PART 1 - ENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods

B. Section 230593: Testing, Adjusting and Balancing

C. Section 230902: Variable Frequency Drives (VFD)

D. Section 233113: Air Distribution

E. Section 234100: Air Filtration

F. Division 26: Electrical

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/200 where "L" is the unsupported span length within completed casings.

C. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[and the unit will be fully operational after the seismic event]."

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide air handling units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Certifications: Provide certified ratings of units based on tests performed in accordance with ARI 430, "Central-Station Air Handling Units."

C. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:

1. Air Movement and Control Association (AMCA):
   a. 99 - Standards Handbook
   b. 210 - Laboratory Methods of Testing Fans for Rating [Unit shall bear AMCA Certified Rating Seal]
   c. 300 - Reverberant Room Method for Sound Testing of Fans [Unit shall bear AMCA Certified Rating Seal]
   d. 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data
   e. 500 - Test Method for Louvers, Dampers, and Shutters
2. American National Standards Institute (ANSI):
   a. 9 - Load Ratings and Fatigue Life for Ball Bearings
   b. 11 - Load Ratings and Fatigue Life for Roller Bearings
   c. 900 - Test Performance of Air Filter Units
3. Air-Conditioning, Heating and Refrigeration Institute (AHRI):
   a. 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
   b. 430 - Central-Station Air-Handling Units
4. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
   a. 15 - Safety Code for Mechanical Refrigeration
5. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
6. National Fire Protection Association (NFPA): Provide air handling unit internal insulation having flame spread rating not higher than 25 and smoke developed rating not higher than 50:
   a. (CEC) - California electrical Code
   b. 90A - Standard for the Installation of Air Conditioning and Ventilating Systems
   c. 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems
7. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
8. Underwriters Laboratories, Inc. (UL): Except for motors, provide electrical components required as part of air handling units, which have been listed and labeled by UL.
9. Units shall be listed and labeled by either UL or ETL for air handler construction.

1.5 PRODUCT SUBSTITUTIONS

A. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:
   1. The proposed substitution does not affect dimensions shown on drawings.
   2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
   3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
   4. Maintenance and service parts available locally are readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to this proposed substitution.

1.6 ACTION SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air handling units showing
   1. Dimensions and weights
   2. Cabinet material, metal thickness, finishes, insulation, and accessories.
   3. Fan including:
      a. Certified fan-performance curves with system operating conditions indicated.
      b. Certified fan-sound power ratings.
      c. Fan construction and accessories.
      d. Motor ratings, electrical characteristics, and motor accessories.
      e. Fan assembly vibration and balance test report.
   4. Certified coil-performance ratings with system operating conditions indicated.
   5. Retain both subparagraphs below if items are furnished as parts of air-handling units.
   6. Dampers, including housings, linkages, and operators.
   7. Filters with performance characteristics.

B. Shop Drawings: Submit shop drawings showing unit dimensions, weight loadings, required clearances, field connection details and methods of support. Draw to a scale of one half inch to one foot. Include field fabricated mixing boxes, dampers and duct connections.

C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals.

1.7 INFORMATIONAL SUBMITTALS

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

B. Source quality-control reports.

C. Field quality-control reports.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit to the site in containers with manufacturer's stamp or label affixed.

B. Store and protect unit against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.10 WARRANTY

A. Provide one-year (12 months) warranty from date of startup or 18 months from date of shipment, whichever occurs first. The manufacturer’s warranty shall include parts and labor to provide factory authorized service.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Energy Labs, CES Group (Governair, Huntair, Venmar, Temtrol, Mammoth), Miller-Picking, Buffalo Forge, Pace, Haakon Industries, Silent-Air, BASX Solutions, Unitech, or Air Enterprises. By listing manufacturers it is not intended to imply that their standard construction is approved or that they are equal. All manufacturers must meet, or exceed, minimum requirements of these specifications and all other standard or optional features provided by the scheduled basis of design air handler.

2.2 GENERAL

A. Any exceptions to the specifications must be clearly defined in the submittal process. The contractor shall be responsible for any additional expenses that may occur due to any exception made.

