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SECTION 237314 – CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Indoor Custom Air Handling Units.
   2. Outdoor Custom Air Handling Units.

1.3 PERFORMANCE REQUIREMENTS

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. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 125 percent of the operating static pressures indicated, without panel joints exceeding a deflection of L/200 where "L" is the unsupported span within the completed casings.

C. Environmental Loading Performance: Custom air-handling units shall withstand the effects of environmental loading (seismic, wind, snow, etc.) determined in accordance with the latest version of ASCE 7. Units located indoors are exempt from loading not encountered in an indoor environment.
   1. The term “withstand” means “the unit will remain in place without separation of any parts from the device when subjected to the forces specified **[and the unit will be fully operational after subjected to the forces specified]**”.
   2. Seismic-Restraint Loading:
      a. Site Class as Defined in the IBC: [**A**] [**B**] [**C**] [**D**] [**E**] [**F**].
      b. Occupancy Category as Defined in the IBC: [**I**] [**II**] [**III**] [**IV**].
         1) Component Importance Factor: [**1.0**] [**1.5**].
   3. Design Spectral Response Acceleration at Short Periods (0.2 Second): <**Insert number**>.
   4. Design Spectral Response Acceleration at 1.0-Second Period: <**Insert number**>.
   5. Wind-Restraint Loading:
      a. Basic Wind Speed: <**Insert value**>.
      b. Building Classification Category: [**I**] [**II**] [**III**] [**IV**].
      c. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

D. Fans shall be rated in accordance with AMCA Standard 210 for performance and AMCA Standard 301 for sound and shall bear the AMCA seal.

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E. Motor shall meet requirements of NEMA, IEEE, ANSI, and NEC standard.

F. Coils shall be rated in accordance with ARI Standard 410.

G. Equipment within unit shall be UL listed where applicable.

H. Complete air handling unit shall bear an ETL Label under UL Standard 1995.

I. Unit construction shall meet NFPA 90 requirements and ASHRAE 62-1.

J. The installation of electrical components shall meet the requirements of the National Electrical Code (NFPA 70).

1.4 ACTION SUBMITTALS

A. Product Data: For each custom air-handling unit indicated.
   1. Shop drawings and datasheets that indicate unit components, installed dimensions, shipping and handling dimensions, weights, unit model number, capacities and clearances required for service/operation.
   2. Summary of all utility requirements (power/flow required, connection size, connection type, etc.) including but not limited too:
      a. Electrical connections.
      b. Hydronic connections.
      c. Steam connections.
      d. Drain connections.
      e. Air (ductwork) connections.
   3. Cabinet materials, finishes, and accessories.
   4. Manufacturer's performance of each component and the custom air-handling unit in its entirety including:
      a. Performance data for fans and coils.
      b. Input data used for the selection.
      c. Net capacity for all components stating the conditions used.
      d. Rated load.
      e. Fan curves..
      f. Internal static pressure loss calculations, including fan system effects.
      g. Finish and color chart.
      h. Filters with performance characteristics for the worst case stated operating condition.
   5. Test procedures for the tests indicated to be performed at the manufacturer's facility.

1.5 INFORMATIONAL SUBMITTALS

A. Provide an electronic copy of the service manuals for the equipment specified.

1.6 OPERATION AND MAINTENANCE CLOSEOUT SUBMITTAL

A. Provide manuals with detailed description of installation, operation, and maintenance, including the following:

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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 and maintenance instructions.
5. Factory test reports.
6. Manuals shall be provided within three weeks after shipment of the air handling units.

B. Provide a printed copy of installation, operation, and maintenance (service) manual with equipment shipment.

1.7 WARRANTY:

A. All equipment, materials, and workmanship shall be warranted for twelve (12) months from startup or eighteen (18) months from shipment, whichever period expires first.

B. Warranty to cover parts only; labor to remove or reinstall parts will be the responsibility of others.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Provide air handling units as manufactured by Buffalo Air Handling.

B. Acceptable alternate manufacturers are Air Enterprises and Environmental Air Systems.

C. 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.

D. The equipment manufacturer shall have been manufacturing custom built air handling units for a minimum of twenty-five (25) years.

2.2 GENERAL

A. Units shall not be smaller than shown on the drawings. Units shall be completely factory assembled and tested. The equipment's cooling, heating, humidifying, ventilating, exhausting capacity and performance shall meet or exceed that shown on the schedule. Tags and decals to aid in service or indicate caution areas shall be provided.

2.3 CABINET CONSTRUCTION

A. Units shall be shipped in one piece when possible. Units shipped in multiple sections shall be engineered for field assembly and testing. Provide full length perimeter angles located inside

units at shipping splits to allow for field bolting of modular sections. Unit manufacturer to provide necessary hardware, sealing gasket, and caulk required to field join and seal the shipping split sections.

B. Units requiring knockdown (KD) construction, units must be completely assembled in the factory prior to disassembly and palletization. Manufacturer shall include services of a field technician to supervise the field reassembly of the air handling unit.

C. The manufacturer's standard cabinet construction shall result in a unit leakage rate that shall not exceed 0.5% of unit capacity at 1.25 times the operating static pressure.

D. All panels shall be 3 inch (75mm) double wall and fabricated of a 0.063 inch (1.60mm) stucco aluminum outer shell with a 0.050 inch (1.27mm) smooth aluminum inner liner. The unit casing shall be of no through metal construction using aluminum extrusions with a polyurethane resin thermal bridge.

E. All unit casing panels and roof shall be insulated with 3 inch (75mm) thick foam insulation fill injected between the outer wall and inner liner for maximum strength and foam to metal adhesion. The insulation shall have a minimum U-value of 0.049 btu/hr-sqft- deg F (0.0086 W/m2-K).

F. All panel seams are to be externally caulked with sealant.

2.4 BASE CONSTRUCTION

A. The units shall be constructed on a minimum 6 inch (150mm**)** high, structural aluminum, full perimeter channel base to minimize unit weight for installation. Floor shall be insulated with minimum 1.5 inch (38mm) thick foam insulation. Tubular or formed channel steel shall not be used as the perimeter base unless the base is comprised of stainless steel. The under floor insulation shall be protected with a 0.0040 inch (1mm) aluminum coversheet. Floors and walls shall be designed so that deflection is limited to no more than L/240 of the span dimension at unit operating pressures.

B. The base frame shall have removable lifting lugs. The lifting lugs shall be fabricated from 1/2 inch (13mm) plate steel with an appropriate rigging hole. Lifting lugs shall be located and sized to allow rigging and handling of the unit.

C. Floor Construction:
1. The unit floor is to be constructed of minimum 3/16 inch (4.76mm) aluminum tread plate.
2. Floor Seams: Continuously welded seams.
3. 2 inch (50mm) turned-up lips around the perimeter of each shipping section and at each opening in the floor.
4. Floor drains: Provide in each section to accommodate wash-down and piped to the exterior of the unit. Drains shall be minimum 1 inch (25mm) MPT and provided with a removable drain cap.
5. Floor shall be welded to the base substructure and designed to prevent oil canning.

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2.5 DRAIN PANS

A. Drain pans serving cooling and heat recovery coils shall be continuously-welded, positively draining, triple-sloped and constructed from 12 gauge 304 stainless steel and shall extend a minimum of 3 inches (75mm) upstream and 18 inches (460mm) downstream. The drain pan shall be recessed with a minimum depth of 2 inches (50mm) at the drain. Drain pan shall have a minimum connection size of 2 inches (50mm) or sufficient size to remove condensate (whichever is greater) extended to the exterior for connection by others. Plastic drain pans and plastic drain lines are not acceptable. Caulking of the drain pan seams is unacceptable. The drain pan shall be insulated with a minimum of 1.5 inches (38mm) thick foam insulation and covered by a minimum 0.0040 inch (1mm) aluminum coversheet.

B. Drain pans serving non-coil devices shall be continuously-welded, positively draining, triple-sloped and constructed from 1/8 inch (3.18mm) aluminum and shall extend a minimum of 3 inches (75mm) upstream and 24 inches (610mm) downstream. The drain pan shall be recessed with a minimum depth of 4 inches (100mm) at the drain. Drain pan shall have a minimum connection size of 2 inches (50mm) or sufficient size to remove condensate (whichever is greater) extended to the exterior for connection by others. Plastic drain pans and plastic drain lines are not acceptable. Caulking of the drain pan seams is unacceptable. The drain pan shall be insulated with a minimum of 1.5 inches (38mm) thick foam insulation and covered by a minimum 0.0040 inch (1mm) aluminum coversheet.

2.6 ROOFING

A. Outdoor units shall incorporate a sloped roof with a minimum 1/4 inch (6.35mm) per foot (2%) slope to assure positive run-off.

B. Roof to be peaked on door side and drain away from the access door side.

C. Roof shall have turned up and capped flanges.

D. For air handling units over 20 feet (6 meters) in width roof shall be peaked in the center and sloped to both sides.

2.7 ACCESS DOORS

A. Access doors shall be same construction as unit casing; double wall, completely insulated between the interior and exterior sheet metal of the door and attached to an extruded aluminum frame.

B. All doors shall have an offset-frame incorporating a double gasket seal.

C. Thermal Break: Provide doors and door frames downstream of the cooling coil section with an integral thermal break.

D. Hinges: Provide each door with a single-continuous heavy-duty stainless piano hinge.

E. High compression latches, operable from both sides of the door, shall be used. Latches shall be Ventlok 310 Standard Finish.

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F. Minimum Door Size: The nominal door size shall be minimum 24 inches x 72 inches (610mm x 1830mm) or as tall as unit allows, and shall open against the section's operating pressure.

