

SECTION 23 77 00
AIR HANDLING UNITS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 410, Forced-Circulation Air-Cooling and Air-Heating Coils.
2. Air Movement and Control Association International, Inc. (AMCA):
 - a. 201, Fans and Systems.
 - b. 204, Balance Quality and Vibration Levels for Fans.
 - c. 300, Reverberant Room Method for Sound Testing of Fans.
 - d. 301, Methods for Calculating Fan Sound Ratings From Laboratory Test Data.
 - e. 99-2408, Operating Limits for Centrifugal Fans.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
 - a. 15, Safety Standard for Refrigeration Systems.
 - b. 52.1, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
 - c. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
 - d. 62.1, Ventilation for Acceptable Indoor Air Quality.
5. ASTM International (ASTM):
 - a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
 - b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100 percent Relative Humidity.
 - c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
 - d. D3363, Standard Test Method for Film Hardness by Pencil Test.
 - e. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. CSA America (CSA).
7. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 841, Standard for Petroleum and Chemical Industry - Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).

8. International Standards Organization (ISO): 9001, Quality Management Systems – Requirements.
9. National Electrical Manufacturers Association (NEMA).
10. National Fire Protection Association (NFPA):
 - a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
 - b. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
11. Occupational Safety and Health Act (OSHA).
12. Society of Protective Coatings (SSPC):
 - a. SP 3, Power Tool Cleaning.
 - b. SP 5, White Metal Blast Cleaning.
 - c. SP 6, Commercial Blast Cleaning.
 - d. SP 10, Near-White Blast Cleaning.
13. UL:
 - a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
 - b. 723, Standard for Safety Test for Surface Burning Characteristics of Building Materials.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. ac: alternating current.
2. AFD: Adjustable Frequency Drive.
3. AHU: Air Handling Unit.
4. cfm: cubic feet per minute.
5. dB: Decibel.
6. DX: Direct Expansion.
7. DWDI: Double Width, Double Inlet.
8. ETL: ETL Testing Laboratories, Inc.
9. FM: Factory Mutual Insurance.
10. fpm: feet per minute.
11. hp: Horsepower.
12. IAQ: Indoor Air Quality.
13. IEC: International Electro-technical Commission.
14. IRI: Industrial Risk Insurance.
15. MAU: Make-Up Air Unit.
16. NRC: Noise Reduction Coefficient.
17. OD: Outside Diameter.
18. ODP: Open Drip Proof.
19. O&M: Operations and Maintenance.
20. psi: pounds per square inch.
21. PVC: Polyvinyl Chloride.
22. rpm: revolutions per minute.
23. SCR: Silicon Control Rectifier.

- 24. SWSI: Single Width, Single Inlet.
- 25. TEFC: Totally Enclosed, Fan Cooled.
- 26. UV: Ultra Violet.
- 27. VFD: Variable Frequency Drive.
- 28. WC: Water Column.
- 29. XP: Explosion Proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide Shop Drawings for products specified, including, as a minimum:
 - a. Unit identification as referenced in Contract Documents.
 - b. Manufacturer's name and model number.
 - c. Descriptive specifications, literature, and drawings.
 - d. Dimensions and weights for unit, including fully assembled and shipping sections.
 - e. Acoustics:
 - 1) Fan sound power level data (ref. 10 to power minus 12 Watts) at design operating point, based on AMCA 300 for unit discharge, inlet and casing.
 - 2) Additional requirements (including by others) to achieve specified sound performance levels.
 - f. Fans:
 - 1) Type, size, quantity, class, drive arrangement, discharge, rotation and bearings.
 - 2) Wheel type, diameter, rpm, and tip speed.
 - 3) Performance curves indicating:
 - a) Relationship of flow rate to static pressure for various fan speeds.
 - b) Brake horsepower curves.
 - c) Acceptable selection range (surge curves, maximum safe operating rpm).
 - d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including drive losses.
 - 4) For variable air volume applications, indicate operating points at 100, 80, 60, and 40 percent of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure and brake horsepower.
 - g. Coils:
 - 1) Type, quantity, dimensions, material of construction, coatings, if applicable, energy transfer capacity, air pressure

- drop, air inlet, and discharge temperature at design conditions.
- 2) DX Coils: Refrigerant saturated suction temperature at design conditions, refrigerant piping configuration (row split, face split, intertwined), coil fin spacing, coil row depth.
- 3) Electric Resistance Coils: Voltage, phase, number of stages, safety features, controls.
- 4) Drain pan details.
- 5) Coil pull details and dimensions for service.
- h. Motor(s) type, quantity, and performance data.
- i. Air filter(s) type, quantity, and performance data.
- j. Unit capacities and ratings, including airflow and static pressure summary.
- k. Construction materials.
- l. Power and control wiring diagrams, including terminals and numbers.
- m. Vibration Isolation:
 - 1) Vibration isolation methods with maximum deflection data.
 - 2) Additional requirements (including by others) to achieve specified vibration isolation levels.
- n. Factory finish system, with color selection charts where applicable.
- o. Corrosion protection coating product data.
- 2. Or Equal Equipment:
 - a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on the Drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
 - b. Where submitted equipment results in change to ductwork and equipment configuration shown on the Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.

B. Informational Submittals:

- 1. Manufacturer's Certificate of Compliance, in accordance with Section 01 67 00, Product Requirements.
- 2. Sample copy of guarantee.
- 3. Manufacturer's Test Reports for the following:
 - a. Electric heating coil.
 - b. DX cooling coil.
- 4. Recommended procedures for protection and handling of products prior to installation.

5. Manufacturer's installation instructions, including component spacing requirements.
6. Operation and Maintenance Data:
 - a. In conformance with Section 01 78 23, Operation and Maintenance Data.
 - b. Include as-built version of equipment schedules.
 - c. Methods for accessing components for maintenance with required service clearances.