B. Fabricate draw-thru or blow-thru type air handling units suitable for the scheduled air pressure operation as indicated.

C. Fabricate units with: fan sections as noted; coil section(s); heat recovery sections, mixing section; filter section(s); access section(s); discharge plenum; bellmouth duct connections; variable frequency drives; dampers; lights and vestibules. Fabricate unit in split sections for field assembly if necessary.

D. Vestibule piping requirements: If shown on plans all piping located within the air handler vestibule is to be supported as specified. Mechanical Contractor to coordinate with air handler supplier to insure that all supports are provided and that adequate structural reinforcement is provided within the air handler to accommodate the operational weight of the pipe supported. The Mechanical Contractor is to provide the air handler manufacturer with an approved shop drawing indicating the location and weight of all equipment and the location of all piping and pipe penetrations located in the air handler vestibule prior to the design of the air handler by the manufacturer.

E. Fans shall be selected for variable volume operation. The scheduled fan arrangement and unit configuration is the basis of selection. Alternate configurations which are equal or smaller in size and weight, energy and acoustic performance will be considered. Include information indicating pertinent differences, either positive or negative, to base design indicated on documents. Unit component face velocity to

remain as designed to conserve motor horsepower. The mechanical contractor and supplier shall bear all costs for redesign of mechanical, plumbing, electrical, structural, architectural and controls that may be associated with the revised configuration. Provide analysis of unit power consumption for code compliance.

F. Factory fabricate and test air handling units of sizes, capacities, and configuration as indicated and specified.

G. All major components used to assemble air handling units with the exception of electrical devices, drives, bearings and controls shall be manufactured by the air handler manufacturer.

H. Motors shall be inverter duty NEMA MG-1 premium efficiency TEFC type. All wiring shall be routed to a single external junction box for each fan section. See Section 230902 for additional requirements.

I. Filter section shall include space for face load or side access slide-in filters with 2" or 4” pre-filters and 22" bag type final filters with an average efficiency of 85% per ASHRAE Standard 52-76 test.

2.3 UNIT CASING

A. Walls and roofs shall be constructed of 16 ga., G90 galvanized steel 4" thick panels. The inner wall shall be a minimum of 22 ga., solid galvanized steel in all sections except fan inlet and fan section which may be perforated metal. The wall panels shall be insulated with 4", 3.0 lbs/cu. ft rigid neoprene coated insulation. All permanently joined flanged panel surfaces shall be sealed with an individual strip of 1/8" x 3/8" tape sealer. Wall seams shall be turned inward to provide a clean flush exterior finish. All panel seams shall be sealed during assembly to produce an airtight unit.

B. All panels shall be joined using bolts rather than sheet metal screws.

C. All insulation edges shall be protected with metal lagging. Insulation systems using stickpins or adhesives are not acceptable.

D. Stiffeners of angle steel shall be supplied as required to maintain casing deflection criteria of 1/200 at 1.5 times the working pressure. If panels cannot meet this deflection, additional internal reinforcing shall be added.

E. Provide duct bellmouth fittings where dimensions allow. Provide walk able grates over all duct floor penetrations, maximum pressure loss not to exceed 0.10-inches WC.

F. Acoustical Performance:
   1. The housing shall have been tested for acoustical performance by an independent laboratory that is accredited.
   2. Test methods and facilities used to establish sound transmission loss values shall conform explicitly with the ASTM designation E90-85 and E413-73.
      a. Sound Transmission Loss DB ASTM E-90 & E413-73.

1 2 3 4 5 6 7 8

4" Walls	20	20	28	41	51	56	55	57	STC=40

b. Test methods and facilities used to establish sound absorption values shall conform explicitly with the requirements of the ASTM Standard Test Method for Sound Absorption Coefficients by the Reverberation Method: ASTM C423-84A and E795-83.

c. Sound Absorption ASTM C423-84A & E795-83.

	1	2	3	4	5	6	7	8	
4" Walls	.40	.65	1.38	1.28	1.09	1.05	1.02	1.02	NRC=1.20

d. Submit lab report for approval.

2.4 BASE CONSTRUCTION

A. Units shall be constructed from structural steel C-channel around the perimeter of the unit with intermediate channel, angle or tube supports.