G. Door viewports shall be a minimum of 12 inches x 12 inches (305mm x 305mm) and constructed of a thermal double-paned Mylar shatter proof design with inert gas. Viewports shall be rated to prevent transmission of UVC rays.

H. Test Port: Provide each door with a 3/4 inch (19mm) NPT, schedule 80 CPVC test port complete with end cap.

I. Door Stops: Door stops shall be provided to prevent the outswinging doors being opened wide enough to damage to the door, casing, or components.

J. Drip Cap: All inswing doors on outdoor units shall be provided with a drip cap above the door (minimum width equal to the door width).

2.8 REMOVABLE PANELS

A. Removable panels shall be provided as indicated on the drawings for component removal and replacement only. Removable panels shall be of the same construction as panels described above. Removable panels shall be designed and constructed such that removal and replacement may be accomplished without disturbing adjacent panels.

2.9 CORROSION PROTECTION SYSTEM

A. Carbon steel components shall be shot-blasted and painted with a Red-Oxide epoxy primer to protect against corrosion.

B. Aluminum or 304 SS exterior casing surfaces do not require painting.

2.10 FANS (GENERAL)

A. Manufacturers:
1. Twin City Fan and Blower.
2. Greenheck.

B. All fans shall be selected to operate at a point no higher than 90% of the peak static pressure rating, as defined by the fan performance curve at the selected operating speed.

C. All fans shall meet the air flow performance specified and shall not exceed the brake horsepower or sound power levels specified on the mechanical equipment schedule (if applicable). Fan performance shall be based on testing and be in accordance with AMCA Standards 210 and 300.

D. Fan assemblies shall be designed for heavy-duty industrial applications.

E. Fan framing assemblies shall be fabricated from structural steel. Formed members are not acceptable.

F. Inlet cones shall be precision spun or die formed. Inlet cones shall be aerodynamically matched to the wheel side plate to provide streamlined airflow in the wheel and ensure full loading of the blades.

G. All fans shall be coated and designed for rugged industrial duty and suitable for continuous operation at the maximum-rated fan speed and motor horsepower.

H. Fan shafts shall be solid AISI 1040 or 1045 steel. Shafts shall be turned, ground and polished to a minimum 16 micro-inch finish. Shafts shall be sized to run at a minimum of 20% greater than the maximum AMCA class speed.

2.11 CENTRIFUGAL FANS (AIRFOIL)

A. Basis of Design (or approved equivalent):
1. Twin City Fan Model BAE/BAF
2. Greenheck Model AF Series 41

B. Fan Wheel: Provide fabricated wheel with airfoil blades, continuously welded to backplate and wheel outer rim. Hub to be keyed to shaft.
1. Materials of Construction: Manufacturer's standard, based on wheel size and pressure class.
2. Statically and dynamically balance wheel.
3. Minimum Balance Quality Grade: G6.3, in accordance with AMCA Standard 204.

C. Bearings: Heavy-duty, grease lubricated, spherical roller or anti-friction ball, self-aligning, pillow block type, based on fan size and mounting orientation.

D. Housing: Continuously welded steel, reinforced with rigid bracing.

E. Supports: Steel angle, intermittently welded with sealant filled between welds.

F. Coating: All carbon steel components shall be cleaned and painted with the fan manufacturer's standard paint.

G. Fan Base: The fan and motor are to be mounted on all-welded structural steel, epoxy-mastic coated, internal isolation base with seismic springs selected to provide a minimum of 97% isolation efficiency. Each spring shall be seismically rated, have a minimum of 2 inches (51 mm) nominal deflection, housed type, welded to a base plate with a 1/4 inch (6.35mm) thick ribbed neoprene sound deadening pad and leveling bolt. Base plates shall be mounted on two threaded studs welded to unit floor for ease of spring replacement. The outlet of the fan is to be separated from the unit casing by means of a factory installed flexible connection.

H. Flexible Connection: Provide flexible connection between fan and fan bulkhead. Fan assembly shall be provided with thrust restraints or thrust bumpers, 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.

I. Housing Access Door: Minimum 4 inches (102 mm) Bolted flush with interior.

J. Drain: 3/4 inch NPT with plug.

K. Inlet Screen: Finger-Safe, steel-wire construction.

L. Piezometer Ring: Ring shall contain a minimum of four orifice ports located in the throat of the fan inlet that are connected with tubing in a continuous ring. Piezometer ring shall be integral to the fan construction.

M. BELT-DRIVE (ARRANGEMENT 3) FAN SPECIAL REQUIREMENTS

1. Bearings: Using AFBMA ratings, bearings shall be selected for a minimum L-10 life of 40,000 hours. All bearings shall have regreasable Zerk fittings and flexible lubrication lines extended to an accessible location on the fan housing for easy access for lubrication.

2. Sheaves and Belts: All sheaves shall be selected with a 1.5 service factor. Sheaves shall be machined from a close grain cast iron and statically balanced by the manufacturer. Drive belt shall be a V- type. Fixed pitch sheaves shall be provided on all motors. Where fixed sheaves are provided one sheave exchange shall be provided. Provide a four-sided OSHA belt guard having sides of galvanized steel with two (2) openings for tachometer readings.
   Fan Shaft: AISI 1040 or 1045 hot-rolled steel shaft, turned, ground, and polished, sized for first critical speed minimum 1.43 times maximum speed for each fan class, keyed to wheel hub; with petroleum based rust preventative coating.

2.12 CENTRIFUGAL FANS (BACKWARD-INCLINED)

A. Basis of Design (or approved equivalent):
1. Twin City Fan Model BC.
2. Greenheck Model BI Series 41.

B. Fan Wheel: Provide fabricated wheel with backward-inclined blades, continuously welded to backplate and wheel outer rim. Hub to be keyed to shaft.
1. Materials of Construction: Manufacturer's standard, based on wheel size and pressure class.
2. Statically and dynamically balance wheel.
3. Minimum Balance Quality Grade: G6.3, in accordance with AMCA Standard 204.

C. Bearings: Heavy-duty, grease lubricated, spherical roller or anti-friction ball, self-aligning, pillow block type, based on fan size and mounting orientation.

D. Housing: Continuously welded steel, reinforced with rigid bracing.

E. Supports: Steel angle, intermittently welded with sealant filled between welds.

F. Coating: All carbon steel components shall be cleaned and painted with the fan manufacturer's standard paint.

G. Fan Base: The fan and motor are to be mounted on all-welded structural steel, epoxy-mastic coated, internal isolation base with seismic springs selected to provide a minimum of 97% isolation efficiency. Each spring shall be seismically rated, have a minimum of 2 inches (51 mm) nominal deflection, housed type, welded to a base plate with a 1/4 inch (6.35mm) thick ribbed neoprene sound deadening pad and leveling bolt. Base plates shall be mounted on two

threaded studs welded to unit floor for ease of spring replacement. The outlet of the fan is to be separated from the unit casing by means of a factory installed flexible connection.

H. Flexible Connection: Provide flexible connection between fan and fan bulkhead. Fan assembly shall be provided with thrust restraints, or thrust bumpers, 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.

I. Housing Access Door: Minimum 4 inches (102 mm) Bolted flush with interior.

J. Drain: 3/4 inch NPT with plug.

K. Inlet Screen: Finger-Safe, steel-wire construction.

L. Piezometer Ring: Ring shall contain a minimum of four orifice ports located in the throat of the fan inlet that are connected with tubing in a continuous ring. Piezometer ring shall be integral to the fan construction.

M. BELT-DRIVE (ARRANGEMENT 3) FAN SPECIAL REQUIREMENTS

1. Bearings: Using AFBMA ratings, bearings shall be selected for a minimum L-10 life of 40,000 hours. All bearings shall have regreasable Zerk fittings and flexible lubrication lines extended to an accessible location on the fan housing for easy access for lubrication.

2. Sheaves and Belts: All sheaves shall be selected with a 1.5 service factor. Sheaves shall be machined from a close grain cast iron and statically balanced by the manufacturer. Drive belt shall be a V- type. Fixed pitch sheaves shall be provided on all motors. Where fixed sheaves are provided one sheave exchange shall be provided. Provide a four-sided OSHA belt guard having sides of galvanized steel with two (2) openings for tachometer readings.
   Fan Shaft: AISI 1040 or 1045 hot-rolled steel shaft, turned, ground, and polished, sized for first critical speed minimum 1.43 times maximum speed for each fan class, keyed to wheel hub; with petroleum based rust preventative coating.

2.13 PLENUM FANS

A. Basis of Design (or approved equivalent):
1. Twin City Fan Model EPF/EPQ/EPFN/EPQN
2. Greenheck Model APH

B. Fan Wheel:
1. Wheels 24.5 inch (622 mm) Diameter and Smaller: Provide wheel with airfoil-shaped extruded aluminum blades, and non-tapered style blade retaining ring on inlet side. Fabricate hollow blade wheels with continuous welds around edges.
2. Wheels 27 Inch (686 mm) Diameter and Larger: Provide wheel with airfoil-shaped extruded aluminum blades, and non-tapered style blade retaining ring on inlet side. Fabricate hollow blade wheels with continuous welds around edges.

C. Housing: None.

D. Coating: All carbon steel components shall be cleaned and painted with the fan manufacturer's standard paint.

E. Fan Base: The fan and motor are to be mounted on all-welded structural steel, epoxy-mastic coated, internal isolation base with seismic springs selected to provide a minimum of 97% isolation efficiency. Each spring shall be seismically rated, have a minimum of 2 inches (51 mm) nominal deflection, housed type, welded to a base plate with a 1/4 inch (6.35mm) thick ribbed neoprene sound deadening pad and leveling bolt. Base plates shall be mounted on two threaded studs welded to unit floor for ease of spring replacement. The outlet of the fan is to be separated from the unit casing by means of a factory installed flexible connection.

