to prevent leakage around frames. Filter banks shall be reinforced with vertical stiffeners to assure rigidity. Unit manufacturer shall provide flashing between filter banks and unit casings to prevent air leakage or bypass around the frames. Installation techniques, sealing methods, and structural reinforcement eliminate unfiltered air bypass and assure system cleanliness based on filter efficiencies specified.
- F. Unit manufacturer shall provide and install a Dwyer series 2000 magnehelic gauge complete with stainless steel static pressure tips and accessories for indicating the operating pressure drop of each filter bank. Indicating range of gauge shall be selected at two times the final resistance of the filter bank.
- G. Unit manufacturer shall provide **xxx (x)** sets of prefilter media and **xxx (x)** sets of final filter media, **(optional) and one (1) set of HEPA filter media with the unit for installation by others.**
- H. Acceptable filter frame and filter manufacturers: American Air Filter, Farr

### **2.13 COOLING COIL SECTION (CHILLED WATER):**

- A. Provide chilled water cooling coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of **500** fpm; maximum head pressure loss of 20 ft.
- B. Chilled water coils shall have minimum 0.025" thick, 5/8" diameter, copper tubes, 0.0075" **(select) aluminum / copper** fins, nonferrous headers with min. 1/2" dia. MPT drain and vent connections. Coil casings shall be minimum 16 gauge 304 stainless steel. Coil fin spacing shall not exceed 10 fpi.
- C. Coils shall be circuited to provide the required performance; the use of internal restrictive devices, or turbulators, to obtain turbulent flow will not be acceptable.
- D. Coils shall be tested to 250 psig under water and shall be guaranteed for 200 psig working pressure.
- E. Coils shall be individually supported by a stainless steel rack system. This rack shall allow any one (1) coil to be removed though the unit casing, normal to the direction of air flow, without disturbing any other coil. Coils stacked one on top of the other will not be accepted.



- F. Each coil shall include a sloped, positive-draining stainless steel condensate pan assembly. Drain pan to be constructed from minimum 18 gauge 304 stainless steel material. Coils shall set above the condensate pan for ease of removal. Intermediate condensate drain pan shall be minimum 1-1/2" deep; extending at least 3" upstream and at least 12" downstream of the coil face. Each drain pan shall be individually piped down to the bottom pan; lower drain pan to be provided with a drain connection of sufficient size to remove condensate extended to the unit exterior for connection by others.
- G. Where necessary to prevent moisture carryover, each coil shall have aluminum or stainless steel moisture eliminators provided on the downstream side. Cooling coils condensate pans shall be designed and manufactured to incorporate future eliminators without any field modification.
- H. Supply and return connections are to be extended and sealed through the casing wall; drain and vent connections shall be terminated internally. **(optional) piped with ball valves and hose bibs for the drain.**
- I. Provide removable access panels in the unit casing on each side of the unit for ease of coil removal.
- J. Acceptable coil manufacturers: Coilmaster, Heatcraft, Aerofin, Greenheck

#### **2.14 HEATING COIL SECTION (HOT WATER):**

- A. Provide hot water heating coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of **550** fpm; maximum head pressure loss of 15 ft.
- B. Coils shall have minimum 0.020" thick, 5/8" diameter, copper tubes, 0.0075" **(select) aluminum / copper** fins, nonferrous headers with min. 1/2" dia. MPT drain and vent connections, and aluminum coil casing. Coil casings shall be minimum 16 gauge galvanized steel; aluminum or stainless steel casings required for coils located downstream of cooling coils or humidifiers. Coil fin spacing shall not exceed 10 fpi.
- C. Coils shall be circuited to provide the required performance; the use of internal restrictive devices, or turbulators, to obtain turbulent flow will not be acceptable.
- D. Coils shall be tested to 250 psig under water and shall be guaranteed for 200 psig working pressure.
- E. Coils shall be individually supported by an all-aluminum rack system. This rack shall allow any one (1) coil to be removed through the unit casing without disturbing any other coil.
- F. Supply and return connections are to be extended and sealed through the casing wall; drain and vent connections shall be terminated internally. **(optional) piped with ball valves and hose bibs for the drain.**
- G. Acceptable coil manufacturers: Coilmaster, Heatcraft, Aerofin, Greenheck