B. Floor shall be flat, reinforced from below, with all seams continuously welded. OR Floor shall be 0.12” checker plate installed on the base. Drive screw attachment and caulking are not acceptable. The base shall be provided with lifting lugs, a minimum four per unit section. The base shall be insulated tight to the floor with 4", 3.0 lbs/cu. ft fiberglass insulation. The insulation is to be protected with 22 ga. solid galvanized steel liner if the unit floor is exposed in a suspended application. Floors that "oil can" are not acceptable.

C. Floor insulation shall be installed beneath the floor panels in the same manner as the wall and ceiling insulation.

D. Condensate Drain Pans:
1. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
2. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
3. Depth: A minimum of 2 inches (50 mm) deep.
4. Integral part of floor plating
5. Single-wall 16 ga. 304 stainless-steel sheet.
6. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
7. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
8. The manufacturer shall provide a 1.5" perimeter collar around the entire unit and around each floor opening to ensure the unit is internally watertight. The entire base shall act as an auxiliary drain pan and hold up to 1.5" of water.
9. The manufacturer shall provide auxiliary drains in mixing and OSA intake sections.
10. All drain connections on floor mounted air handling units shall terminate at the side of the unit.

E. Maximum base deflection shall be 1/4" on 20 ft unsupported span.

F. Maintenance Rails: Provide overhead lifting rails in sections where motor service will

be required.

2.5 INSPECTION AND ACCESS PANELS AND ACCESS DOORS:

A. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.

B. Inspection and Access Panels:
1. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
2. Gasket: Neoprene, applied around entire perimeters of panel frames.
3. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

C. Access Doors:
1. Hinges: A minimum of two ball-bearing hinges and two roller cam-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
2. Gasket: Neoprene, applied around entire perimeters of panel frames.
3. Size: The minimum door clearance shall not be less than 19”x 70" (where unit height permits) and shall be large enough to allow the largest assembled internal compound to be removed through the doorway. Internal components must have a door of minimum width to remove the assembled components. Vestibule doors to the exterior shall be 42”x70” (where unit height permits).

D. Locations and Applications:
1. Verify that the sections listed below are large enough for panels and doors. Verify applicability with listed manufacturers.

2.6 FAN, DRIVE, AND MOTOR SECTION

A. All fans shall be tested in accordance with AMCA Standard 210-70 Test Code for Air Moving Devices. Fans shall bear the AMCA sticker for both air and sound performance.

B. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil. Hollow shafts are unacceptable.
b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range. The critical speed will be based on the top of the speed range for the fans’ AMCA class. The lateral static deflection shall not exceed 0.003” per foot of the length of the shaft.
2. Fan assembly shall be balanced per ISO standard G6.3 with a copy of the balance test data for this project with deflection and critical speed of the shat and wheel submitted to the engineer

C. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
   1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
   2. Horizontal-Flanged, Split Housing: Bolted construction.
   3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
   4. Flexible Connector: Factory fabricated with a fabric strip [3-1/2 inches (89 mm)] [5-3/4 inches (146 mm)] wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch (0.7-mm-) thick, galvanized-steel sheet or 0.032-inch-(0.8-mm-) thick aluminum sheets; select metal compatible with casing.
      a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
         1) Fabric Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
         2) Fabric Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
         3) Fabric Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

D. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.
   1. Arrangement #4 direct drive fans or AMCA Arrangement #1 either horizontal or vertical as shown on plans and drawings. There shall be no obstructions (i.e., bearings or bearing supports, etc.,) at the inlet of the fan. Fan wheel shall be aluminum with aluminum extruded airfoil blades. The fan inlet on plenum fans shall be isolated from the cabinet by means of a neoprene-coated flexible connection. Plenum fans shall be provided with spring-style thrust restraints.
   2. Each fan shall be sized to perform as indicated on the equipment schedule. The wheel diameter shall not be less than that shown on the equipment schedule. The fan shall be constructed to AMCA Standards for the Class Rating as indicated on the Equipment Schedule.

E. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws. Aluminum wheel.