1.04 QUALITY ASSURANCE

- A. Fans: Licensed to bear AMCA seal for air flow and sound performance.
- B. Manufacturer's Qualifications:
 1. The air handling unit manufacturer shall have been successfully manufacturing air handling units for a period of no less than 5 years.
 2. Manufacturer's qualifications are subject to review by the Contracting Officer to determine acceptance.
- C. Fan Performance:
 1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
 2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure.
 3. Motor shall not operate into motor service factor in any listed case.
 4. Accommodate drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA 203, Appendix L.
- D. Thermal Insulation: Shall meet the erosion requirements of UL 181 facing the air stream and fire hazard classification of 25/50 (per ASTM E84 and UL 723).
- E. Heating and Cooling Equipment: Minimum operating efficiencies, defined as COP and EER, as specified in ASHRAE 90.1-2022.
- F. Units shall be certified by UL and CSA and shall be UL or ETL listed and labeled.
- G. Cooling Performance rated in accordance with AHRI testing procedures.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Air handling unit manufacturer shall coordinate with the Contractor as to the requirements for proper delivery, storage, and handling of the air handling

unit and its components required in this Specification to ensure that the unit is properly cared for prior to final installation.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following materials:

<u>Item</u>	<u>Quantity</u>
Prefilters	Four complete sets per unit.
Filters	One complete set per unit.
Fan Belts	One complete set for each belt driven fan.
Special tools required to maintain and dismantle	One complete set for each unit size.

B. Delivery: In accordance with Section 01 67 00, Product Requirements.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Article Supplements.

2.02 OPERATING LIMITS

A. Fans designated to meet a specified Fan Class shall comply with requirements of AMCA 99-2408.

2.03 ACOUSTICAL LEVELS

A. Equipment selections shall produce sound power levels in each octave band no greater than shown in the Fans Schedule.

B. Perform noise tests in accordance with AMCA 300.

2.04 FINISHES

A. Carbon Steel Parts:

1. Factory finished as follows:
 - a. Parts cleaned and chemically pretreated with a phosphatizing process.
 - b. Alkyd enamel primer.
 - c. Air-dry enamel topcoat.

- B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.
- C. Stainless Steel Parts: Finished smooth and left unpainted.

2.05 PACKAGED DEDICATED OUTDOOR AIR HANDLING UNITS (DOAU-1&2)
ADMIN BUILDING

A. General Unit Description:

- 1. Physical Characteristics:
 - a. Unit(s) furnished and installed shall be packaged outdoor air unit(s) as scheduled on data sheets.
 - b. Compressor Hot Gas Reheat (HGRH) shall be factory installed.
 - c. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.
- 2. Functional Characteristics:
 - a. For dehumidification and cooling modes, the evaporator temperature shall be monitored, reported at unit controller.
 - b. Compressor controls shall modulate capacity to maintain evaporator leaving set point.
 - c. Hot Gas Bypass shall not be used to control compressor capacity.
 - d. To prevent rehydration of evaporator condensate the reheat coil face shall be located a minimum of 6 inches downstream from the leaving face of the evaporator coil.
 - e. Heating system shall include modulating controls. Compressor on-off only or primary heating on-off only controls shall not be acceptable control strategies.
 - f. Unit Discharge Airflow Configuration Shall Be: Horizontal or vertical discharge.
- 3. Performance Characteristics: Unit(s) shall be designed for dehumidification, cooling, and heating of 100 percent outdoor air.

2.06 CABINET

A. Physical Characteristics:

- 1. Cabinet Panels: Two-inch double-wall foamed panel construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed.
- 2. Insulation: 2-inch polyisocyanurate foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.
- 3. Cabinet base shall be double wall construction designed to prevent trapping or ponding of water within the unit base. Cabinet base pan shall be insulated with 2-inch thick polyisocyanurate foam. Foam insulation shall be fully enclosed with galvanized steel insulation cover. Insulation shall not be applied to underside of unit base.

4. Cabinet Base Rails: Side and end base rails shall include openings for forklift and tie-down access. To protect unit base from fork damage side rails shall include removable heavy gauge fork pockets.
5. Shipping anchors attach to and/or through unit base rails. Straps over unit shall not be used to secure unit for shipping.
6. Cabinet Material Interior and Base Rails: Shall be G-90 zinc-coated galvanized steel. Material gauge shall be a minimum of 14-gauge for base rails, 16-gauge for structural members and 20-gauge for access doors and cabinet panels.
7. Exterior Corrosion Protection: Exterior cabinet panels shall be a base coat of G-90 galvanized steel with both exterior and interior surfaces cleaned, phosphatized and finished with a weather-resistant baked enamel finish. Unit's surface shall be in compliance with ASTM B45 salt spray testing at a minimum of 672-hour duration.
8. Cabinet construction shall provide hinged panels providing easy access for all parts requiring routine service.
9. Cabinet top cover shall be one piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.
10. Hinged Access Panels: Water-tight and air-tight hinged access panels shall provide access to all areas requiring routine service including air filters, heating section, electrical and control cabinet sections, optional ERV and power exhaust fan section, supply air fan section, evaporator and reheat coil sections. Insulated doors shall be constructed to allow the hinges to be reversed in the field.
 - a. Hold-open devices shall be factory installed on all hinged access doors. Chains shall not be used as hold-open devices.
 - b. Latches with locking hasp or tool operated closure devices shall be factory installed on all hinged access panels.
11. Drain pan material shall be Type 430 stainless steel drain and constructed to sloped in two directions to ensure positive drainage with corners exposed to standing water and drain fittings welded liquid tight to prevent leaks. Pan shall have a minimum depth of 2 inches. Base of drain pan shall be insulated with 1-inch thick foam insulation.
12. Provide openings either on side of unit or thru the base for power, control and gas connections.
13. Cabinet shall include optional interior liner constructed of Type 304 stainless steel with sealed seams.
14. Unit shall be equipped with a 6-inch filter rack upstream of the evaporator. Frame shall be field-adjustable to match any filter combination specified in the following section.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.07 FANS AND MOTORS

A. Physical Characteristics:

1. Indoor fans shall be high efficiency backward curved impeller.
2. The indoor fan motor shall be an electronic commutated motor with integrated power electronics for variable motor speed.
3. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.08 AIR FILTERS

A. Physical Characteristics: Evaporator Inlet shall include a full compliment of pleated media air filters. Filters shall be 2-inch MERV 13.