#### **2.15 STEAM HEATING COILS**

- A. Provide steam heating coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of 700 fpm; maximum tube length of 8 ft.
- B. Coils shall be non-freeze type heating coils. Coils shall have 1" seamless copper condensing tubes and 5/8" OD seamless copper distribution tubes, 0.035" tube wall thickness, 0.0075" **(select) aluminum / copper** fins, and steel headers. Coil casings shall be minimum 16 gauge galvanized steel; aluminum or stainless steel casings required for coils located downstream of cooling coils or humidifiers. Coil fin spacing shall not exceed 10 fpi.
- C. The coil design shall allow for one end of the tubes to be free floating to allow for expansion.



- D. Complete coils shall be tested to 315 psig under water and shall be guaranteed for 250 psig working pressure.
- E. Coils shall be individually supported by an all-aluminum rack system. This rack shall allow any one (1) coil to be removed through the unit casing without disturbing any other coil.
- F. Supply and return connections are to be extended and sealed through the casing wall.
- G. The coils shall be located in the unit such that the condensate connections shall be a minimum of 18" above the unit base to allow for proper trapping.
- H. Acceptable coil manufacturers: Coilmaster, Heatcraft, Aerofin, Greenheck

**2.16 INTEGRAL FACE & BYPASS HEATING COILS (STEAM/HOT WATER)**

- A. Provide heating coils with integral face and bypass dampers of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of **750** fpm; maximum head pressure loss of 10 ft.
- B. Coils shall consist of built-in series of finned heating elements and by-passes with interlocked dampers controlled by a damper motor and air-stream thermostat. Dampers shall completely enclose and isolate the heating coil passes when no heating is required. Face & bypass arrangements not utilizing an integral coil and damper are not acceptable.
- C. Coils shall have minimum 0.035" thick, 5/8" diameter, copper tubes, 0.0075" **(select) aluminum / copper** fins, steel headers, galvanized finish steel dampers, and galvanized steel casing. Coil fin spacing shall not exceed 11 fpi.
- D. Coils shall be provided with coil manufacturer supplied destratification baffles and minimum 36" downstream clearance to next component for proper mixing of air downstream of coil.
- E. Complete coils shall be tested to 250 psig under water and shall be guaranteed for 200 psig working pressure.
- F. Damper motor to be provided and installed by **(select) others / air handling unit manufacturer**. Air handling unit manufacturer to coordinate with supplier of damper motor to assure proper mounting bracket is provided with the coil.
- G. **(optional) Airstream thermostat shall be provided with the coil by the air handling unit manufacturer.**
- H. Provide removable access plug panels on each side of the unit for ease of coil removal.
- I. Supply and return connections are to be extended and sealed through the casing wall; drain and vent connections shall be terminated internally. **(optional) piped with ball valves and hose bibs for the drain.**
- J. Acceptable coil manufacturers: Aerofin, Wing, Marlo 'Stratomizer'

**2.17 HUMIDIFIERS:**

- A. Provide panel type, steam dispersion humidifier designed for short absorption distribution of size, arrangement, and capacity as required for air handling system indicated on drawings and as stated in these specifications. Multiple dispersion tube type distribution will not be acceptable. Humidifier panel to be selected with maximum face velocity of **650** fpm.
- B. Absorption distance shall not exceed 24" at desired conditions. Air handling manufacturer shall be responsible for proper absorption distance for steam between humidifier and downstream components.



- C. Dispersion panel to be provided with stainless steel casings. Panel to be mounted on a stainless steel support structure with stainless flashing between humidifier and casing walls to prevent air bypass.
- D. Steam supply and condensate return connections are to be extended and sealed through the casing wall. The condensate connections shall be a minimum of 18” above the unit base to allow for proper trapping; if required, condensate trap to be installed by AHU manufacturer internal to unit.
- E. Humidifier is to be provided with pneumatic or electric operator with pilot positioner, F&T traps as required and Y-type strainer for steam supply line.
- F. Acceptable humidifier manufacturers: Armstrong, Carel, Dri-Steem.