F. Fan Array Installation:
   1. Provide individual fan back draft dampers and acoustical treatment.
   2. Each fan and motor shall be mounted on an all welded, structural steel, prime coated, internal isolation base with springs selected to provide 99% isolation efficiency with minimum 1” deflection. The inlet of the fan shall be separated from the unit casing by means of a factory installed flexible fabric connection. Provide unit mounted red LED indicator lights to monitor status of all fan array fans, one light per fan. LED to light up indicating loss of respective fan operation. Label lights “FAN FAILURE LIGHTS”.

G. Fan Shaft Bearings:
   1. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an L10 rated life of 200,000 hours according to ABMA 9. Bearings are to be mounted on the fan structural bracing. Provide extended bearing lubrication lines and zerk fittings to assure accessibility of all lubrication points without

disassembly of unit access.

H. Internal Vibration Isolation and Seismic Control:
1. Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 2”.
2. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration Isolation and Seismic Restraint for Piping, Ductwork, and Equipment " when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.
3. Fan Assembly Testing:
   a. Following assembly, the fan balance shall be tested using an electronic balance analyzer with tunable filter and stroboscope.
   b. Direct drive fan wheels shall be factory dynamically balanced and shall meet or exceed guidelines in AMCA 204-96 for Balance Quality and Vibration Levels for Fan Application Category BV-5. Following fan assembly, the complete spring isolated fan assembly shall be tested using an electronic balance analyzer with tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 Axial). The maximum allowable velocity shall not exceed 0.125 inches per second peak amplitude (filter in) on any of 5 readings and shall not exceed .5 mils @ 1170 rpm.
   c. A copy of the Vibration test report (Vibration Nomograph) shall be provided with the Operation and Maintenance Manual upon request. The fan assembly shall also be vibration tested at design RPM with the spring isolators at the specified deflection, with the tunable filter utilized and frequencies from 500 cpm to 50,000 cpm shall be scanned to detect misalignment, bearing defects, mechanical looseness or foundation weakness. A copy of the balance test data for this project showing calculations for deflection and critical speed of the shaft and wheel assembly shall be submitted to the engineer review
4. Motor:
   a. Enclosure Type: Totally enclosed, fan cooled.
   b. NEMA Premium (TM) efficient motors as defined in NEMA MG1.
   c. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
   e. Mount unit-mounted disconnect switches on exterior of unit.

2.7 COILS

A. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall be mounted in the unit casing to be accessible for service and can be removed from the unit through the side. Capacities, pressure drops and selection procedure shall be certified in accordance with ARI Standard

410-81.

B. Coils shall be fully enclosed within casing and mounted on primed and painted angle iron racks manufactured to allow coils to slide out individually. Cooling coil racks shall be primed with zinc rich chromate primer. Racks to be designed to allow coil removal from the face of the coil rack. All coils to be removable from either side of the unit by easily removable end panels. End panels that open to coil header and return bend section shall be installed with drive screws and nut-serts to allow access to header and return bend sections for coil inspection without disruption to unit air seal. Individual end panels to be supplied for each coil on the supply and return side of the cabinet to allow single coil piping breakdown for coil removal.

C. Coil penetrations through cabinet shall be grommeted, sealed airtight by a double escutcheon plate on the exterior of the casing. The escutcheon plate shall have a rolled collar around the pipe opening to protect the pipe and be equipped with an “O” ring rubber gasket between the collar and the pipe to prevent chaffing and provide an air tight seal around the opening. All supply and return connections shall be plainly and permanently marked

D. Both ends of the coil to be sealed off from the main air stream by full height blank-offs on both the entering-air and leaving-air sides. Blank-offs to be the same material as the coil casing. Headers and return bends to be further insulated with a closed cell neoprene gasket the full height and width of the coil casing to reduce condensation.

E. Drain pans shall be continuously welded type 304 stainless steel. Intermediate drain pans shall be interconnected with 1 in. stainless steel drain lines. Drain pans shall be sloped and fully drainable.