B. Functional Characteristics: None.

C. Performance Characteristics: None.

2.09 DAMPERS

A. Physical Characteristics:

1. Unit shall include a motor operated outdoor air damper constructed of galvanized steel.
2. Damper blades shall be air foil design with rubber edge seals designed not to exceed a 4 cfm per square feet leakage rate exceeding ASHRAE 90.1 damper leakage requirements.
3. Damper actuator shall be factory mounted and wired sealed spring return and either two-position or fully modulating.

B. Functional Characteristics: Dampers air velocity shall not exceed 2,000 fpm.

C. Performance Characteristics: None.

2.10 HEATING

A. Modulating Electric Resistance Heating System:

1. Physical Characteristics:
 - a. Completely assembled and factory installed electric heating system shall be fully modulating, SCR controlled and listed for use in roof top handler. The heating section will include open coil heating elements, automatic and manual cut-outs, low voltage

controls, air proving switch, maximum 48 amps per circuit and fusing for heaters over 48 amps.

- 1) Electric heater shall be located:
 - a) In the primary heating position located downstream of the indoor fan assembly.
 - b) In the secondary heating position located upstream of the unit return air section and will be staged and of fin tubular type.
2. Functional Characteristics: None.
3. Performance Characteristics: Heater shall be UL or CSA listed and approved and provide single point power connection.

2.11 ELECTRICAL RATINGS AND CONNECTIONS

A. Physical Characteristics:

1. All high voltage power components such as fuses, switches and contactors shall include a service personnel protection barrier or shall be a listed as touch-safe design.
2. Field wiring access to be provided thru unit base into isolated enclosure with removable cover.
3. Power wiring to be single point connection.
4. Wiring internal to the unit shall be colored and numbered for identification.
5. Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.
6. Factory wired main power disconnect and overcurrent device shall be rated for total unit connected power.
7. Factory to mount and wire optional 120-volt convenience outlet. Field wiring of convenience outlet not acceptable.
8. All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.

B. Functional Characteristics:

1. Factory wired Voltage/Phase monitor shall be included as standard. In the event of any of the following, the units will be shut down and a fault code will be stored in the monitor for the most recent 25 faults. Upon correction of the fault condition the unit will reset and restart automatically.
 - a. Phase Unbalance Protection: Factory set 2 percent.
 - b. Over/Under/Brown Out Voltage Protection: Plus or minus 10 percent of nameplate voltage.
 - c. Phase Loss/Reversal.

C. Performance Characteristics: None.

1. Unit SCCR rating shall be a minimum of 42 kA.
2. Optional unit SCCR rating shall be a minimum of 65 kA.

2.12 UNIT CONTROLS

A. Physical Characteristics:

1. Main Unit Controller (MCM) shall be a microprocessor based controller with resident control logic.
 - a. Controller program logic shall include:
 - 1) Include single program with field selectable:
 - a) Discharge air control with unit conditioning modes enabled based on outdoor air conditions and controlled to maintain discharge air setpoints.
 - b) Space control with unit conditioning modes enabled and controlled to maintain space setpoints.
2. Optional MCM Touch Screen shall include full color display and shall be (factory installed in unit control compartment / field mounted remote from unit and field wired up to a maximum of 300 feet.) and provide a full list of points included in the MCM. The display shall provide a list and history of all unit alarms.
3. System Sensors shall include: Factory installed and wired Outdoor Air Temperature, Outdoor Air Humidity and Evaporator Leaving Air Temperature and factory furnished, field installed Discharge Air Temperature.
 - a. Space Control or Single Zone VAV: Factory shall furnish Space Temperature and Space Humidity sensor for field installation and connection to the unit.
4. Optional Smoke Detectors to sense (Return Air / Discharge Air / Return and Discharge Air) stream(s) shall be factory installed and wired.

B. Functional Characteristics:

1. MCM shall:
 - a. Prevent simultaneous operation of any conditioning modes.
 - b. Accept separate setpoints for Occupied and Unoccupied states.
 - c. Call for Dehumidification based on dew point setpoints. When no call for Dehumidification is present MCM shall control calls for Cooling, Heating and Economizer modes based on sensible or enthalpy temperature setpoints. MCM shall have onboard clock and scheduling function for occupancy.
 - d. Include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.

- e. Enable HGRH dehumidification and cooling modes and control modulation to maintain (discharge air temperature / space temperature).
- f. Unit shall include minimum discharge air control.
- 2. System controls shall include:
 - a. Anti-cycle timing.
 - b. Minimum compressor run/off-times.

C. Performance Characteristics: None.

2.13 MAKE-UP AIR UNITS

A. Manufacturers:

- 1. Engineered Air.
- 2. Or equal.

B. General:

- 1. Physical Characteristics:
 - a. Custom air handling unit, constructed by assembly of factory-fabricated components such as fan units, motor and drive assembly, heat transfer devices, dampers, plenums, filters, condensate pans, heating units, control devices and accessories.
 - b. Required unit components as indicated on plans and equipment schedule.
 - c. Assembly shall be a complete and fully functioning system with all components and accessories as specified.
- 2. Functional Characteristics: None.
- 3. Performance Characteristics:
 - a. Fan Air and Sound Performance: Tested and rated in accordance with AMCA and guaranteed by manufacturer.

C. Unit Casing:

- 1. Physical Characteristics:
 - a. General:
 - 1) Fully enclosed housing, with casing consisting of sheet metal side, floor and roof panels.
 - 2) Lifting lugs and unit support frames, factory installed, to facilitate installation.
 - 3) All casing to consist of formed and reinforced sheet metal panels, insulated as indicated; flat panel design not acceptable.