**2.18 SOUND ATTENUATOR SECTION:**

- A. Sound attenuator sections shall be complete with individual battens the full height and full width of the section in order to provide uniform leaving air velocities and lower pressure drops. Modularized sound attenuator assemblies with horizontal air restrictions are not acceptable.
- B. The battens shall be of aluminum construction; filled with a fibrous inert core. Each batten shall consist of a solid aerodynamically styled nose piece with parallel perforated walls. Core material is to be covered with a tight weave cloth to prevent out-migration of fiber materials into the airstream; covering shall be porous material not diminishing the attenuating properties of the attenuators. Unit manufacturer shall guarantee lining cloth provided prevents out-migration of fibers.
- C. The attenuator manufacturer shall have published literature documented by independent test laboratories for acoustic performance of the sound attenuators.
- D. Minimum Net Insertion Loss (db) of the attenuators shall be as follows:
 

Octave Band No.	2	3	4	5	6	7	8
Center Frequency (kHz)	.125	.25	.5	1	2	4	8
Supply Air	-	-	-	-	-	-	-
Return Air	-	-	-	-	-	-	-
- E. Custom air handling unit inlet and outlet airborne sound power levels and radiated sound pressure levels shall be guaranteed to meet the specified sound levels and shall be the responsibility of the unit manufacturer

**2.19 UNIT DISCHARGE SECTION**

- A. Discharge section with exit velocities exceeding 2000 fpm shall be complete with aerodynamically designed framed discharge openings or spun bellmouth fittings in order to reduce overall system static pressures.
- B. Bellmouth fittings shall have minimum radius equal to 20% of the diameter (round or oval) or shortest side (rectangular) to provide optimum performance. Bellmouths with radius less than 2” are not acceptable. Bellmouth to be mounted flush with unit interior edge to minimize exit loss.
- C. Openings shall conform to the size and configuration of the ductwork where shown.
- D. Smoke dampers shall be furnished and installed by the unit manufacturer for supply air (and return air) openings as shown on the drawings. Dampers shall be as specified below:
  1. Dampers shall be parallel blade design capable of with standing 8” wg differential pressure at 2,000 fpm approach velocity. Damper shall meet requirements of Leakage Class II.
  2. Damper frames shall be made of extruded aluminum. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures. Dampers shall be

provided with stainless steel blade end seals and flexible synthetic blade edge seals to keep leakage to a minimum.

3. Damper linkage to be concealed in frame channel outside of the airstream. Dampers shall be provided with extended shaft for connection to actuators.
4. Damper actuators to be mounted by unit manufacturer. Provide a minimum of one pneumatic damper actuator per 16 ft.<sup>2</sup> maximum damper area. Damper actuator to be Johnson Controls - model D3153 or equal. Actuators for dampers with modulating control to be provided with pilot positioners.
5. Smoke dampers and operators shall be qualified under UL555S to a minimum elevated temperature of 250° F.
6. Acceptable dampers: Ruskin 'SD-50'.

## **2.20** **(optional for outdoor units) SERVICE CORRIDORS / SERVICE CLOSETS:**

- A. Unit to be provided with an **(select)** integral service vestibule / service closet.  
**(use for service vestibule)** Access corridor to be minimum five (5) ft. clear wide by full height and length of the unit. Access corridor to be of the same construction as the unit previously described. Access corridor floor shall be level without obstructions such as at joining sections that might act as trip points.  
**(use for service closet)** Provide a minimum 3 ft. wide service closet extending from the upstream side of the heating coils to the downstream side of the cooling coils to house and protect coil piping. The service closet shall be provided with dual full height access doors to allow complete access to closet interior and piping
- B. Provide a 3KW 3/60/460V electric unit heater with wall mounted thermostat for maintaining a minimum of 50°F temperature during winter operation. Provide factory mounted and wired heater, disconnect switch and thermostat. Provide ventilation for removing heat of variable speed drives and other devices within the vestibule.
- C. The service corridor shall provide for floor supporting of field piping installations. The support structure shall include a means for pipe hangers to be attached to supporting members. The support members shall be three feet on center and sized to support a uniform piping load of 250 lbs./ft.