F. Coils shall be designed for chilled water, heat recovery or hot water service and be of the counter flow design.

G. All coils shall be fabricated of 5/8" O.D. seamless copper tubing of 0.020 wall thickness minimum mechanically expanded into copper fins of 0.008 minimum thickness. All return bends shall be 0.035 copper minimum. Headers shall be of seamless copper. Supply and return connections on each coil shall be raised/lowered a minimum 6” from the bottom/top of the coil to allow room for piping connection hookup between stacked coils, coils near floors and coils near roofs. Each coil shall be provided with capped vent and drain connections extended to the exterior of the cabinet. All coils shall be fully drained with no trapped tubes. Coil casing to be 304 stainless steel for cooling coils and 16 ga galvanized for heating coils.

H. Coils shall be hydrostatically tested at 400 psi, and shall be suitable for working pressures and temperature up to 200 psi and 220 degrees F.

I. Pipe connections shall be on the same end, and shall be threaded. On units with split coils, extend coil pipe connections from coil header through unit side casing using specified pipe material.

J. Water coils handling recently mixed air, or direct outside air, shall be fully drainable by removing a single threaded plug for each coil row.

K. Coils indicated as being cleanable shall have either a cleanout plug for each tube or shall have a gasketed removable header cover.

L. On cooling coils and heat recovery coils using vertically corrugated fins or spiral wound fins, provide moisture eliminators on the downstream side of cooling coils and heat recovery coils when the face velocity exceeds 550 fpm. On cooling coils and heat recovery coils using horizontally corrugated fins, provide moisture eliminators when the face velocity exceeds 525 fpm. Moisture eliminators shall be 304 stainless steel, 3-break type draining directly into the cooling coil drain.

M. Coils for direct expansion refrigerant applications connected to multiple compressors shall be full face intertwined type.

2.8 FILTERS

A. Provide pre-filters and front loading final filters.

2.9 FILTER GAUGES

A. The manufacturer shall provide a DWYER (0-2 inch, 0-500 Pa) magnehelic gauge.

B. Magnehelic gauges shall be accurate to +/- 2% of full range.

C. One gauge shall be provided for each type of filter in filter bank.

D. Gauges shall be recessed into the cabinet casing with a weather cover.

2.10 FINISH

A. Factory Applied Finish for steel and galvanized steel casings:
1. Standard Two-coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, ASTM 2000 hour enamel finish, consisting of prime coat and thermosetting topcoat.

2.11 ALUMINUM AIRFOIL DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 5 percent of air quantity at 2000 fpm face velocity through damper and 3-inch wg (1000-Pa) pressure differential.

B. Aluminum airfoil frames and blades shall be a minimum of 12 gauge extruded aluminum. Blades shall be of a single unit airfoil design 6" wide.

C. Frames shall be extruded aluminum channel with grooved inserts for vinyl seals. Standard frames shall be 2" x 4" x 5/8" on the linkage side, 1" x 4" x 1" on the other 3 sides.

D. Pivot rods shall be 7/8" hexagon extruded aluminum interlocking into the blade section. Bearings shall be of a double sealed type with a Celcon inner bearing on a rod within a Polycarbonate outer bearing inserted into the frame to prevent the outer bearing from rotating.

E. The bearing shall be designed so there are no metal-to-metal or metal-to-bearing riding surfaces. The interconnecting linkage shall have a separate Celcon bearing to eliminate friction inside the linkage.

F. Blade linkage hardware shall be installed in a frame outside the airstream. All hardware shall be of non-corrosive, reinforced cadmium plated steel.

G. Multiple damper motors are to be used rather than jack shaft assemblies.

H. Dampers shall be Ruskin #CD50, T.A. Morrison #1000, or equivalent.

2.12 SOUND POWER LEVELS

A. Air handling unit sound power levels shall be submitted for review. Sound power data shall be given at the supply connections and return connections in addition to radiated sound power from the cabinet. Raw fan sound power data shall be derived from testing on the identical fans as used in the units. Data extrapolated from different fans is not acceptable.