- 4) For double wall units, distance between inner and outer panels as required to accommodate insulation thickness as specified below:
 - a) Double Wall Casing Units: Insulation fully encased between outside and inside panels.
 - b) Properties:
 - (1) 2-inch thickness, 1.5 pounds per cubic foot density.
 - (2) Units with Perforated Liner or Exposed Insulation: Black composite protective coating on surface exposed to airstream.
- 5) Double wall units are required, unless noted otherwise.
- b. Panel Arrangement: Panels mechanically fastened together forming a self-framing housing with no additional structural support required or mechanically fastened to a fully welded unitized frame assembly.
- c. Outdoor Units:
 - 1) Weathertight and rated for outdoor use.
 - 2) Cross broken and sloped roof cap system.
 - 3) Drip shield/overhang provided on all four sides of unit.
 - 4) Caulked/sealed standing top seams to assure waterproofing.
- d. Material: Panels, fasteners, and structural metal frame members constructed from G-90 galvanized steel.
- e. Outer Panels:
 - 1) Outdoor Units:
 - a) Walls: Minimum 18-gauge thickness sheet metal.
 - b) Roof: Minimum 18-gauge thickness sheet metal.
- f. Inner Panels:
 - 1) Walls and Roof: Minimum 22-gauge thickness sheet metal.
 - 2) Floor Plate: Minimum 18-gauge thickness sheet metal.
- g. Joints:
 - 1) Joints between exterior panels and structural frames shall have seals and gaskets with appropriate material type for air seal and acoustical break.
 - 2) Seams caulked and sealed for an airtight unit.
 - 3) Fully through-bolted section to section joints.
- h. Access Doors:
 - 1) Heavy-gauge, 0.0625-inch minimum, oversized access doors insulated, double wall construction, internal sheet metal skin.
 - 2) Sized and located to provide easy access to unit internal components.
 - 3) Hinged, latched, and gasketed to provide a weatherproof seal.

- 4) Latches:
 - a) “Ventlok” style noncorrosive alloy latches operable from inside and outside of unit.
 - b) For access doors configured to open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.
- 2. Functional Characteristics: None.
- 3. Performance Characteristics: None.

D. Drain Pans:

- 1. Physical Characteristics:
 - a. Location: Under each cooling coil, and as specified.
 - b. IAQ style drain pans, complying with requirements of ASHRAE 62.1.
 - c. Formed sections of minimum 16-gauge (0.0625 in.) Type 304 stainless steel.
 - d. Triple pitched for complete drainage, with no standing water in unit.
 - e. Double Wall Construction:
 - 1) Space between walls filled with foam insulation.
 - 2) Sealed moisture tight.
 - 3) Welded corners.
 - f. Drain Connections:
 - 1) Type 304 stainless steel, male pipe thread.
 - 2) Both ends of pan.
 - 3) Extended to exterior of unit cabinet.
 - 4) Connection centerline shall be a minimum of 3 inches above base rail. Drain connections that protrude from the base rail are not acceptable.
- 2. Functional Characteristics: None.
- 3. Performance Characteristics: None.

E. Unit Base:

- 1. Physical Characteristics:
 - a. Full perimeter base frame.
 - b. Minimum 10-gauge (0.135 inch) structural steel construction, with C channel cross support members, on close centers.
 - c. All joints fully welded.
 - d. Fitted with lifting lugs at corner of unit.
 - e. Attached to unit at factory, unless noted otherwise for field assembly.

2. Functional Characteristics: None.
3. Performance Characteristics: None.

F. Supply Fan Section:

1. General:
 - a. Physical Characteristics:
 - 1) Supply air section with fan assembly, consisting of housing (where applicable), wheel, fan shaft, bearings, motor, disconnect switch, drive assembly, support structure, and accessories.
 - 2) Casing constructed in accordance with Paragraph Unit Casing.
 - 3) Suitable to convey air at temperatures up to 250 degrees F.
 - b. Functional Characteristics:
 - 1) Fan Assemblies: Statically and dynamically balanced, designed for continuous operation at maximum rated fan speed and motor horsepower.
 - c. Performance Characteristics:
 - 1) Fan Performance: AMCA 99-2408 class rating corresponding to the static pressure at which the fan is designed to operate.
2. Centrifugal Fan Housing:
 - a. Physical Characteristics:
 - 1) Material: G-90 galvanized steel.
 - 2) Construction:
 - a) Formed and reinforced sheet metal panels, curved scroll configuration with shaped cutoff, continuous seam welding and side angle reinforcement.
 - b) Flanged and drilled outlet to permit duct connection.
 - c) Spun-formed aerodynamic bell mouth inlet.
 - d) Access doors or panels to allow entry to internal parts and components.
 - e) Base:
 - (1) All-welded heavy-gauge metal.
 - (2) Fan and motor mounted on common base.
 - (3) Motor Mount: Adjustable slide mount.
 - 3) Plug Fans: Fabricate without fan scroll and volute housing.
 - 4) Hardware: Type 304 stainless steel or Type 316 stainless steel.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.

3. Fan Wheel:
 - a. Physical Characteristics:
 - 1) Centrifugal, one-piece, blade type as scheduled.
 - 2) Backward Inclined Fans:
 - a) DWDI backward inclined fan wheel.
 - b) Nonoverloading performance characteristics.
 - c) Backward inclined blades, heavy gauge metal construction, continuously welded to backplate and curved inlet flange.
 - 3) Material: Aluminum. Headworks 20-MAU-1 to have Type 304 stainless steel or Type 316 stainless steel.
 - 4) Attached to fan shaft with split taper lock bushing.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
4. Fan Shaft, Bearings, Drive:
 - a. Physical Characteristics:
 - 1) Shafts:
 - a) Turned, ground, and polished Type 304 stainless steel or Type 316 stainless steel.
 - b) Ends drilled and countersunk for tachometer readings.
 - c) Keyed for sheave installation.
 - d) Coated with lubricating oil.
 - 2) Bearings:
 - a) Grease lubricated, precision anti-friction ball, self-aligning type.
 - b) Mounted in cast iron pillow block housing.
 - c) Selected for average life (ABMA 9 L₅₀) of not less than 200,000 hours operation at maximum cataloged operating speed.
 - 3) Drives:
 - a) Factory set to specified fan revolutions per minute.
 - b) Type: Belt.
 - c) Arrangement: 3.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
5. Internal Vibration Isolation:
 - a. Physical Characteristics:
 - 1) Fan/Motor Base: Isolate base from unit casing with open spring isolators with 2-inch deflection.
 - 2) Flexible Connectors: Install flexible polychloroprene coated canvas ducts between fan and unit casing to ensure complete isolation.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.