F. Flexible Connection: Provide flexible connection between fan and fan bulkhead. Fan assembly shall be provided with thrust restraints, or thrust bumpers, 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. Inlet Screen: Welded wire safety screens.

H. Outlet Guard: Welded wire safety screens open at bottom.

I. Piezometer Ring: Ring shall contain a minimum of four orifice ports located in the throat of the fan inlet that are connected with tubing in a continuous ring. Piezometer ring shall be integral to the fan construction.

J. BELT-DRIVE (ARRANGEMENT 3) FAN SPECIAL REQUIREMENTS

1. Bearings: Using AFBMA ratings, bearings shall be selected for a minimum L-10 life of 40,000 hours. All bearings shall have regreasable Zerk fittings and flexible lubrication lines extended to an accessible location on the fan housing for easy access for lubrication.

2. Sheaves and Belts: All sheaves shall be selected with a 1.5 service factor. Sheaves shall be machined from a close grain cast iron and statically balanced by the manufacturer. Drive belt shall be a V- type. Fixed pitch sheaves shall be provided on all motors. Where fixed sheaves are provided one sheave exchange shall be provided. Provide a four-sided OSHA belt guard having sides of galvanized steel with two (2) openings for tachometer readings.
   Fan Shaft: AISI 1040 or 1045 hot-rolled steel shaft, turned, ground, and polished, sized for first critical speed minimum 1.43 times maximum speed for each fan class, keyed to wheel hub; with petroleum based rust preventative coating.

2.14 PLENUM FAN ARRAYS

A. Basis of Design (or approved equivalent):
1. Twin City Fan Model MPLFN/MPLQN
2. Greenheck Model HPA

B. Fan Wheel: Provide wheel with airfoil-shaped extruded aluminum blades, and non-tapered style blade retaining ring on inlet side. Fabricate hollow blade wheels with continuous welds around edges.

C. Housing: Provide galvanized steel structural housing which allows fans to be bolted together in multiple fan array configurations. Provide outer skin for each fan to direct sound and air flow axially through fan.

D. Insulation: Provide minimum 2 inches (51 mm) acoustical insulation. Protect airflow insulation face with non-friable vapor barrier. Provide perforated galvanized steel shield over insulation.

E. Coating: All carbon steel components shall be cleaned and painted with the fan manufacturer's standard paint.

F. Fan Base: The fan and motor are to be mounted on all-welded structural aluminum channel base, a minimum of 4 inches (101.6mm) tall, around the full perimeter of each fan housing located on the bottom of each vertical stack of fans.

G. Vibration Isolation: Each fan shall be internally isolated with a minimum of four elastomeric isolators, have a minimum of 1/4 inch (6.4 mm) minimum nominal deflection. Vibration isolator to be fan manufacturer's standard isolator.

H. Inlet Screen: Welded wire safety screens.

I. Piezometer Ring: Ring shall contain a minimum of four orifice ports located in the throat of the fan inlet that are connected with tubing in a continuous ring. Piezometer ring shall be integral to the fan construction.

J. Fan Inlet Blank-off Panel: Provide metal panel matched to fan inlet to block fan inlet when fan is not in service.

2.15 FAN SECTION ACCESSORIES

A. The fan section shall include a structural I-beam monorail capable of lifting the motor through the fan section access door in the side of the unit.

B. For blow-through applications using DWDI fans a full height by full width diffuser plate shall be provided a minimum 8 inches (200mm) downstream of the fan discharge. Diffuser plate shall have target area that is 25% free area and is 1.25 times the fan discharge height and 1.4 times the fan discharge width, centered on the fan discharge. Remainder of diffuser plate shall be 50% free area with 1-1/2 inch (40mm) diameter openings.

2.16 MOTORS

A. Manufacturers:
   1. WEG
   2. Baldor-Reliance
   3. GE
   4. Toshiba

B. General Motor Requirements:
   1. Comply with NEMA MG 1 unless otherwise indicated.
   2. Comply with IEEE 841 for severe-duty motors.

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3. Motors shall be suitable for use with variable frequency drives (VFDs).

C. Motor Characteristics
1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven loadwill not require motor to operate in service factor range above 1.0.
4. Efficiency: NEMA Premium Efficient.
5. Enclosure Type: TEFC. TEAO enclosures are not an acceptable alternative.
6. Turndown Ratio: Motor shall be able to reduce speed to 1/20 of the nominal RPM without adversely effecting motor performance.
7. Frame Material: Cast iron.
8. Bearings: Shielded, antifriction ball bearings suitable for radial and thrust loading.
9. Bearing (Belt-drive 75HP and larger): Shielded, antifriction roller bearings suitable for radial and thrust loading.
10. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
11. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
12. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
13. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
14. Shaft-Grounding Ring: Provide on each motor shaft.
15. Service Factor: 1.15.

D. Motor Slide Bases: Provide all belt-driven motors with adjustable slide bases.

2.17 COOLING AND HEAT RECOVERY COILS (WATER OR GLYCOL)

A. Manufacturer: Aerofin.

B. All coils shall meet or exceed all capacities specified on the mechanical schedule for the project. All water coil performances shall be certified by the manufacturer to be in accordance with ARI Standard 410. Coils shall be mounted in the unit for horizontal airflow. Coil air face velocities shall not exceed 500 FPM (2.54m/s).

C. All coils shall be tested to 250 psig compressed air under water. Coils shall be designed to operate at 250 psig internal pressure and up to 300°F (149°C).

D. 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.

E. Coils shall not act as structural component of unit.

F. Fabricate coil section to allow removal, replacement, service, and maintenance of the coil(s).

G. Stacked coils shall be individually supported by a 304 stainless steel rack system for independent coil removal, so that, in the case of stacked coils, the bottom coil can be removed without disturbing the top coil. Coils stacked one directly on top of the other will not be accepted.

H. For stacked coils, a triple sloped, positive draining intermediate condensate drain pan with recessed drain connection shall be provided. Intermediate condensate drain pans shall extend underneath each coil a minimum of 3 inches upstream and sufficient length downstream of each coil (as described below) to contain potential carryover. Each intermediate drain pan shall be individually piped (non-cascading) down to the main drain pan. Intermediate drain pan and drain pipes shall be type 304 stainless steel. Downspouts to be a minimum 1-1/2 inch (40mm) diameter stainless steel. Plastic downspouts are not acceptable.
   1. Downstream intermediate condensate pan length:
      a. Coil finned height ≤ 30 inches (760mm): 6 inches (152mm).
      b. 30 inches (760mm) < Coil finned height ≤ 38 inches (965mm): 9 inches (229mm).
      c. 38 inches (965mm) < Coil finned height ≤ 45 inches (1143mm): 12 inches (305mm).
      d. Coil finned height > 45 inches (1143mm): 15 inches (381mm).

I. Provide removable access panels in the unit casing on the side opposite of the coil connections for ease of coil removal.

J. Chilled water coils shall be constructed with the following characteristics:
   1. Fluid: See schedule.
   2. Tubes: 0.035 inch thick, 5/8 inch (16mm) diameter, seamless copper tubes.
   3. Fins: 0.0095 inch aluminum fins.
   4. Headers: Non-ferrous headers with steel MPT connections.
   5. Drain and Vent: Minimum 3/8 inch (10mm) diameter MPT drain and vent connections.
   6. Coil casings shall be constructed of minimum 16 gauge 304 stainless steel.
   7. Coil connections are to be extended through the unit casing wall by the unit manufacturer. Drain and vent connections shall be terminated internally.
   8. Coil casing reinforcement: Required for fin lengths exceeding 42 inches (1067mm).
   9. Maximum Finned Height per Coil: 48 inches (1220mm).
   10. Maximum Fin Density: Shall not exceed 12 fins per inch.
   11. Tube fluid velocities shall be between 2 fps (0.6 m/s) and 8 fps (2.4 m/s).
   12. Max fluid pressure drop: 20 ft. H2O (60 kPa).

2.18 DIRECT-EXPANSION (DX) COOLING COILS

A. Manufacturers:
   1. Aerofin.
   2. RAE Corp.

B. All coils shall meet or exceed all capacities specified on the mechanical schedule for the project. All water coil performances shall be certified by the manufacturer to be in accordance with ARI Standard 410. Coils shall be mounted in the unit for horizontal airflow. Coil air face velocities shall not exceed 500 FPM (2.54m/s).

C. All coils shall be tested to 250 psig compressed air under water. Coils shall be designed to operate at 250 psig internal pressure and up to 300°F (149°C).

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D. 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.

E. Coils shall not act as structural component of unit.

F. Fabricate coil section to allow removal, replacement, service, and maintenance of the coil(s).

G. Stacked coils shall be individually supported by a 304 stainless steel rack system for independent coil removal, so that, in the case of stacked coils, the bottom coil can be removed without disturbing the top coil. Coils stacked one directly on top of the other will not be accepted.

H. For stacked coils a triple sloped, positive draining intermediate condensate drain pan with recessed drain connection. Intermediate condensate drain pans shall extend underneath each coil a minimum of 3 inches upstream and sufficient length downstream of each coil (as described below) to contain potential carryover. Each intermediate drain pan shall be individually piped (non-cascading) down to the main drain pan. Intermediate drain pan and drain pipes shall be type 304 stainless steel. Downspouts to be a minimum 1-1/2 inch (40mm) diameter stainless steel. Plastic downspouts are not acceptable.
   1. Downstream intermediate condensate pan length:
      a. Coil finned height ≤ 30 inches (760mm): 6 inches (152mm).
      b. 30 inches (760mm) < Coil finned height ≤ 38 inches (965mm): 9 inches (229mm).
      c. 38 inches (965mm) < Coil finned height ≤ 45 inches (1143mm): 12 inches (305mm).
      d. Coil finned height > 45 inches (1143mm): 15 inches (381mm).