2.13 VARIABLE FREQUENCY DRIVES

A. Both supply and return fans are to be powered by drives. See Section 230902 for additional requirements.

2.14 FLOW MEASURING PROVISIONS

A. Air flow measurement - General
1. Provide one thermal dispersion airflow/temperature measurement device (ATMD) at each location indicated on the plans, schedules and/or control schematics.
2. Each ATMD shall consist of one to four sensor probes and a single, remote transmitter. Each sensor probe shall consist of one to eight independent sensor nodes in a gold anodized, aluminum 6063 alloy tube with 304 stainless steel mounting brackets.
3. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Chip thermistors of any type or packaging are not acceptable.
4. The velocity-weighted average temperature output performance of the ATMD is preferred to that of the specified temperature measuring device (TMD), when the location of the ATMD and TMD are effectively the same.

B. Supply and/or Return Fan Measurement:
1. Measurement device to be mounted in either the fan inlet or the AHU duct opening.
a. Fan inlet air measuring devices shall not obstruct the inlet cone to the fan, nor add any pressure losses or sound level increases to the fan performance.
b. Air measuring devices mounted in the AHU opening to be mounted upstream of the damper and spaced a minimum of 6” from the damper (if damper).

C. Outside Air Flow Measurement
1. Air measuring devices to be mounted in the AHU opening upstream of the damper and spaced a minimum of 6” from the damper.

a. If the outside air intake dampers are sized for 100% fresh air capability configure the dampers to enable separate control and measurement of the minimum outside air required for the project area served by the AHU.
b. If the AHU is installed on the interior with ducted fresh air, install the measuring station in a straight duct section upstream from the minimum outside air dampers and interfacing control for providing an electronic signal for use by the control contractor in controlling a minimum outside airflow and temperature.
c. If the AHU is an outdoor mounted unit, the minimum outside airflow measurement station is to be factory mounted on the exterior side of the outside air intake in a protective weatherhood.

D. Sensor Performance:
1. The ATMD shall be capable of measuring airflow rates over the full calibrated range of 0 to 5,000 FPM (25.4 m/s) between -20°F to 160°F (-28.9°C to 71°C).
2. Each sensing node shall have an airflow accuracy of ± 2% of reading throughout the entire calibrated operating range.
3. Each sensing node shall have a temperature accuracy of ± 0.14°F (0.08°C) over the entire operating temperature range of -20°F to 160°F (-28.9°C to 71°C).
4. Fan Airflow Installation:
   a. Installed airflow accuracy: +/- 3% to 10% of reading with +/- 0.25% repeatability.
   b. Sensor probe performance: +/- 2% of reading, 0-5000 fpm, 0.15°F temperature accuracy +/-.
5. Outside Air Installation:
   a. Installed airflow accuracy: +/- 2% of reading with +/- 0.25% repeatability.
   b. Sensor probe performance: +/- 2% of reading, 0-5000 fpm, 0.15°F temperature accuracy +/-.

E. Transmitter:
1. Flow measuring array to include a transmitter for flow and temperature analog output signal for the building energy management system to be user selectable in either 4-20 mA or 0-10VDC, or BACnet digital compatible. Coordinate signal output with controls installer.
2. Transmitter to include an airflow gauge to provide direct readout in cfm. Mount on the outside of the air handler if air handler is located in a mechanical room. Mount in a NEMA 3R control cabinet if located outside.
3. Device to provide switch selectable Modbus or Johnson N2 outputs. Device to be UL listed.
4. The transmitter shall be powered by 24 VAC, shall include over-voltage and over-current protection, and shall include watchdog circuitry to ensure continuous operation following power failures and/or brown- outs.
5. The transmitter shall determine the airflow rate and temperature of each sensing node prior to averaging.
6. The transmitter shall include self-diagnostics and other features to ensure reliability and continued operation despite a limited failure. The transmitter shall automatically detect sensor damage and correctly calculate the average using the remaining functional sensor nodes, while reporting a system fault over the network and by local visual indication.
7. All integrated circuits shall be industrial rated for operation down to -40°F (-

40°C).

8. The environmental operating temperature limits for the transmitter shall be -20°F to 120°F (-28.8°C to 48.8°C).
9. The system shall be factory tested prior to shipment and not require calibration or adjustment over the life of the equipment when installed in accordance to manufacturer's guidelines.
10. The Sensors shall be calibrated to NIST traceable standards.

F. Airflow measuring station to be by Ebtron. KURZ, Fluid Components and Sierra Instruments are acceptable with temperature readout and UL listing.