6. Accessories:
 - a. Physical Characteristics:
 - 1) Extended Lubrication Lines: For any bearing requiring lubrication, grease lines shall be extended to fan support bracket on drive side.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.

G. Refrigerant Coil Section:

1. General:
 - a. Physical Characteristics:
 - 1) Fin-tube direct expansion refrigerant cooling coil, complete with refrigerant controls, and related accessories.
 - 2) Casing constructed in accordance with Paragraph Unit Casing.
 - 3) Coil shipped with end connections sealed and filled with a charge of dry nitrogen.
 - b. Functional Characteristics:
 - 1) Factory tested with air at 300 psig while immersed in an illuminated water tank.
 - 2) Coils designed for use with refrigerant type in associated refrigerant compressor.
 - c. Performance Characteristics:
 - 1) AHRI 410 performance rated and certified.
 - 2) Designed and tested in accordance with ASHRAE 15.
2. Coil Assembly:
 - a. Physical Characteristics:
 - 1) Refrigerant Piping Connections:
 - a) On same side of unit.
 - b) Extended a minimum of 5 inches beyond exterior of the unit casing by manufacturer.
 - 2) Coils removable from the unit at header end, unless shown otherwise on the Drawings.
 - 3) Clearly label liquid and suction headers on outside of unit.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
3. Refrigerant Circuiting:
 - a. Physical Characteristics:
 - 1) Alternate tube circuited in order to distribute the cooling effect over the entire coil face at reduced load conditions.
 - 2) Refrigerant Distributors: Brass, replaceable nozzle type, connected to the coil by copper tubes.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.

4. Fins:
 - a. Physical Characteristics:
 - 1) Die-formed plate type, rippled for maximum heat transfer.
 - 2) Continuous metal across coil casing; split fins not acceptable.
 - 3) Shall have fully drawn collars and be mechanically bonded to tubes by mechanical expansion of tubes.
 - 4) Material: Minimum 0.006 -inch aluminum.
 - 5) Fin density no greater than 12 fins per inch.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
5. Tubes:
 - a. Physical Characteristics:
 - 1) Material: Minimum 1/2-inch OD seamless copper tubing.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
6. Headers:
 - a. Physical Characteristics:
 - 1) Located inside unit.
 - 2) Constructed from seamless copper tubing with die formed tube holes and brazed joints.
 - 3) Refrigerant Piping Connections: Terminate with OD sweat copper.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
7. Casings:
 - a. Physical Characteristics:
 - 1) Construct from minimum 16-gauge (0.0625 in.) G-90 galvanized steel.
 - 2) Formed end supports and top and bottom channels.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
8. Drain Pan:
 - a. Physical Characteristics:
 - 1) Construction in accordance with Paragraph Drain Pans.
 - 2) Furnish drain pan under each cooling coil.
 - 3) Intermediate Drain Pan:
 - a) Provide intermediate drain pans on stacked cooling coils.
 - b) Intermediate pan shall drain to main drain pan through a copper downspout.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.

9. Accessories:
 - a. Physical Characteristics:
 - 1) Coil Protective Coating:
 - a) Provide factory applied corrosion protection coating on these coil components:
 - (1) Coil assembly, including all exterior surfaces of fins and tubes.
 - (2) Refrigerant piping, headers, distributors, exposed to the air stream.
 - (3) Coil casings.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.

H. Filters:

1. Manufacturers:
 - a. Farr.
 - b. Or equal.
2. General:
 - a. Physical Characteristics:
 - 1) Air filtration section, complete with filter media and filter racks.
 - 2) Casing constructed in accordance with Paragraph Unit Casing.
 - 3) Double wall, hinged, removable access doors on one side of unit.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: Maximum 500 fpm face velocity across filters.
3. Media Schedule:
 - a. Physical Characteristics:
 - 1) Main Filter:
 - a) Vertical arrangement.
 - b) Disposable pleated type.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.
4. Media Construction:
 - a. Physical Characteristics:
 - 1) General:
 - a) Contain in a rigid frame.
 - b) Meet UL Class 2 standards.
 - c) Rigid supporting mesh across the leaving face of media.
 - d) Quality certified by ISO 9001.
 - 2) Preformed, Disposable Dry Extended Area Type: Rated at mean efficiency of 60 percent to 65 percent and average

arrestance of 98 percent in accordance with ASHRAE 52.1, by ASHRAE Atmospheric Dust Test Method.

- 3) Disposable Pleated Type:
 - a) Pleated panel disposable filters.
 - b) Nonwoven reinforced cotton/poly fabric media with a metal support grid and heavy-duty beverage board-enclosing frame.
 - c) Two-inch thickness.
 - d) MERV 8 efficiency per ASHRAE 52.2.
- b. Functional Characteristics: None.
- c. Performance Characteristics: None.
- 5. Frame and Filter Assembly:
 - a. Physical Characteristics:
 - 1) Suitable for space indicated.
 - 2) Permanent reusable, side-loading 16-gauge steel holding frame, retainer, and sealer frame.
 - 3) Filter blank-offs to prevent air bypass around filters, same material as frame.
 - b. Functional Characteristics: None.
 - c. Performance Characteristics: None.