## **2.21** **ELECTRICAL:**

- A. All electrical work shall be installed in full compliance with the National Electric Code, and all local codes and requirements. Where applicable, components shall be UL approved. All wiring and components inside air handling plenums shall be weatherproof and rated for such use. All equipment shall contain a grounding conductor.
  1. WIRING: 600 volt rated, type #12 THHN copper (minimum size).
  2. CONDUIT: EMT **(optional)** Aluminum rigid / Galvanized rigid conduit utilizing compression type fittings. All conduit penetrations in the unit housing and penetrations across the cooling coil sections and humidifier sections shall be internally sealed with foam sealant to prevent the migration of water vapor in the conduit.
- B. Unit manufacturer shall furnish, install and wire a complete lighting system to one (1) identified 120 volt feed location. Lighting system to include light fixtures, switches, and a GFCI receptacle per the following:
  1. LIGHT FIXTURES: vapor tight incandescent marine type guarded service light fixture, 100 watt (A-21) R.S. bulb. **(optional)** 120 volt, dust and moisture resistant, fluorescent light fixture, (2) 40 watt,

- cool white, rapid start bulbs. Each access section to be provided with minimum of one (1) light fixture. **(use for incandescent systems) Fan sections and filter sections to be provided with minimum of two (2) light fixtures.** Access corridors to have a minimum of three (3) light fixtures.
2. LIGHT SWITCHES: 20 AMP, single pole, specification grade, toggle switch in lug type device box with **(select) (indoor applications)** stainless steel / **(outdoor applications)** weatherproof cover.
  3. GFCI CONVENIENCE OUTLETS: 20 AMP, specification grade, NEMA 5-20R, duplex receptacle in lug type device box with **(select) (indoor applications)** stainless steel / **(outdoor applications)** weatherproof cover. Unit to be provided with one (1) convenience outlet on unit exterior at the fan section.
- C. Unit manufacturer shall furnish, install and wire a **(select) safety switch / fan motor disconnect** for each fan motor to one (1) identified 460 volt feed location. Final connection to motors shall be made through Sealtight flexible conduit.
1. FAN SAFETY SWITCH: 3-pole, heavy duty, horsepower rated, non-fusible, visible blade, disconnect switch in a **NEMA (select) (indoor use) 12 / (outdoor use) 3R or 4** enclosure.
- or FAN MOTOR DISCONNECTS: 3 pole, 600V, horsepower rated, heavy duty, visible blade, non-fused, NEMA **(select) (indoor use) 12 / (outdoor use) 3R or 4** safety switch with 2 pole control circuit interlock if used in conjunction with variable speed drive.

### **PART 3 -- EXECUTION**

#### **3.01 (optional as applicable) FACTORY UNIT TESTING:**

- A. Unit manufacturer shall provide tests at the factory to insure structural integrity, as well as compliance with this specification. **(select any assortment of tests)**
1. The unit fan shall be operated at the design RPM and a complete vibration spectrum shall be conducted. Such tests shall be performed on a completely assembled unit including all components. Readings shall be taken in the horizontal, vertical, and axial direction at each fan and motor bearing.
  2. The heating and cooling coils included with the air handling units shall be pressure tested.
  3. Unit manufacturer shall demonstrate that the actual performance matches scheduled unit performance by testing and operating unit at the design conditions; simulating external static pressure (providing for dirty filters and wet coils). Test shall include measurements of CFM, BHP and RPM at design TSP.
  4. The casing leakage test shall verify that unit casing leakage is less than 1/2% of design air flow at 1-1/2 times the design static pressure. The unit shall be sealed; pressure sections shall be put under positive pressure and suction sections shall be put under negative pressure. The leakage shall be measured in each section using a calibrated orifice plate. The total casing leakage (positive plus negative) shall be considered the sum of the positive and negative leakage.  
  