I. Provide removable access panels in the unit casing on the side opposite of the coil connections for ease of coil removal.

J. The use of microchannel coils is not permitted.

K. Coils shall ship charged with nitrogen.

L. DX cooling coils shall be constructed with the following characteristics:
   1. Refrigerant: See schedule.
   2. Tubes: 0.035 inch thick, 5/8 inch (16mm) diameter, seamless copper tubes.
   3. Fins: 0.0095 inch aluminum fins.
   4. Circuiting (less than 4 circuits): Interlaced (Intertwined).
   5. Circuiting (4 circuits or more): Face Split / Interlaced (Intertwined).
   6. Headers: Non-ferrous with sweat connections.
   7. Coil casings shall be constructed of minimum 16 gauge 304 stainless steel.
   8. Coil connections are to be extended through the unit casing wall by the unit manufacturer.
   9. Coil casing reinforcement: Required for fin lengths exceeding 42 inches (1067mm).
   10. Maximum Finned Height per Coil: 48 inches (1220mm).
   11. Maximum Fin Density: Shall not exceed 12 fins per inch.
   12. Provide Thermal expansion valves (TXV).
   13. Provide capped hot-gas port for field connection.

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2.19 HEATING COILS (WATER OR GLYCOL)

A. Manufacturer: Aerofin.

B. All coils shall meet or exceed all capacities specified on the mechanical schedule for the project. All water coil performances shall be certified by the manufacturer to be in accordance with ARI Standard 410. Coils shall be mounted in the unit for horizontal airflow. Coil air face velocities shall not exceed 600 FPM (3 m/s).

C. All coils shall be tested to 250 psig compressed air under water. Coils shall be designed to operate at 250 psig internal pressure and up to 300°F (149°C).

D. 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.

E. Coils shall not act as structural component of unit.

F. Fabricate coil section to allow removal, replacement, service, and maintenance of the coil(s).

G. Coils shall be individually supported by a minimum 1/8" aluminum rack system for independent coil removal, so that, in the case of stacked coils, the bottom coil can be removed without disturbing the top coil. Coils stacked one directly on top of the other will not be accepted.

H. Provide removable access panels in the unit casing on the side opposite of the coil connections for ease of coil removal.

I. Hot water coils shall be constructed with the following characteristics:
   1. Fluid: See schedule.
   2. Tubes: 0.035 inch thick, 5/8 inch (16mm) diameter, seamless copper tubes.
   3. Fins: 0.0095 inch aluminum fins.
   4. Headers: Steel headers with steel MPT connections.
   5. Drain and Vent: Minimum 3/8 inch (10mm) diameter MPT drain and vent connections.
   6. Coil casings shall be constructed of minimum 16ga galvanized steel.
   7. Coil connections are to be extended through the unit casing wall by the unit manufacturer. Drain and vent connections shall be terminated internally.
   8. Coil casing reinforcement: Required for fin lengths exceeding 42 inches (1067mm).
   9. Maximum Finned Height per Coil: 51 inches (1300mm).
   10. Maximum Fin Density: Shall not exceed 12 fins per inch.
   11. Tube fluid velocities shall be between 2 fps (0.6 m/s) and 8 fps (2.4 m/s).
   12. Max fluid pressure drop: 10 ft. H2O (29.8 kPa).

2.20 HEATING COILS (STEAM)

A. Manufacturer: Aerofin.

B. All coils shall meet or exceed all capacities specified on the mechanical schedule for the project. All water coil performances shall be certified by the manufacturer to be in accordance with ARI Standard 410. Coils shall be mounted in the unit for horizontal airflow. Coil air face velocities shall not exceed 650 FPM (3.3 m/s).

C. All coils shall be tested to 315 psig compressed air under water. Coils shall be designed to operate at 250 psig internal pressure and up to 300°F (149°C).

D. Steam coils shall be non-freeze, tube within a tube, type.

E. 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.

F. Coils shall not act as structural component of unit.

G. Fabricate coil section to allow removal, replacement, service, and maintenance of the coil(s).

H. Coils shall be individually supported by a minimum 1/8" aluminum rack system for independent coil removal, so that, in the case of stacked coils, the bottom coil can be removed without disturbing the top coil. Coils stacked one directly on top of the other will not be accepted.

I. Provide removable access panels in the unit casing on the side opposite of the coil connections for ease of coil removal.

J. Steam coils shall be constructed with the following characteristics:
1. Steam pressure: See schedule.
2. Tubes: 0.035 inch thick, 1 inch (25mm) diameter outer tubes, seamless copper tubes.
3. Fins: 0.0095 inch aluminum fins.
4. Headers: Steel headers with steel MPT connections.
5. Coil casings shall be constructed of minimum 16 gauge galvanized steel.
6. Coil connections are to be extended through the unit casing wall by the unit manufacturer.
7. Coil casing reinforcement: Required for fin lengths exceeding 42 inches (1067mm).
8. Maximum Finned Height per Coil: 51 inches (1300mm).
9. Maximum Fin Density: Shall not exceed 12 fins per inch.

K. Coils shall be raised in the unit a minimum 18” above the unit base to allow for proper trapping.

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

A. Manufacturer: Aerofin.

B. All coils shall meet or exceed all capacities specified on the mechanical schedule for the project. All water coil performances shall be certified by the manufacturer to be in accordance with ARI Standard 410. Coils shall be mounted in the unit for horizontal airflow. Coil air face velocities shall not exceed 700 FPM (3.5 m/s) for the IFB coils.

C. All coils shall be tested to 250 psig compressed air under water. Coils shall be designed to operate at 250 psig internal pressure and up to 300°F (149°C).

D. 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.

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E. Steam coils shall be non-freeze type.

F. Steam IFB coils shall be constructed with the following characteristics:
1. Steam pressure: See schedule.
2. Tubes: 0.035 inch thick, 5/8 inch (16mm) diameter, seamless copper tubes.
3. Fins: 0.0095 inch aluminum fins.
4. Headers: Steel headers with steel MPT connections.
5. Coil casings shall be constructed of minimum 16 gauge galvanized steel.
6. Coil connections are to be extended through the unit casing wall by the unit manufacturer.
7. Maximum Fin Density: Shall not exceed 12 fins per inch.

G. Hot Water IFB coils shall be constructed with the following characteristics:
1. Fluid: See schedule.
2. Tubes: 0.035 inch thick, 5/8 inch (16mm) diameter, seamless copper tubes.
3. Fins: 0.0095 inch aluminum fins.
4. Headers: Steel headers with steel MPT connections
5. Drain and Vent: Minimum 3/4 inch (19mm) diameter MPT drain and vent connections.
6. Coil casings shall be constructed of minimum 16 gauge galvanized steel.
7. Coil connections are to be extended through the unit casing wall by the unit manufacturer. Drain and vent connections shall be terminated internally.
8. Maximum Fin Density: Shall not exceed 12 fins per inch.

H. Coils shall be provided with coil manufacturer supplied bypass destratification baffles and minimum 24 inches (610mm) downstream clearance to next component for proper mixing of air downstream of coil.

I. Provide removable access panels in the unit casing on the side opposite of the coil connections for ease of coil removal.

J. Coils shall be raised in the unit a minimum 18 inches (460mm) above the unit base to allow for proper trapping.

K. Damper motor to be 24VAC/DC electric. Air handling unit manufacturer to coordinate with supplier of damper motor to assure proper mounting bracket is provided with the coil.

2.22 FILTERS

A. Manufacturers:
1. American Air Filter
2. Camfil USA.
3. Flanders.

B. General:
1. Provide all filters of type, quantity, size and capacity as required for air handling system indicated on drawings and as stated in these specifications.
2. Filters to be selected for a maximum face velocity of 500 FPM (2.54 m/s).
3. Filter initial pressure drop shall not exceed the rating indicated for each filter media type listed below.

4. Fan(s) will be rated based on the final resistance indicated for each filter type listed below.
5. Each cell shall be 24 inches x 24 inches (610mm x 610mm), or 12 inches x 24 inches (305mm x 610mm).
6. Media shall be approved and listed as Underwriters Laboratories (UL) Standard 900.
7. Media shall be tested in accordance with the latest version of ASHRAE Standard 52.2.

C. Filter Media:
1. Medium Efficiency Pleated Pre-filters:
   a. Depth: 2 inch (50mm).
   b. MERV Rating: 8
   c. Initial resistance at 500 FPM (2.54 m/s) shall not exceed 0.28 in H2O (70Pa).
   d. Final resistance at 500 FPM (2.54 m/s): 0.90 in H2O (224Pa).
   e. Based on AAF Perfect Pleat HC M8 | Camfil 30/30.
2. High Efficiency Rigid Final Filters:
   a. Depth: 12 inch (305mm).
   b. MERV Rating: 14.
   c. Initial resistance at 500 FPM (2.54 m/s) shall not exceed:
      1) MERV 14/15: 0.60 in H2O (150Pa).
   d. Final resistance at 500 FPM (2.54 m/s): 1.30 in H2O (324Pa).
   e. Based on AAF Varicel RF | Camfil Riga-Flo.
3. High Efficiency Bag Final Filters:
   a. Depth: 22 inch (560mm).
   b. MERV Rating: 14.
   c. Initial resistance at 500 FPM (2.54 m/s) shall not exceed:
      1) MERV 14: 0.60 in H2O (150Pa).
   d. Final resistance at 500 FPM (2.54 m/s): 1.30 in H2O (324Pa).
   e. Based on AAF Dri-Pak | Camfil High-Flo.
4. HEPA Filters:
   a. Depth: 12 inch (305mm).
   b. Efficiency: 99.97%.
   c. Seal: Gasket.
   d. Initial resistance at 500 FPM (2.54 m/s): Shall not exceed 1.35 in H2O (336Pa).
   e. Final resistance at 500 FPM (2.54 m/s): 1.75 in H2O (436Pa).
   f. Based on AAF AstroCel I | Camfil Absolute.