I. Outside Air Intake:

- 1. Physical Characteristics:
 - a. Weather Hood: Fully welded construction, fabricated from same material as unit casing.
 - b. Louver: Drainable type, S-shaped rainproof blades, spaced 2 inches maximum.
 - c. 1/2-inch mesh PVC-coated galvanized bird screen on inside face of louver.
- 2. Functional Characteristics: None.
- 3. Performance Characteristics: None.

J. Control Dampers:

- 1. Physical Characteristics:
 - a. Internally mounted ultra low leak dampers.
 - b. Construction:
 - 1) Extruded aluminum blades.
 - 2) Galvanized steel frame, U-shaped galvanized metal sections securely screwed or welded to unit chassis.
 - 3) Vinyl blade seals, stainless steel jam seals.
 - 4) Type 304 stainless steel linkage, shafts, and hardware.
 - 5) Type 304 stainless steel sleeve bearings.
- 2. Functional Characteristics: None.

3. Performance Characteristics: Leakage rate shall not exceed 5 cfm per square foot at 1 inch-WC and 9 cfm per square foot at 4-inch WC.

K. Unit Electrical and Controls:

1. Physical Characteristics:

- a. General:

- 1) Electrical and control components shall meet requirements of Division 26, Electrical.
 - 2) All electrical and controls components and assemblies UL or ETL listed and labeled.
 - 3) Factory wired units shall bear an ETL or UL label with all necessary identification marks, electrical data, and cautions, as required by NEC.
 - 4) Provide as-built wiring diagrams and schematics for electrical and control systems, secured to inside of control panel door, or enclosed in plastic jackets placed inside control panel.
 - 5) For additional requirements, refer to Specification paragraphs for individual sections and components, and Section 23 09 00, Instrumentation and Control Devices for HVAC.

- b. Main Power Connection: Provide single point power connection to unit, serving both primary unit voltage and unit control voltage.

- c. Main Control Panel:

- 1) Provide unit main control panel, with electrical and control components housed in a single enclosure, integral to unit.
 - 2) NEMA 4X enclosure.
 - 3) Compartment ventilated with supply air from unit to provide adequate cooling of components mounted within.
 - 4) Access Doors:
 - a) Heavy-gauge, insulated, double wall construction, internal sheet metal skin.
 - b) Sized and located to provide easy access to unit internal components.
 - c) Hinged, latched, and gasketed to provide a weatherproof seal.

- d. Factory Installed Disconnects:

- 1) Provide main electric power lockable disconnect for unit.
 - 2) Provide electric power lockable disconnect for each section containing electrical components.
 - 3) NEMA 4X enclosure.
 - 4) Nonfused type.
 - 5) Factory installed on outside of unit cabinet, and factory wired to electrical component terminals.

2. Functional Characteristics: None.
3. Performance Characteristics: None.

L. Accessories:

1. Physical Characteristics:
 - a. Provide as follows:
 - 1) Roof Curb:
 - a) Factory fabricated.
 - b) Sloped to match roof pitch, and to provide level top.
 - c) Height above Finished Roof: 24 inches.
 - d) Galvanized steel construction.
 - e) Mitered, continuous welded corner seams.
 - f) Provide wind and seismic bracing per Section 01 88 15 Anchoring and Bracing Specifications.
 - g) Pressure-treated wood nailer.
 - h) Insulation: Minimum 1-1/2-inch thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.
 - 2) Corrosion Protection Coating:
 - a) Provide factory applied corrosion protection coating on these unit components:
 - (1) Fan housing.
 - (2) Interior surfaces in contact with air stream.
 - (3) Exterior cabinet.
 - b) Coating system shall be baked enamel or epoxy paint and shall be in accordance with Article Corrosion Protection.
 2. Functional Characteristics: None.
 3. Performance Characteristics: None.

2.14 MOTORS

A. Physical Characteristics:

1. General:
 - a. Fan motors shall comply with provisions of Section 26 20 00, Low-Voltage AC Induction Motors.
 - b. Provide integral self-resetting overload protection on single-phase motors. Provide ODP motor, unless noted otherwise.
 - c. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
 - d. Fan motors shall not operate into service factor in any case.

B. Functional Characteristics:

1. Motor requirements shall be as follows unless designated otherwise on fan equipment schedule:
 - a. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
 - b. Winding Thermal Protection: None.
 - c. Space Heater: No.
 - d. Number of Speeds: Single.
 - e. Number of Windings: One.
 - f. Motor Efficiency: Premium efficient.
 - g. Shaft Type: Solid, carbon steel.
 - h. Mounting: As required for fan arrangement.

C. Performance Characteristics: None.

2.15 CORROSION PROTECTION

A. General:

1. Factory applied corrosion protection coating for application to unit components and accessories, where in required by this section.
2. Quality Control:
 - a. Verify dry film thickness before final baking.
 - b. Finished coating system shall be free from voids, checks, cracks and blisters.
3. Surface Cleaning:
 - a. For all coating systems, parts to be coated shall be cleaned as follows:
 - 1) Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
 - 2) Follow with immersion in potable water bath to neutralize and remove cleaning solution.
 - 3) Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Baked Enamel:

1. Physical Characteristics:
 - a. Material: Alkyd modified urea-melamine single component baking enamel.
 - b. Surface Preparation: Clean surface to SSPC SP 3, Power Tool Cleaning.
 - c. Application: Standard air-pressurized spray equipment.
 - d. Finished Thickness: 1 mil to 2 mils, dry film thickness.

2. Functional Characteristics:
 - a. Curing: Oven baked at a metal temperature not to exceed 300 degrees F.
3. Performance Characteristics:
 - a. Coating shall meet or exceed following criteria:
 - 1) Impact Resistance: 10 in. lbs, ASTM D2794 test method.
 - 2) Pencil Hardness: 2H, ASTM D3363 test method.
 - 3) UV Resistance: UV inhibited life of minimum 10 years when exposed to sun.
 - 4) Maximum Service Temperature: 230 degrees F, continuous.