Failure to pass leakage test will subject the AHU manufacturer to penalties based on the total summation of energy cost for the additional casing leakage above 1/2% extended thru a 10-year operating period up to a maximum of 5% of the air handling unit value
  5. The assembled air handling unit shall be factory tested for sound power at the unit inlet and outlet; and sound pressure level at a three (3) foot distance from the unit casing. During test, unit shall be isolated from background noise and vibration or tested during periods when background noise and vibration are at a minimum.
- B. Factory testing shall assure the Owner and Engineer that any potential system performance concerns are addressed in the factory before unit shipment. Any unit modifications necessary as a result of



factory testing not meeting specified performance levels shall be done by the unit manufacturer at no additional cost to the owner prior to unit shipment. A formal written report including all test procedures and accepted results shall be submitted to the Engineer.

- C. The Owners representative/Engineer shall have the option to witness all tests. The manufacturer shall notify the Owners representative/Engineer four weeks prior to the scheduled factory test. Engineer will inform the manufacturer if a representative will witness the tests.

**3.02** **(optional as applicable) PRE-VALIDATION/INSPECTION:**

- A. The unit manufacturer shall inspect the unit to assure conformance to this specification. The inspections shall be verified by the Owner's representative. A formal inspection report including the Owner representative's verification shall be submitted by the unit manufacturer to the Engineer.
- B. Inspections shall include but not be limited to the following inspection requirements.
1. Verify materials of construction including material type, finish and thickness; perform magnet tests to confirm stainless steel material.
  2. Visually inspect weld quality. Check for proper weld size, contour and freedom from undercut (less than 1/32"), burn through, lack of fusion or full penetration, cracks, porosity, weld splatter, arc strikes, etc.
  3. Dimensionally inspect component and overall dimensions to confirm the accuracy of vendor records. Concentrate on field connection and mounting dimensions.
  4. Visually inspect surface finish as specified. Check freedom from sharp corners and edges; verify surfaces are smooth and snag-free.
  5. Visually inspect surface preparation prior to coating, plating, or painting. All mill scale, oil, weld slag, splatter, burrs, sharp edges, saw cut flashing, etc. must be removed.
  6. Visually inspect final assemble quality. Check paint, plating, or coating finish, thickness, and workmanship. Check for any distortion on welded components.
  7. Verify that the proper quantity, type, model no. and construction of bill of material and specification items are provided, including electrical components.
  8. Witness functional operation of all adjustable components.

**3.03** **INSTALLATION:**

- A. The unit manufacturer shall coordinate unit shipping and installation schedule with mechanical contractor. Mechanical contractor shall be responsible for the rigging, hoisting and coordination of the entire custom built-up air handling unit installation. Lifting and rigging instructions are to be provided by the unit manufacturer with the submittal drawings.
- B. **(optional)** The unit manufacturer shall provide factory authorized supervision to guide and assist in the joining and assembly of the air handling unit sections in the field. Manufacturer shall include a minimum of **xxx (x)** man days and one (1) trip for supervising joining of the unit sections. The unit manufacturer shall coordinate with other trade contractors, all necessary requirements to assure proper air handling unit installation.
- C. Mechanical contractor shall make all final ductwork and piping connections required for a complete operating system. **(optional)** Mechanical contractor shall coordinate roof curb installation with the general contractor and unit manufacturer.
- D. Electrical contractor shall provide connection of 460V/3Ph/60Hz power from motor control device to fan disconnect located on unit exterior. Electrical contractor shall also provide connection of 120V/1Ph/60Hz power from the building system to the lighting circuit provided with the unit.

- E. The temperature controls contractor shall install temperature controls and panel, including, pneumatic tubing, control wiring, etc., required for a complete and operating control system. Electrical contractor shall make final connections to the temperature control panel after the unit is installed.

**3.04 START-UP AND OWNER ORIENTATION:**

- A. **(optional)** Equipment start-up and owner maintenance orientation shall be the responsibility of the unit manufacturer in order to activate equipment warranty and assure that the Owner and his facility personnel are comfortable and familiar with equipment maintenance. Manufacturer shall include a minimum of **xxx (x)** man days and one (1) trip for start-up and owner maintenance training and orientation.
- B. The air handling unit manufacturer shall be responsible for proper operation and shall be required to meet the scheduled capacities and specified performance for this equipment.