D. Frame Construction:
1. “Type 8” filter holding frames: Heavy-duty construction designed for industrial applications:
   a. Material: Minimum 16 gauge galvanized steel.
   b. Gasket: Closed-cell foam.
   c. Filter fastener attachments: Attachment points shall permit the installation of filter fasteners without the requirements of tools, nuts, or bolts.
   d. Reinforcement: Filter banks larger than 60 inches (1.5m) wide by three 72 inches (1.8m) tall shall be reinforced to prevent appreciable deflection under “dirty” filter conditions at the design airflow.
   e. Filter removal: Holding frames shall permit either upstream or downstream filter removal.
2. Side-service filter holding frames:

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a. Material: Aluminum frames capable of holding both low efficiency pre-filter and high efficiency final-filter media at the same time. Frames are mechanically fastened to formed sheet metal vertical posts.
b. Frame Gasket: Gasketing provided within filter tracks.
c. Side seals: Provide removable, adjustable sheet metal blank-offs with gaskets to seal between the filter media and air handling unit side casing.
d. Rack shall be designed to remove pre-filter media without disturbing final filter media and vice-versa.
e. Filter access door shall be provided to permit installation and removal of all filter media. The filter door construction shall match the construction criteria of air handling unit section access doors.

3. HEPA filter holding frames: Heavy-duty construction designed for industrial applications:
a. Material: Minimum 14ga galvanized steel.
b. Depth: Minimum 8 inches (200mm).
c. Sealing Surface: Compatible with selected filter media seal type.
d. Filter fastener attachments: Attachment points shall accommodate the installation of filters without the requirements of tools, nuts, or bolts.
e. Filter removal: Holding frames shall permit either upstream or downstream filter removal.
f. Frame modules shall be continuously welded together to provide an air-tight seal.

E. Differential Pressure Dial Gauge: A differential pressure gauge for measuring the pressure drop across each filter bank shall be installed. Gauges installed in outdoor environments shall be suitable for use in outdoor environments or provided an enclosure with a clear door to enable viewing of gauges without opening the enclosure. The gauge shall be dial type with white dial face, black or blue figures and graduations and pointer zero adjustment. Gauge shall be surface mounted. Recessing gauges into unit casing shall not be acceptable.

2.23 DAMPERS

A. Manufacturers:
1. Ruskin.
2. Tamco.
3. Greenheck.

B. General Requirements:
1. Sizing:
a. Wall Duct Connections: Max 1800 FPM (9.1 m/s).
b. Floor Openings: Max 1200 FPM (6.1 m/s).
c. Unducted Economizer Exhaust: Max 650 FPM (3.3 m/s).
d. Unducted Economizer Mixed / Return Air: Max 1500 FPM (7.6 m/s).
e. Unducted Economizer Outdoor Air: Max 500 FPM (2.54 m/s).
f. Ducted Economizer Exhaust: Max 1800 FPM (9.1 m/s).
g. Ducted Economizer Mixed / Return Air: Max 1500 FPM (7.6 m/s).
h. Ducted Economizer Outdoor Air: Max 1200 FPM (6.1 m/s).
2. Mounting: All dampers should be provided with a front-, rear-, or double-flange for mounting unless it can be demonstrated that providing flanges will interfere with damper installation.
3. Location:

a. Exposed to outdoor environment: **[Aluminum Control] [Heavy-Duty Control] [Aluminum Smoke]**.
b. Exposed to unit interior or indoor environment: **[Aluminum Control] [Heavy-Duty Control] [Aluminum Smoke]**.
c. Fan Isolation: **[Aluminum Control] [Heavy-Duty Control] [Backdraft] [Heavy-Duty Backdraft]**.

C. Aluminum Control Dampers:
1. Blades: Aluminum, airfoil blade.
2. Frame: Aluminum.
3. Blade Stops: Not to exceed 1.25 inches (32mm) in height.
4. Blade Seals: **[Extruded EPDM or neoprene] [Silicone]** mechanically attached to blade.
5. Jamb Seals: 304SS compression or extruded silicone.
6. Axles: Plated-Steel, mechanically-fastened or integral to blade
7. Bearings: Molded synthetic sleeve or dual-bearing system.
8. Linkage: Aluminum and/or [**zinc-plated steel] [304SS]** hardware concealed in damper frame.
9. Leakage: AMCA Standard 511 leakage class 1A @ 1 in. wg.
10. Based on Ruskin CD50 | Tamco 1000/1500 | Greenheck VCD-40.

D. Heavy-Duty Control Dampers:
1. Blades: Aluminum, airfoil blade.
2. Frame: Galvanized steel or aluminum.
3. Blade Stops: Not to extend into airstream.
4. Blade Seals: Silicone mechanically attached to blade.
5. Jamb Seals: Silicone mechanically attached to frame.
6. Axles: Aluminum integral to blade.
7. Bearings: Dual bronze oilite bearing.
8. Linkage: Aluminum and/or [**zinc-plated steel] [304SS]** hardware concealed in damper frame. Trunion bearings to be bronze iolite.
9. Leakage: Not to exceed 4 cfm/sqft for a 24”x24” damper at 1 in. wg.
10. Based on Ruskin CD/OD102 | Tamco 8800.

E. Aluminum Smoke Dampers:
1. Rating: All smoke dampers shall be UL 555S rated.
2. Blades: Aluminum, airfoil blade.
3. Frame: Aluminum.
4. Blade Stops: Not to exceed 1.25 inches (32mm) in height.
5. Blade Seals: Silicone mechanically attached to blade.
6. Jamb Seals: 304SS compression or extruded silicone.
7. Axles: Plated-Steel, mechanically-fastened or integral to blade
8. Bearings: Self-lubricating stainless steel sleeve or dual-bearing system.
9. Linkage: Aluminum and/or [**zinc-plated steel]** hardware concealed in damper frame.
10. Leakage: UL555S leakage class I.
11. Actuator: **[Electric, 120V, two-position, fail close] [Electric, 24V, two-position, fail close] [Pneumatic, two-position, fail close]**.
12. Position Indication (mechanically-fastened to damper or integral to actuator): Two SPDT switches to indicate damper position. One switch to indicate open damper and one switch to indicate closed damper.
13. Based on Ruskin SD50(M) | Tamco 1000 SM.

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F. Backdraft Dampers:
1. Blades: Aluminum.
2. Frame: Aluminum.
3. Blade Seals: Vinyl or silicone mechanically attached to blade.
4. Jamb Seals: **[Extruded silicone]**.
5. Axles: Synthetic or aluminum, mechanically-fastened or integral to blade
6. Bearings: Synthetic, maintenance free.
7. Linkage: Aluminum and/or [**zinc-plated steel]** hardware concealed in damper frame.
8. Leakage: AMCA Standard 511 leakage class 2 at 1 in. wg.
9. Based on Ruskin BD6 | Tamco 7000 | Greenheck EM3X Series.

G. Heavy-Duty Backdraft Dampers:
1. Blades: Aluminum.
2. Frame: Aluminum.
3. Blade Seals: Silicone mechanically attached to blade.
4. Jamb Seals: **[Vinyl or extruded silicone]**.
5. Axles: Plated steel, mechanically-fastened or integral to blade
6. Bearings: Ball bearings.
7. Linkage: Aluminum and/or [**zinc-plated steel]** hardware concealed in damper frame.
8. Based on Ruskin CBS92 | Tamco 7600 | Greenheck HB-240.

H. Damper Accessories:
1. Manual locking quadrant.
2. Actuators (Control Dampers):
   a. Electric: Two-position, **[24VAC/VDC] [120VAC]**, **[spring return] [fail-last position]**, **[with dual auxiliary switches]**.
   b. Electric: Modulating, 24VAC/VDC, **[spring return] [fail-last position]**, **[with position feedback]**.
   c. Sizing: Actuators must be selected to provide 125% of the calculated torque rating of the damper at the design pressure. Multiple actuators shall be provided to operate in tandem as necessary to meet this requirement.
3. Mounting: **[In airstream] [Damper frame]**.

2.24 WEATHERHOODS

A. General:
1. Weatherhoods shall be designed to withstand the design windloading as specified.
2. Weatherhoods shall be sized and designed to minimize rain and snow entrainment.
3. Weatherhoods shall be provided on all non-ducted air intakes exposed to the unit exterior.

B. Construction:
1. Material: 0.063 Stucco Aluminum.
2. Birdscreen: 1/4" aluminum wire mesh screen.
3. Drip leg: The leading edge of the weatherhood shall be provided a formed drip leg to divert water to the sides of the weatherhood.

2.25 LOUVERS

A. Manufacturers:

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1. Ruskin.
2. Greenheck.

B. General:
1. Intake Louvers: Drain pans shall be installed below each louver to carry away any condensation that forms internally on the louver frame. Drain pan minimum length shall be 18 inches (460mm) or 1/3 of the louver height, whichever is greater.

C. Construction:
1. Sizing: Max 500 FPM (2.54 m/s) for air intakes and 650 FPM (3.3 m/s) for air exhausts based on louver total face area.
2. Type: Stationary, drainable blade, drainable head.
3. Ratings: Shall be AMCA certified for water penetration and air performance.
4. Free Area: Minimum 60%.
5. Frame: Aluminum, minimum 6 inch (150mm) depth.
6. Blades: Aluminum, flat or rounded.
7. Birdscreen: ½ inch (13mm) expanded aluminum in removable frame.
8. Based on Ruskin ELF6375DX | Greenheck ESD-635.

2.26 BLENDERS

A. Manufacturers:
1. Kees.
2. Blender Products.

B. Construction:
1. If indicated on the drawings, blenders shall be provided downstream of economizer section to prevent stratification of the airstream.
2. Maximum Velocity: 1100 FPM (5.6 m/s) at entering face of blender.
3. Downstream space: Minimum distance equal to the average of the height and width of the largest single blender module.
4. Material: Aluminum.

2.27 HUMIDIFIERS

A. Manufacturers:
1. Armstrong.
2. Dri-Steem.
3. Nortec.
4. Pure Humidifier Co.

B. General Requirements:
1. Maximum Design Air Velocity: Humidifier panel to be selected with maximum face velocity of 650 FPM (3.3 m/s).
2. Absorption distance: Shall not exceed 24 inches (610mm) at design conditions. Air handling manufacturer shall be responsible for proper absorption distance for steam between humidifier and downstream components.

C. Construction:

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1. Provide panel type, steam dispersion humidifier 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.
2. **[Humidifier panel and all components shall be compatible with clean steam]**.
3. Dispersion panel to be provided with stainless steel casings.
4. Humidifier manufacturer to provide the following accessories:
   a. Control Valve(s): Control valves and trim shall be stainless steel.
   b. Actuators (compatible with control valves provided):
      1) Electric: Two-position, **[24VAC/VDC][120VAC]**, **[spring return][fail-last position]**, **[with dual auxiliary switches]**.
      2) Electric: Modulating, 24VAC/VDC, **[spring return][fail-last position]**, **[with position feedback]**.
      3) Pneumatic: **[Two-position][Modulating]**.
   c. Y-type strainer: Stainless steel.
   d. Float and Thermostatic (F&T) Trap: Provide as required per the humidifier manufacturer's installation, operation, and maintenance manual and the design documents.
   e. Drain Heat Exchanger: Thermostatically controlled water valve shall meter cold water into a stainless steel heat exchanger to temper condensate drain water to a maximum 140°F (60°C) discharge temperature.

D. Installation
1. Piping and trapping of all humidifiers shall be installed by others in the field in accordance with the humidifier manufacturer's installation, operation, and maintenance manual unless otherwise specified.
2. Humidifier panel to be mounted on a stainless steel support structure. The support structure shall locate the bottom of the humidifier a minimum of 20 inches (510mm) above the bottom of the air handling unit base if the air handling unit is not provided a service corridor. If the air handling unit is provided a service corridor, the support structure shall locate the bottom of the humidifier a minimum of 20 inches (510mm) above the air handling unit floor.
3. Humidifier shall be provided with stainless steel flashing between humidifier and casing walls to prevent air bypass if required by the humidifier selection.
4. Steam supply and condensate return connections are to be extended and sealed through the casing wall.
5. All piping in the airstream shall be 304 stainless steel.
6. If the air handling unit is not provided a service corridor, condensate connections requiring "P" trapping shall be located a minimum of 12 inches (305mm) above the bottom of the air handling unit base for proper trapping. If the air handling unit is provided a service corridor, condensate connections requiring "P" trapping shall be located a minimum of 12 inches (305mm) above the air handling unit floor for proper trapping.
7. If the air handling unit is not provided a service corridor, condensate connections requiring "F&T" trapping shall be located a minimum of 8 inches (204 mm) above the bottom of the air handling unit base for proper trapping. If the air handling unit is provided a service corridor, condensate connections requiring "F&T" trapping shall be located a minimum of 8 inches (204 mm) above the air handling unit floor for proper trapping.

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2.28 ENERGY RECOVERY WHEELS

A. Manufacturers:
   1. SEMCO.
   2. Thermotech.
   3. Innergytech.

B. General:
   1. All rotor media shall have a flame spread rating of less than 25 and a smoke developed rating of less than 50 when rated in accordance with ASTM E84.
   2. Energy recovery wheels shall comply with ASHRAE 84-78P and ARI 1060 “Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment”.

C. Construction:
   1. 12 inch (300mm) Nominal Depth Rotors
      a. Rotor Media: 300mm nominal depth aluminum or polymer segmented wheel strengthened with radial spokes.
      b. Rotor Media Coating: **[3 angstrom molecular sieve desiccant] [4 angstrom molecular sieve desiccant] [Sensible-only].** Molecular sieve maybe impregnated into or coated on to rotor media.
      c. Maximum solid size for media to pass: 900 micrometer.
      d. Rotor media shall be segmented to aid in field installation and media replacement.
      e. A purge section shall be provided to eliminate transfer of exhaust air into the supply air.
      f. Frame: Structural steel frame shall be provided to support the rotor media. Frame shall be segmented for rotor media larger than 10 feet (3m) in diameter.
      g. Drive system: The drive system shall be gravity or spring tensioned and shall use V-Belts. Link media belts are not acceptable.
      h. Motor: Inverter duty, VFD-ready motor. Motor electrical characteristics as specified on the contract drawings.
      i. Based on SEMCO TE/TS.
   2. 8 inch (200mm) Nominal Depth Rotors
      a. Rotor Media: 200mm nominal depth aluminum or polymer segmented wheel strengthened with radial spokes.
      b. Rotor Media Coating: **[3 angstrom molecular sieve desiccant] [4 angstrom molecular sieve desiccant] [Sensible-only].** Molecular sieve maybe impregnated into or coated on to rotor media.
      c. Maximum solid size for media to pass: 900 micrometer.
      d. Rotor media shall be segmented to aid in field installation and media replacement.
      e. A purge section shall be provided to eliminate transfer of exhaust air into the supply air.
      f. Frame: Structural steel frame shall be provided to support the rotor media. Frame shall be segmented for rotor media larger than 10 feet (3m) in diameter.
      g. Drive system: The drive system shall be gravity or spring tensioned and shall use V-Belts. Link media belts are not acceptable.
      h. Motor: Inverter duty, VFD-ready motor. Motor electrical characteristics as specified on the contract drawings.
      i. Based on Thermotech Thermowheel | Innergytech I3| SEMCO FUSION.

D. Control

1. A speed control system shall be provided with a variable frequency drive (VFD) to spin the rotor at various speeds. The rotor speed control system will be integrated with the temperature control system to deliver air at the desired supply air setpoint.
2. The temperature control system shall monitor the entering and leaving air temperatures of the supply and exhaust airstreams. Supply air set points, summer/winter changeover, and wheel frost control sequences shall be user adjustable.
3. The wheel manufacturer shall provide anti-reversing bearings or a rotation detector. If a rotation detector is used, the rotor control system shall stop the wheel and signal an alarm.

2.29 AIR-TO-AIR PLATE HEAT EXCHANGER

A. Manufacturers:
1. Innergytech.
2. Recouperator.

B. General
1. Air-to-air plate heat exchangers shall be tested in accordance with ASHRAE Standard 84 “method of testing air-to-air heat exchangers” and shall be rated in accordance with AHRI standard 1060.
2. Air-to-air plate heat exchangers shall bear the AHRI Certified Product Seal.

C. Construction
1. Exchanger Plates: Aluminum or polymer design.
2. Exchanger plate housing: Self-supporting frame with aluminum or galvanized steel end plates.
3. Pressure Rating: The plate heat exchanger shall be able to withstand, without permanent deformation, pressure differentials up to 10 inches H2O (2.5kPa).

2.30 ELECTRIC HEATING COIL

A. Manufacters:
1. Indeeco.

B. General
1. Electric heating coils shall be UL Recognized or UL Listed.
2. Electric heating coils shall be constructed in compliance with the latest version of UL 1995.
3. Electric heating coils shall be constructed in compliance with the National Electric Code (NEC / NFPA70)
4. Electric heating coils shall not be installed within 48 inches (1.2m) upstream or downstream from fan outlets, abrupt transitions, or other obstructions.
5. Electric heating coils shall not be installed 48 inches (1.2m) upstream or 24 inches (610mm) downstream of an elbow or other turn in excess of 45 degrees without the use of a field-adjustable diffuser plate to ensure uniform airflow across the heating elements.
6. Electric heating coils shall be sized to operate at the lesser of 50% of the design airflow or the scheduled minimum airflow. Heating elements shall have a minimum of 2:1 turndown at the minimum airflow using the design entering air conditions.

C. Construction

1. Heating Elements: Open Coil elements constructed of 80% nickel / 20% chromium (NiChrome), Type A resistance wire.
2. Finned Tubular Elements: Shall be centered in a minimum 0.475 inch (12 mm) stainless steel tube filled with granular magnesium oxide. The entire assembly is to be compacted to maximize both the heat transfer and dielectric properties of the magnesium oxide. After compaction, the tube must be sized and insulated sufficiently for operation up to 600 volts. A corrugated stainless steel fin is to be wrapped around the tube to increase its heat transfer surface. Both straight and U-bent elements are to be furnished with mounting flanges, making them individually removable from the terminal box.
3. Maximum Power Density of Elements: 25 watts / square inch.
4. Element Cold Section: The first and last 6 inches (150mm) of each element (adjacent to the element terminal box) shall not be heated.
5. Heater Frame: Slip-in construction, corrosion resistant steel.
6. Heater Enclosure: NEMA 1 (indoor applications) or NEMA 4 (outdoor applications) enclosure with a hinged latching cover. Enclosure shall include 2 inches (50mm) of 1-1/2 lb density fiberglass insulation covering the back of the heater terminal section.
7. Control Panel – Integral to heater enclosure if possible, otherwise remote control panels to be NEMA 1 (indoor applications) or NEMA 4 (outdoor applications) enclosure with a hinged latching cover. Remote panels are to be provided with door interlocking disconnect switch, disconnecting contactors, power fusing, control circuit transformer, and controllers are to be mounted inside the control panel for easy access and servicing.
8. Diffuser Plates: Provide a full height by full width primary diffuser plate shall be provided a minimum 8 inches (200mm) upstream of the electric heating coil. Diffuser plate shall have field-adjustable secondary plate(s) and designed to have a 25% free area when overlapped with the primary plates. The secondary diffuser plates shall be sized to ensure uniform airflow across the electric heating coil. The remainder of diffuser plate shall be 50% free area with 1-1/2 inch (40mm) diameter openings. Diffuser plate material shall match the air handling unit inside casing sheet material and shall be a minimum of 14ga steel or 1/8 inch thick aluminum.
9. Electrical:
    a. Open coil heaters shall be furnished with a disk type, automatic reset thermal cutout for primary overtemperature protection. Heaters shall also be furnished with disk type, load-carrying manual reset thermal cutouts, factory wired in series with heater stages for secondary protection. Heat limiters or other fusible overtemperature devices are not acceptable.
    b. Heaters shall be rated for the voltage, phase and number of heating stages indicated in the schedule. All three-phase heaters shall have equal, balanced, three-phase stages. All internal wiring shall be stranded copper with 105°C minimum insulation and shall be terminated in crimped connectors or box lugs.
    c. Power and control terminal blocks shall be provided and clearly marked for all field wiring and shall be sized for installation of 75°C copper wire rated in accordance with NEC Table 310-16, not more than three conductors in a conduit.
    d. Heaters shall be furnished with built-in fuses per NEC. Heaters will be furnished with built-in fusing. Heaters shall be sub-circuited into a maximum of 48 amps per circuit. Low resistance single element fuses will be mounted in phenolic fuse blocks fitted with extra tension springs to assure cool connections. Fuses shall be sized at least 125% of the load.
10. Control:
    a. SCR Proportional Control: SCR power controller is required for heaters drawing 96 amps or less. One master SCR will be provided for full proportional output.

SCR's are to have field switchable temperature inputs for: 4-20 mA or 0-10 VDC for building automation control. SCR power controller shall be furnished with the following:

1) Failsafe circuitry for shorted or opened input.
2) LED status lights for: power on and system operation.
3) All SCR's are equipped with transient/surge absorbers.
4) SCR's are zero cross firing.
5) Snubber network protection against false firing.
6) Control circuit is to be optically isolated from the power circuit.
7) SCR is to be suitable for indoor, dusty, and wet or outdoor applications corresponding with the control enclosure NEMA rating.

b. SCR Vernier Control: Vernier control is required for heaters drawing more than 96 amps. One slave SCR stage and a sufficient number of step-controlled stages are to be provided for full proportional control over the entire heater KW range. Vernier control system is to have field switchable temperature inputs for: 4-20 mA or 0-10 VDC for building automation control. Vernier control shall be furnished with the following:

1) Adjustable time delay between stages.
2) LIFO - Last in, first out stage sequencing.
3) LED status lights for power on, system operation and each stage on.
4) Self-diagnostic program with trouble-shooting LED to verify input settings, wiring, contactor and stage operation.
5) Step controller with TRIAC outputs for each stage.
6) Slave SCR stage size at 100-125% larger than step controlled stages.
7) Slave SCR to provide proportional control for 0-100% of connected load.
8) All SCR's are equipped with transient load surge absorbers.
9) SCR's are zero cross firing.

2.31 INDIRECT GAS-FIRED HEATER

A. Manufacturers:
1. Heatco.
2. Nagas.

B. General:
1. Heaters shall be installed in compliance with NFPA 54.
2. Heaters shall be ETL or UL listed/recognized in accordance with ANSI Z83.8.
3. Heater shall be suitable for operation on the positive pressure side of the fan and listed for use downstream of a refrigeration and/or cooling system.
4. Heaters shall be suitable for the altitude specified.
5. Heaters shall be suitable for installation within an air handling unit.
6. Heaters shall be provided with a complete control system to independently control heater operation.

C. Construction
1. Heat Exchanger: 409 stainless steel
2. Burners: 304L stainless steel.
   a. Combustion: Forced draft, variable speed.
   b. Fuel: See schedule.
   c. Minimum Combustion Efficiency: 80%.

d. Minimum Turndown Ratio: 10:1.
e. Ignition: Electronically controlled electric spark with flame sensor.

3. Venting:
   a. Outdoor Units: The heater manufacturer shall provide a complete venting system, suitable for use with the heater. Heater shall discharge a minimum of 18" above the highest point of the AHU roof or the minimum required by the NFPA and applicable Fuel and Gas Code, whichever is greater.
   b. Indoor Units: The heater manufacturer shall provide a list of compatible venting systems in their submittal. The venting system for the heater shall be provided by the installing contractor. The AHU manufacturer shall provide provisions for wall casing penetrations required for venting.
4. Support Frame:
   a. Frame: Galvanized steel, mechanically fastened or welded.
   b. Air-tunnel divider wall: 2 inch (50mm) thick double wall construction, with 1.5lb high temperature insulation. Wall shall be gasketed and sealed with caulking to prevent water infiltration and air leakage.
5. Electrical: Configured for 120V/1/60Hz operation.
6. Safeties:
   a. All safeties, gas piping, and control wire shall be provided by the heater manufacturer.
   b. Low-Gas Pressure Switch: Adjustable switch for indicating low gas pressure.
   c. Vent Flow Verification (Indoor Units Only): Differential pressure switch.
   d. High Limit: Thermal switch or fuse to stop burner.
   e. Gas-Train: Regulated, redundant, 24VAC gas valve assembly containing pilot solenoid valves, modulating temperature control valves, pressure regulator, and manual shutoffs.
   f. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
   g. Gas Manifold: Safety switches and controls complying with ANSI standards and **[FM Global] [IRI]**.
   h. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
   i. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.32 DIRECT GAS-FIRED HEATER

A. Manufacturers:
   1. Heatco.
   2. Nagas.
   3. Maxon.

B. General:
   1. Heaters shall be installed in compliance with NFPA 54.
   2. Heaters shall be ETL or UL listed/recognized in accordance with ANSI Z83.8.
   3. Heater shall be suitable for operation on the positive pressure side of the fan and listed for use downstream of a refrigeration and/or cooling system.
   4. Heaters shall be suitable for the altitude specified.
   5. Heaters shall be suitable for installation within an air handling unit.

6. Heaters shall be provided with a complete control system to independently control heater operation.

C. Construction
1. Heat Exchanger: 409 stainless steel
2. Burners: 304L stainless steel.
   a. Combustion: Forced draft, variable speed.
   b. Fuel: As scheduled.
   c. Minimum Combustion Efficiency: 80%.
   d. Minimum Turndown Ratio: 5:1.
   e. Ignition: Electronically controlled electric spark with flame sensor.
3. Venting:
   a. Outdoor Units: The heater manufacturer shall provide a complete venting system, suitable for use with the heater. Heater shall discharge a minimum of 18” above the highest point of the AHU roof or the minimum required by the NFPA and applicable Fuel and Gas Code, whichever is greater.
   b. Indoor Units: The heater manufacturer shall provide a list of compatible venting systems in their submittal. The venting system for the heater shall be provided by the installing contractor. The AHU manufacturer shall provide provisions for wall casing penetrations required for venting.
4. Support Frame:
   a. Frame: Galvanized steel, mechanically fastened or welded.
   b. Air-tunnel divider wall: 2 inch (50mm) thick double wall construction, with 1.5lb high temperature insulation. Wall shall be gasketed and sealed with caulking to prevent water infiltration and air leakage.
5. Electrical: Configured for 120V/1/60Hz operation.
6. Safeties:
   a. All safeties, gas piping, and control wire shall be provided by the heater manufacturer.
   b. Vent Flow Verification: Differential pressure switch.
   c. High Limit: Thermal switch or fuse to stop burner.
   d. Gas-Train: Regulated, redundant, 24VAC gas valve assembly containing pilot solenoid valves, modulating temperature control valves, pressure regulator, and manual shutoffs.
   e. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
   f. Gas Manifold: Safety switches and controls complying with ANSI standards and **[FM Global] [IRI]**.
   g. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
   h. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.33 SOUND ATTENUATOR

A. Manufacturers:
1. VAW.
2. Vibroacoustics.

B. General:

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1. Sound attenuators performance must have been substantiated by laboratory testing in accordance with the latest version of ASTM E-447.
2. Sound attenuators media shall not exceed a flame-spread index of 25 and a smoke developed index of 50 when tested in accordance with ASTM-E84, NFPA 255, or UL723.

C. Construction:
1. Sound attenuators shall be of the size, configuration, capacity, and acoustic performance as scheduled on the drawings.
2. Sound attenuators shall be constructed in accordance with ASHRAE and SMACNA standard for the pressure and velocity classification specified.
3. Structural Performance: Sound attenuators shall not fail structurally when subjected to a differential air pressure of 8 inches H2O (2kPa).
4. Outer Casing: Solid galvanized steel.
5. Inner Casing: Perforated aluminum.
6. Sealing: All casing seams and joints shall be lock-formed and sealed, stitch-welded and sealed, or continuously welded for leakage resistant construction.
7. Acoustical Liner: **[Unlined][Dissipative fiberglass][Film-lined fiberglass]**.

2.34 ELECTRICAL

A. General:
1. All electrical work shall be installed in full compliance with the National Electric Code and all local codes and requirements.
2. Where applicable, components shall bear UL listed, UL recognized, or ETL listing marks.
3. All wiring and components inside air handling plenums shall be weatherproof and rated for such use.

B. Routing:
1. Conduit
   a. All wiring shall be run in EMT conduit utilizing compression type fittings.
   b. All conduit in wet sections and on the exterior of outdoor units (including but not limited to outdoor air intakes, humidifier, and cooling coil sections) shall be rigid aluminum.
   c. All conduit penetrations in the unit housing and penetrations across air seal and insulated walls shall be internally sealed airtight with caulk to prevent the migration of water vapor in the conduit.
2. Conductors: All power conductors to be 600V rated, copper MTW, THHN, or THWN.
3. Shipping-splits:
   a. A junction box shall be provided at each shipping-split to aid in field connection of wiring.
   b. All conductors servicing circuits 300V or less shall be spliced with wire nuts at each shipping split.
   c. All conductors servicing circuits greater then 300V shall be pulled back to the shipping split nearest to the component served. Alternatively, circuits may be spliced with the aid of panel mounted terminal blocks rated for the voltage and current of the application. Other means of splicing are not permitted.
4. Boxes, Enclosures, and Cabinets:

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a. All boxes, enclosures and cabinets exposed to the outdoor environment shall be NEMA 3R rated.
b. All boxes, enclosures, and cabinets exposed to the indoor environment or within a service corridors shall be NEMA 1 rated.

C. Motors:
1. **[Each motor shall be wired to a VFD located on the exterior of the unit (unless size prohibits). If the VFD is remotely mounted, one non-fused disconnect shall be provided on the air handling unit for each motor connection.] [All motors of each fan array are to be wired to a common VFD. Each motor shall be provided individual motor overload protection and manual, lockable disconnecting means for each motor. If the VFD is remotely mounted, one non-fused disconnect shall be provided on the air handling unit for each motor connection.]**
2. Motor wiring to each motor shall be in separate conduits. Wiring multiple motors within the same conduit, wireway, or trough is not permitted.
3. Control wiring shall not be located in the same conduit(s) as power wiring.

D. Lighting: Each access section of the unit shall be provided one vapor-proof, 100W minimum marine light fixture for every 12 feet (3.7 meters) of access section width. Lighting circuits shall be wired a common 120V feed location. Lighting shall be controlled with 20A rated, 2-way w/ pilot light switches. Bulbs for light fixtures shall be provided by others.

E. For units 20 feet (6.1 meters) long or greater, a minimum of two light switches shall be provided. Light switches shall be located at the fan and filter section access doors.

F. Convenience Receptacles: Each fan section shall be provided with a duplex, 20-amp GFCI receptacle wired to a common 120V feed location. Receptacles for use in outdoor or wet environments shall bear the “WR” mark and be enclosed with a while-in-use cover.

G. Field Wiring Connections
1. All 460V connections shall terminate at each component junction box, VFD, or disconnect.
2. All 120V wiring shall be wired to a common point terminating in a junction box.

PART 3 - EXECUTION

3.1 UNIT FACTORY TESTING

A. Standard Factory Tests: The fans shall be factory run tested to ensure structural integrity and proper RPM. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass quality control and be thoroughly cleaned prior to shipment. A representative of the owner, the installing contractor, and the engineer may witness the testing if they choose. The manufacture must notify the parties involved a minimum of two weeks prior to testing.

B. Cabinet Leak Testing: The cabinet shall be tested at the unit's design operating static pressures for both the high and low pressure sides. Unit leakage rate shall not exceed 0.5% of unit airflow capacity at 1.25 times the operating static pressure (50 cfm (23.6 l/s) minimum per air tunnel). Leak testing shall be performed by measuring the airflow used to pressurize the air handling

unit positively or negatively at the cabinet design operating static pressure via a calibrated orifice method. All supply and return air openings shall be sealed along with the air seal at the supply fan bulkhead wall to isolate the high and low side of the unit. The unit shall then be pressurized with air until the appropriate operating static pressures are achieved.

C. Cabinet Deflection Testing: A unit deflection test shall be conducted at 1.15 times the peak fan shutoff static pressure on the supply fan performance curve (not to exceed 15 in. H2O). Deflection shall not exceed L/200.

D. Performance Testing (Pitot Traverse): For fans without piezometer rings, airflow measurements shall be performed in accordance with AMCA Standard 203, Field Performance Measurements of Fan Systems, which utilizes a pitot tube traverse of the velocity pressures in a short section of straight ductwork. A test duct shall be attached to either the inlet or discharge opening(s) of the air handling unit. The duct shall be sized to increase the air velocity to approximately 2500 FPM (12.7 m/s). The test duct shall not induce non-uniform airflow that may result in additional system effects. Filter losses and external losses shall be simulated by reducing the cross sectional area of a component within the air handling unit. The test shall include two performance test points, which shall be achieved by throttling as stated. The testing shall be performed at the factory and witnessed by the owner's representatives. A detailed report, including all data and test methods, shall be presented to the owner.

E. Performance Testing (Piezometer Ring): For fans with piezometer rings, airflow measurements shall be performed utilizing the fan piezometer rings. The piezometer rings shall be connected to a central measuring station to convert the differential pressure, air temperature, and air pressure readings to an airflow measurement. Filter losses and external losses shall be simulated by reducing the cross sectional area of a component within the air handling unit. The test shall include two performance test points, which shall be achieved by throttling as stated. The testing shall be performed at the factory and witnessed by the owner's representatives. A detailed report, including all data and test methods, shall be presented to the owner.

F. Sound Testing: The equipment manufacturer shall furnish calculations showing the estimated sound power levels at the supply and, return connections, as well as unit casing radiation for each air conditioning unit. Calculations shall be based on fan sound power levels, which were determined in accordance with AMCA Standard 300 and 301.

G. A sound pressure test of the assemble air handling unit shall be conducted with the unit operating at the desired rating point. The sound pressure measurements will be taken at the unit inlet and outlet and 3 feet (1 m) from the unit casing. This testing requires that care be taken to minimize intrusions from background noise, so testing may be conducted when background noise is at a minimum. A detailed report, including all data and test methods, shall be presented to the owner.

H. Fan Vibration Testing: Fan wheel and shaft assemblies shall be dynamically analyzed after the fan, motor and drive assemblies have been installed in the unit. The fan is analyzed with an electronic balance analyzer with a tunable filter. Vibration measurements are taken on each bearing housing in the horizontal, vertical, and axial positions with the filter tuned to the fan RPM. The maximum acceptable filter-in vibration reading for at any of the tested positions shall not exceed 0.16 inches per second. The testing shall be performed at the factory and witnessed by the owner's representatives. A detailed report, including all data and test methods, shall be presented to the owner.

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3.2 START-UP

A. Manufacturer's Field Inspection: Engage a factory-authorized service representative to perform the following:
   1. Inspect field assembly of components and installation of central-station air-handling units.
   2. Prepare a written report on findings and recommended corrective actions.
   3. Unit start-up

B. Final Checks before Startup: The installing contractor shall perform the following before startup:
   1. Verify that shipping, blocking, and bracing are removed.
   2. Verify that unit is secure on mountings and supporting devices and that piping, ductwork, and electrical connections are complete. Verify that proper thermal overload protection is installed in motors, starters, and disconnects.
   3. Verify 120V and 460V power are brought to air handling unit.
   4. Verify all shipping splits are sealed.
   5. Verify that concrete is poured into inertia bases.
   6. Verify proper motor rotation direction, free fan wheel rotation and smooth bearings operations. Check fan drive system for alignment and proper belt tension.
   7. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
   8. Set face-and-bypass dampers to full face flow.
   9. Set outside-air and return-air mixing dampers to minimum outside-air setting.
   10. Comb coil fins for parallel orientation.
   11. Install clean filters.
   12. Verify that zone dampers, manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

C. Start-Up Procedures for Custom Air Handling Units: The manufacturer’s start-up service technician shall perform the following:
   1. Check all foundations: fan, isolator base and motor bolts for tightness.
   2. Check set screws in the fan wheel hub for tightness to shaft.
   3. Remove fan bearing caps and check for proper amount of grease.
   4. Check for proper locking ring position in the held bearing.
   5. Check that the free bearing is in the center of the running groove.
   6. Check the set screws in the bearings to insure bearing is locked.
   7. Remove belt guard and check for sheave alignment and proper belt tension.
   8. Check all sheave and bushing hardware for tightness.
   9. Check height of the isolation base to insure that the base and isolators are level.
   10. Check to insure all shipping hold down brackets have been removed.
   11. Bump fan/motor to check for proper wheel rotation.
   12. Bring fan up to speed, checking for noise, vibration, pulsations, etc.
   13. Check vibration levels on the fan and motor bearings. Rebalance if necessary.
   14. Measure and record motor electrical values for voltage, amperage and horsepower.
   15. Check for any damage to the unit interior and exterior. Repair, if necessary.
   16. Check all lights, doors, door handles, filter gauges for any damage. Repair if necessary.
   17. Check all coil fins for damage. Repair if necessary.
   18. Check all dampers for proper movement and operation of the blades.
   19. Manually operate dampers from fully closed to fully open position.

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D. Operation and Maintenance Manuals: Manual shall be provided complete with descriptive literature, model, and serial number of all equipment, performance data, manufacturer's instructions for operating and maintenance and lubrication recommendation and schedule.

3.3 DEMONSTRATION

A. Engage the services of a factory-authorized service representative to train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

B. Review data in the operation and maintenance manuals. Refer to Division 1 Section "Contract Closeout."

C. Schedule all training with a minimum ten (10) days' advance notice.