C. Baked Polyester:

1. Physical Characteristics:
 - a. Material: Polyester.
 - b. Surface Preparation: Sandblast surface to SSPC SP 5.
 - c. Application: Electrostatic spray.
 - d. Finished Thickness: 1.5-mil to 2.5-mil dry film thickness.
2. Functional Characteristics:
 - a. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
3. Performance Characteristics:
 - a. Coating shall meet or exceed following criteria:
 - 1) Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
 - 2) Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
 - 3) Impact Resistance: 100 inch pounds, ASTM D2794 test method.
 - 4) Pencil Hardness: 2H, ASTM D3363 test method.
 - 5) UV Resistance: UV inhibited life of minimum 10 years when exposed to sun.
 - 6) Service Temperature: Maximum 230 degrees F, continuous.

D. Air-Dry Epoxy:

1. Physical Characteristics:
 - a. Material: Two-part catalyzed epoxy.
 - b. Surface Preparation: Clean surface to SSPC SP 3.
 - c. Application: Standard air-pressurized spray equipment.
 - d. Finished Thickness: 4-mil to 6-mil dry film thickness.
2. Functional Characteristics:
 - a. Curing: Air dry.

3. Performance Characteristics:
 - a. Coating shall meet or exceed following criteria:
 - 1) Salt Spray Test: Minimum 1,500-hour duration, ASTM B117 test method.
 - 2) Pencil Hardness: H-2H, ASTM D3363 test method.
 - 3) UV Resistance: UV inhibited life of minimum 10 years when exposed to sun.
 - 4) Service Temperature: Maximum 150 degrees F, continuous.

E. Baked Epoxy:

1. Physical Characteristics:
 - a. Material: Epoxy.
 - b. Surface Preparation: Sandblast surface to SSPC SP 10.
 - c. Application: Electrostatic spray.
 - d. Finished Thickness: 2.5-mil to 3.5-mil dry film thickness.
2. Functional Characteristics:
 - a. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
3. Performance Characteristics:
 - a. Coating shall meet or exceed following criteria:
 - 1) Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
 - 2) Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
 - 3) Impact Resistance: 100-inch-pounds, ASTM D2794 test method.
 - 4) Pencil Hardness: 2H, ASTM D3363 test method.
 - 5) UV Resistance: UV inhibited life of minimum 10 years when exposed to sun.
 - 6) Service Temperature: Maximum 230 degrees F, continuous.

F. Air Dry Phenolic:

1. Physical Characteristics:
 - a. Material:
 - 1) Phenolic resin, Heresite VR-500 Series.
 - 2) For outdoor applications, apply UV-resistant topcoat, Heresite UC-5500.
 - b. Surface Preparation: Sandblast surface to SSPC-SP 6.
 - c. Application: Standard air-pressurized spray equipment.
 - d. Finished Thickness: 4-mil to 6-mil dry film thickness.
2. Functional Characteristics:
 - a. Curing: Air dry.

3. Performance:
 - a. Coating shall meet or exceed following criteria:
 - 1) Salt Spray Test: Minimum 500-hour duration, ASTM B117 test method.
 - 2) Humidity Resistance: Minimum 500-hour duration, ASTM D2247 test method.
 - 3) UV Resistance: UV inhibited life of minimum 10 years when exposed to sun.
 - 4) Service Temperature: Maximum 180 degrees F, continuous.

G. Baked Phenolic:

1. Physical Characteristics:
 - a. Material: Phenolic resin, Heresite P-403.
 - b. Surface Preparation: Sandblast surface to SSPC SP 5.
 - c. Application: Standard air-pressurized spray equipment.
 - d. Finished Thickness: 5-mil to 7-mil dry film thickness.
2. Functional Characteristics:
 - a. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
3. Performance Characteristics:
 - a. Coating shall meet or exceed following criteria:
 - 1) Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
 - 2) Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
 - 3) Impact Resistance: 100-inch-pounds, ASTM D2794 test method.
 - 4) Pencil Hardness: 2H, ASTM D3363 test method.
 - 5) UV Resistance: UV inhibited life of minimum 10 years when exposed to sun.
 - 6) Service Temperature: Maximum 250 degrees F, continuous.

H. Baked Epoxy Phenolic:

1. Physical Characteristics:
 - a. Material:
 - 1) Baking cross-linked epoxy-phenolic.
 - 2) For outdoor applications, apply an UV resistant topcoat.
 - b. Surface Preparation: Sandblast surface to SSPC SP 5.
 - c. Application: Electrostatic or conventional compressed air spray equipment.
 - d. Finished Thickness: 6-mil to 8-mil dry film thickness.
2. Functional Characteristics:
 - a. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.

3. Performance Characteristics:
 - a. Coating shall meet or exceed following criteria:
 - 1) Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
 - 2) Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
 - 3) Impact Resistance: 160-inch pounds, ASTM D2794 test method.
 - 4) Pencil Hardness: 3H, ASTM D3363 test method.
 - 5) UV Resistance: UV inhibited life of minimum 10 years when exposed to sun.
 - 6) Service Temperature: Maximum 350 degrees F, continuous.

2.16 COIL PROTECTIVE COATING

A. Manufacturers and Products:

1. Aero-Marine Engineering Inc.; Technicoat 10-1.
2. Or equal.

B. Physical Characteristics:

1. General:
 - a. Factory dip-applied protective coating for application to plate fin and tube coils.
 - b. Coil factory assembled and tested before coating application.
 - c. Coating suitable for coils with maximum 30 fins per inch fin density. Bridging of product across coil fins is unacceptable.
 - d. After application and proper curing, product shall endure bending of coil assembly in standard manufacturing process without cracking.
2. Coating Material:
 - a. Use one of the following materials:
 - 1) Epoxy Modified Phenolic. Straight phenolic materials are not acceptable.
 - 2) Epoxy or epoxy-urethane.
 - 3) Polyelastomer: Complex chain linked polyelastomer material.
3. Coating Process:
 - a. Coil Inspection and Sealing:
 - 1) Inspect coil for open tubes, headers, capillary tubes; repair as necessary.
 - 2) Fill with dry nitrogen, cap and seal, to prevent contamination of internal coil surfaces with cleaning or coating solutions.

- b. Coil Cleaning:
 - 1) Immerse coil in heated alkaline cleaning solution to remove lubricants, machining oils, and residual factory contamination.
 - 2) Followed with immersion in potable water bath to neutralize and remove cleaning solution.
- c. Coating Application:
 - 1) Immerse coil assembly in coating bath, including headers, casing, and heat exchange surfaces.
 - 2) Coil shall be completely removed from equipment during coating application.
 - 3) Spray-on coatings are not acceptable.
- d. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
- e. Quality Control: Free from voids, checks, cracks and blisters.

C. Functional Characteristics: None.

D. Performance Characteristics:

- 1. Coil finish shall meet or exceed the following criteria:
 - a. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no fin corrosion or degradation.
 - b. Thermal Efficiency: Loss no greater than 1 percent after coating application.
 - c. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun.

2.17 ACCESSORIES

- A. Equipment Identification Plates: Furnish 16-gauge stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number as specified.
- B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.18 SOURCE QUALITY CONTROL

- A. Factory Tests and Adjustments: Test equipment actually furnished.
- B. Testing Provisions:
 - 1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
 - 2. Center punch fan shaft to accommodate tachometer readings.

C. Manufacturer's Tests:

1. Electric Heating Coil Test: 2,000-volt dielectric test.
2. DX Coil Test: Leak tested under water with 300 psi air.
3. Electrical Circuits:
 - a. Tested and checked as to proper function.
 - b. Perform dielectric strength test.
4. Air Handling Unit Cabinet Tests:
 - a. Air Pressure Leak Testing: For modules under positive pressure located on discharge side of a fan, maximum permissible air leakage shall not exceed 1 percent of specified airflow, when subject to 8-inch water gauge differential pressure.
 - b. Panel Deflection Testing: For modules under negative pressure located on the suction side of the fan, maximum permissible panel deflection shall not exceed 1/200th of panel length, when subject to 8-inch water gauge differential pressure.
 - c. Leakage Test Failure Guarantee: Upon completion of leakage test, if unit does not meet specified performance for deflection or leakage, Contracting Officer may elect to have unit modified to meet specified performance or may request a credit according to performance failure.

D. Acoustical Test:

1. Perform factory noise tests in accordance with AMCA 300 and AMCA 301.
2. Fan sound power levels (dB, Reference 10^{-12} Watts) shall be no greater than scheduled values.

E. Balancing:

1. Completed fan assemblies shall be dynamically balanced to minimum grade of G 6.3 per AMCA 204 at design operating speed.
2. Fans controlled by variable frequency drives shall be dynamically balanced at speeds 25 percent, 50 percent, 75 percent, and 100 percent of design rpm.

F. Vibration Test:

1. Each fan furnished with a 5-hp, or larger motor shall have factory run vibration test, including vibration signatures taken on each bearing in horizontal, vertical, and axial direction.
2. Vibration reading as measured at fan scheduled rotational speed shall not exceed the following values when fan is rigidly mounted:
 - a. Belt Drive (except Vane Axial): 0.15 inch per second peak velocity.
 - b. Belt Drive Vane Axial: 0.08 inch per second peak velocity.

- c. Direct Drive: 0.08 inch per second peak velocity.
- d. Written records of run test and vibration test shall be made available upon request.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install units level and plumb.
- B. Install floor-mounted units on concrete bases.
- C. Secure vibration controls to concrete bases using anchor bolts cast in concrete base.
- D. Secure roof-mounted units to roof curbs with Type 316 stainless steel hardware.
- E. Inspect internal casing insulation, seal all exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.
- F. All condensate drain connections piped and trapped separately for proper drainage.
- G. Labeling: In accordance with Article Accessories.
- H. Service Access: Locate units to provide access spaces required for filter changing; motor, drive, and bearing servicing; and fan shaft and coil removal.
- I. Equipment Restraints:
 - 1. Restrain equipment against wind loads as required by Code.
 - 2. Refer Section 23 05 48, Vibration Isolation for HVAC Piping and Equipment.
- J. Connections:
 - 1. Isolate sheet metal duct connections from all noninternal spring-isolated fan units or other rotating equipment.
 - 2. Install ductwork adjacent to fans so as to allow proper service and maintenance.
 - 3. Pipe drain pan connection through trap running to floor drain.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify shipping blocking and bracing are removed.
2. Verify unit is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed in motors, starters and disconnect switches.
4. Verify cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system, align and adjust belts and install belt guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:
 - a. Energize motor and adjust fan to indicated rpm.
 - b. Measure and record motor voltage and amperage.
2. Operational Test:
 - a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
 - c. Test and adjust control safeties.
 - d. Replace damaged and malfunctioning controls and equipment.

3.03 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate non-sealed bearings prior to startup.

D. Air Balancing:

1. Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
2. Replace fan and motor sheaves as required to achieve design airflow.

3.04 CLEANING

- A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.
- B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

3.05 MANUFACTURER'S SERVICES

- A. Provide manufacturer's representative at site for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Contracting Officer's personnel for specified component, subsystem, equipment, or system.
- B. Manufacturer's Representative: Present at Site or classroom designated by Contracting Officer, for minimum person-days listed below, travel time excluded:
 - 1. 1 person-day for installation assistance and inspection.
 - 2. 3 person-days for functional testing and completion of Manufacturer's Certificate of Proper Installation.
 - 3. 1 person-day for prestartup classroom or site training.
 - 4. 1 person-day for facility startup.
 - 5. 1 person-day for post-startup training of Contracting Officer's personnel.
 - 6. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Contracting Officer.
- C. Refer Section 01 91 14, Equipment Testing and Facility Startup.

3.06 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are a part of this specification:
 - 1. Air Handling Units Schedule.
 - 2. Make-Up Air Units Schedule.

END OF SECTION