2.15 ELECTRICAL

A. Each fan motor shall be wired to its respective VFD.

B. All wiring shall be 6600 volt rated type XLPE, RW90 stranded copper, enclosed in conduit run internal to the unit. All junction boxes shall be CSA approved. Three phase loads to be color coded for phase matching.

C. All unit VFD's shall be wired to a surface or recessed mounted vestibule electrical panel for a single point three phase power connection provided by Division 26. Control panel shall be NEMA Type 3R enclosure with a single hinged access door. The control panel shall include:
1. Non-fused main disconnect switch, lockable in the off position
2. Dual element fuses
3. Distribution block

D. All wiring shall be numbered, and all remote connection terminals and components in the control panel shall be identified by tag suitable attached. Wiring diagram shall be provided for each unit showing all components, wire number and remote connection terminals.

E. Electrical wiring for lighting and power supply to fan motors shall be run in separate conduits internal to the unit. No external conduit runs are permitted. If the unit requires section splits, junction boxes shall be furnished at each section to allow the electrical contractor to make final connections in the field. Wiring to be clearly labeled at junction points to facilitate reconnection. Air handler manufacturer shall allow a minimum 1.5" clearance above the entire width of each interior bulk headers (coils, filters, fan blank-off, etc.) for field-wiring of any 110v or 24v runs internally to the unit as required by the controls contractor and reduce the number penetrations of the exterior panels.

F. All electrical wiring and components shall be installed to conform to NEC and UL listing requirements. Provide a UL or ETL listing and label for the entire air handler.

2.16 LIGHTS

A. Provide vapor-proof marine grade lights with protective metal cage, sealed glass enclosure and LED or compact florescent light for each section containing an access door and for unit vestibule. Duplex receptacles shall be installed at the light switch at each fan section and unit vestibule.

B. A switch with an indicator light shall be installed on the unit controlling both lights and

receptacles. Electrical power shall be 120V/1/60 and wired by fan manufacturer to a junction box in the unit vestibule for a single point one phase connection by Division 26.

2.17 AIR LEAKAGE TESTING

A. Before shipment the unit manufacturer shall factory pressure test (positive pressure) each air handling unit to ensure the leakage rate of the casing does not exceed 1.0% of the unit air flow at 1.5 times the rated static pressure. Testing shall be done on one unit of each type.

B. The test shall be conducted in accordance with SMACNA duct construction manual. A calibrated orifice shall be used to measure leakage airflow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Install in accordance with manufacturer's instructions.

B. Examine site to verify if site is ready to receive work. Provide a layout drawing of air handler and fan locations to electrical installer.

C. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

D. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Air Handler Mounting:
1. Base Mounted: Install air-handling units on equipment base as described and specified elsewhere
2. Suspended Mounting: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers.
3. Isolation and Seismic Control: Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Arrange installation of units to provide access space around air-handling units for service and maintenance.
5. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
6. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems.

B. Comply with requirements for piping specified in other Sections.

C. Install piping adjacent to air-handling unit to allow service and maintenance.

D. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

E. Connect condensate drain pans using copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

F. Heating and Chilled Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232113 HVAC Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

G. Coordinate duct installations and specialty arrangements with schematics on Drawings and with requirements specified in Section 233113 "Metal Ducts" and Section 233300 "Air Duct Accessories."

H. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233113 "Air Distribution."

I. Control installers shall install all wiring associated with control signals into the air handlers.

J. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

K. Airflow measuring arrays installed in fan inlet volutes must be designed to withstand velocities encountered in this location. Mounting system is to be warranted against failure and consequent fan damage.

3.4 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Verify that shipping, blocking, and bracing are removed.
   3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
   4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
   5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
   6. Verify that zone dampers fully open and close for each zone.
   7. Verify that face-and-bypass dampers provide full face flow.

8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
9. Comb coil fins for parallel orientation.
10. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.[Replace fan and motor pulleys as required to achieve design conditions.]
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

C. ADJUSTING
1. Adjust damper linkages for proper damper operation.
2. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

D. CLEANING
1. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

E. DEMONSTRATION
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION