SECTION 237343.19 - OUTDOOR, CUSTOM AIR-HANDLING UNITS

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Revise this Section by deleting and inserting text to meet Project-specific requirements.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
   * + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
      1. SUMMARY
         1. Section includes outdoor, custom air-handling units with capacities, characteristics and configurations indicated on Drawings.
         2. Related Requirements:

Retain subparagraph below to cross-reference requirements Contractor might expect to find in this Section but are specified in other Sections.

Section 237313.19 "Indoor, Custom Air-Handling Units."

* + - 1. SUBMITTALS
         1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
         2. Manufacturer’s installation instructions shall be provided along with product data.
         3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
         4. Product Data: For each air handling unit.

Product information organized to show compliance with each performance requirement of "Performance Requirements" article.

Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

Include unit dimensions and weight.

Include cabinet material, metal thickness, finishes, insulation, and accessories.

Fans:

Include certified fan-performance curves with system operating conditions indicated. For fans operating at variable speeds include curves in **[10] <Insert number>** percent speed increments starting at design speed down to minimum speed.

Include fan-sound power ratings in all eight octave bands. Include inlet or outlet sound power levels to coincide with sound requirements indicated on Drawings.

Include fan construction and accessories. Submit sufficient information to show product compliance with requirements indicated.

Include dimensions and weight.

Include motor ratings, electrical characteristics, and motor accessories.

Vibration isolation product data with performance ratings. Uniquely identify and include information for each different isolator type and indicate for each air-handling unit where each isolator type is being used.

Include certified coil-performance ratings with system operating conditions indicated. Product data to include: dimensions, dry and operating weight, volume of fluid contained, materials of construction, and performance ratings with system operating conditions indicated.

Casing insulation product data and performance ratings.

Access door and access panel product data and performance ratings.

Roofing product data and performance ratings.

Louver product data and performance ratings.

Paint product data and performance ratings.

Electrical product data and performance ratings.

Metal grating product data and performance ratings.

Retain subparagraphs below where retained under Part 2.

Electric heater product data with performance ratings.

Steam humidifier product data with performance ratings.

Dampers product data, including housings, linkages, and operators with performance ratings.

Filters product data with performance characteristics.

Heat wheels product data with performance ratings.

Fixed plate heat exchangers product data with performance ratings.

Heat pipe heat exchangers product data with performance ratings.

Duct silencers product data with performance ratings.

Air blender product data with dimensions, weights, materials of construction, performance ratings, and installation requirements.

UV-C lamp systems product data with performance ratings.

Pumps product data with performance ratings.

Hydronic pipe, valves, fittings, vents, strainers, and hydronic accessories product data.

Steam and condensate pipe, valves, fittings, vents, strainers, and steam specialties product data.

Pipe insulation and jacket product data.

Roof curbs product data.

**<Insert requirements>**.

* + - * 1. Sustainable Design Submittals:
        2. Shop Drawings: For each type and configuration of outdoor, custom air-handling unit.

Prepared by manufacturer's factory employees with review and sign-off by those individuals responsible for manufacturing the air-handling units.

Include plans, elevations, sections, and **[mounting] [attachment]** details.**[ For air-handling units consisting of multiple levels, create drawings for each level showing interrelationship of levels superimposed.]**

Retain any of remaining subparagraphs below as applicable.

Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, methods of field assembly, components, and location and size of each field connection.

Detail fabrication and assembly of outdoor, custom air-handling units, as well as procedures and diagrams.

Indicate details of construction with materials description including applicable specified standards and material grades in sufficient detail for reviewers to evaluate point by point compliance with requirements indicated for each air-handling unit.

Use actual dimensions of internal equipment in preparing Shop Drawings. Identify mechanical equipment shown on Shop Drawings with equipment designations on Drawings.

Thickness and finish of all casing materials with cross references indicated where each is used. Uniquely identify and include information for each different casing construction.

Details for each unique casing joint and reinforcing. Indicate wall joints, wall to floor joints, wall to roof joints, floor joints, and roof joints.

Roofing details.

Assembly details of base and casing for units consisting of multiple sections requiring field assembly.

Sizes and dimensioned locations of field connections for ductwork, piping, electrical, and controls.

Base and casing penetration and sealing details for factory-installed conduit.

Base and casing penetration and sealing details for factory-installed piping including coils[ and steam humidifiers].

Details of casing connections to field-installed ductwork.

Size, shape and layout of base members including localized support of internal components.

Base materials, thickness, finishes, lifting provisions, and mounting requirements. Uniquely identify and include information for each different base construction. Clearly indicate for each air-handling unit.

Recommended points of field attachment with dimensioned locations.

Size and location of each access door, including clearing opening size, with door swing indicated.

Size and location of each access panel with service equipment superimposed to show relationship of panel to internal equipment.

Drain pans and associated piping, with sizes and locations dimensioned, including relationship to internal equipment.

Floor drains and associated piping, with sizes and locations dimensioned, including relation to internal equipment.

Coil framework and support including enlarged details showing framework attachment to air-handling unit base, coil attachment to framework, and means for individual coil removal.

Mounting details of all internal components, such as fans, filters, and dampers.

Hoist rails layout for internal equipment showing size of members, attachments to structure, and serviced equipment superimposed to indicate relationships.

Size and location of catwalks, handrails, ladders, and safety cages including construction details and details of attachment to air-handling unit base.

Location of UV-C lamp systems, service clearances, and mounting details.

Location of receptacles, service lights, and switches.

Location of motor controllers and disconnect switches.

Size and location of junction boxes used for interface with field electrical power.

Point-to-point electrical power wiring diagrams including wire size, conduit size, motor controllers sizes, switch types and ratings, receptacle types and ratings, service light fixture types and ratings.

Point-to-point control wiring diagrams including cable types and sizes, conduit sizes, and connected control devices.

Point-to-point control tubing diagrams including tubing types and sizes, conduit sizes, and connection controls devices.

Control panel drawings drawn to scale showing detailed internal layout.

Plans, sections and isometric reviews of **[hydronic] [and] [steam and condensate]** piping systems showing pipe, fittings, flanges, unions, valves, vents, strainers, accessories, specialties and insulation.

Indicate code, operating, and maintenance clearances drawn to scale using dashed lines.

Indicate weights of internal components, weight of each separately shipped section, and air-handling unit total weight.

**<Insert requirements>**.

* + - * 1. Comparison Schedule:

Submit a schedule to indicate performance of equipment scheduled on Drawings directly compared to performance of submitted equipment.

Clearly identify each line in schedule to indicate "Scheduled" where indicating performance scheduled on Drawings and "Submitted" where indicating performance of submitted equipment.

Organize schedule to first indicate performance scheduled on Drawings on one line followed by line directly below that indicates performance of submitted equipment.

Comparison schedule shall follow arrangement and organization of scheduled information indicated on Drawings.

Submitted equipment shall have a value for each scheduled value indicated.

Retain "Delegated-Design Submittal" paragraph below if design services have been delegated to Contractor.

In "Delegated-Design Submittal" paragraph, if retaining first option, also retain second option requiring professional engineer sign and seal.

* + - * 1. Delegated-Design Submittal: For vibration isolation**[ and seismic restraints]** indicated to comply with performance requirements and design criteria, including analysis data**[ signed and sealed by the professional engineer responsible for their preparation]**.

For seismic restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

Include design calculations for selecting seismic restraints.

**<Insert requirements>**.

Retain "Coordination Drawings" paragraph below for situations where limited space necessitates maximum utilization for efficient installation of different components or if coordination is required for installation of products and materials by separate installers. Coordinate paragraph with other Sections specifying products listed below. Preparation of coordination drawings requires the participation of each trade involved in installations within the limited space.

* + - * 1. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

Retain "Seismic Qualification Data" paragraph below if required by seismic criteria applicable to Project. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC." See ASCE/SEI 7 for certification requirements for equipment and components.

* + - * 1. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.

Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

Restraint of internal components.

* + - * 1. Source quality-control reports.
        2. Startup service reports.

Retain "Field quality-control reports" paragraph below if Contractor is responsible for field quality-control testing and inspecting.

* + - * 1. Field quality-control reports.
        2. Sample Warranty: For manufacturer's warranty.
      1. CLOSEOUT SUBMITTALS
         1. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.
      2. MAINTENANCE MATERIAL SUBMITTALS
         1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

Retain any of "Bag Filters," "Cartridge Filters," "Panel Filters," "Absolute Filters," "Gas-Phase Filters," "Access Door Gaskets," "Fan Belts," and "Heat Wheel Belts" subparagraphs below.

Bag Filters: **[One] <Insert number>** set(s) for each air-handling unit.

Cartridge Filters: **[One] <Insert number>** set(s) for each air-handling unit.

Panel Filters: **[One] <Insert number>** set(s) for each air-handling unit.

Absolute Filters: **[One] <Insert number>** set(s) for each air-handling unit.

Gas-Phase Filters: **[One] <Insert number>** set(s) for each air-handling unit.

Access Door Gaskets: **[One] <Insert number>** set(s) for each [unique ]access door.

Fan Belts: **[One] <Insert number>** set(s) for each fan with belt-drive assembly.

Heat Wheel Belts: **[One] <Insert number>** set(s) for each heat wheel with belt-drive assembly.

* + - * 1. Tool Kit: Manufacturer to provide a tool kit including special tools required for air-handling unit service. See "Accessories" Article for additional requirements.
      1. COORDINATION
         1. Coordinate sizes and locations of concrete bases with actual equipment provided.
         2. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.
      2. DELIVERY, STORAGE, HANDLING
         1. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers. Cover units with heat-shrinkable plastic sheeting suitable for shipping from point of manufacture to Project.
         2. Handle air-handling units carefully to avoid damage to components, casing, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.
         3. Store air-handling units in a clean dry place and protect them from weather and construction activities.
         4. Keep air-handling units fully covered and protected during construction. Remove dirt and debris and clean units to a factory-cleaned condition.
         5. Comply with manufacturer's written rigging and installation instructions for unloading air-handling units and moving them to their final locations.

Retain paragraph below to restrict access inside of air-handling units.

* + - * 1. For air-handling units equipped with key locks on access doors, keep doors locked during construction.

If access is required within air-handling units, only open the doors to sections that require access and lock doors at the end of each **[workday] [work shift] <Insert requirement>**.

Protect inside of air-handling units from damage and keep inside of units as clean as the factory-cleaned condition.

Report observed abuse to **<Insert entity>** for immediate corrective action.

* + - 1. WARRANTY

When warranties are required, verify with Owner's counsel that warranties stated in this article are not less than remedies available to Owner under prevailing local laws.

* + - * 1. Warranty: Manufacturer agrees to repair or replace components of air-handling units that fails in materials or workmanship within specified warranty period.

Verify available warranties and warranty periods.

Warranty Period: **<Insert number>** year(s) from date of Substantial Completion.

* + - * 1. Extended warranties include, but are not limited to, the following:

Complete Air-Handling Unit: **[Two] [Three] [Five] <Insert number>** years from date of Substantial Completion for entire air-handling unit and longer where indicated for individual components.

Air-Handling Unit Casing: **[25] [30] <Insert number>** years from date of Substantial Completion.

Air-Handling Unit Roofing: **[25] [30] <Insert number>** years from date of Substantial Completion.

Motors: **[Two] [Five] <Insert number>** years from date of Substantial Completion

Heat Wheels: **[Five] [10] <Insert number>** years from date of Substantial Completion.

**<Insert requirement>**.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. PERFORMANCE REQUIREMENTS
         1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
         2. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handing units and components.

"ASHRAE 62.1 Compliance" paragraph below may be required to comply with Project requirements or authorities having jurisdiction. Sustainable design may require compliance with requirements in ASHRAE 62.1, including requirements for controls, surfaces in contact with the airstream, particulate and gaseous filtration, humidification and dehumidification, drain pan construction and connection, finned-tube coil selection and cleaning, and equipment access. Verify, with manufacturers, the availability of units with components and features that comply with these requirements.

* + - * 1. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

"ASHRAE/IES 90.1 Compliance" paragraph below may be required to comply with Project requirements or authorities having jurisdiction. Sustainable design may require minimum efficiency equal to requirements in ASHRAE/IES 90.1. Insert a specific version of the standard if required to satisfy a Project sustainability requirement.

* + - * 1. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
        2. Casing Structural Performance:

Floor: Capable of withstanding positive/negative **[8 inches wg] <Insert value>** of internal static pressure, without exceeding a deflection of **[L/300] [L/360] <Insert deflection>** of span.

Walls and Roof: Capable of withstanding positive/negative **[8 inches wg] <Insert value>** of internal static pressure, without exceeding a midpoint deflection of **[L/200] [L/240] <Insert deflection>** of span.

Retain "Casing Leakage Performance, ASHRAE 111" or "Casing Leakage Performance" paragraph below.

* + - * 1. Casing Leakage Performance, ASHRAE 111: **[Class 3 leakage] <Insert leakage class>** or better at **[plus or minus 8 inches wg] <Insert pressure>**.
        2. Casing Leakage Performance: Comply with more stringent of the following requirements:

ASHRAE 111, **[Class 3 leakage] <Insert leakage class>** or better at **[plus or minus 8 inches wg] <Insert pressure>**.

Not more than **[0.5] <Insert number>** percent of the total unit airflow at **[8 inches wg] <Insert pressure>**.

* + - * 1. Casing Thermal Performance:

Surface Condensation: Air-handling manufacturer shall evaluate potential for condensation and design and manufacture entire unit casing to prevent condensation at most extreme operating conditions encountered.

Thermal Break: Incorporate a thermal break at each through metal path to prevent condensation from occurring on interior and exterior of casing.

U-Value: Overall U-value or equivalent R-value of casing shall not exceed governing codes and ASHRAE/IES 90.1 while considering the effects of metal-to-metal contact and thermal bridging in calculations.

* + - * 1. Air Tunnel Aerodynamic Performance: Position air-handling unit internal components and transition between internal components to maintain uniform airflow; minimize sound levels and energy consumption. Use methods indicated and other means to ensure compliance.

Use turning vanes if necessary to direct the air path.

Design, manufacture, and install vanes in accordance with applicable requirements in ASHRAE and SMACNA guidelines, handbooks, and standards.

Install vanes firmly in place so that no vane movement occurs at worst-case airflow capacity possible.

Use fan inlet and discharge transitions and other devices to maximize system regain and minimize airborne sound levels.

Center system components such as coils, fans, and filters, vertically and horizontally, in the airstream.

Maintain spacing between components such that airflow patterns to adjacent components are as uniform as possible and that component "dead spots" or "jetted areas" are avoided.

Design and install internal structural supports, piping, and conduit that do not block airflow and impede performance of coils, fans, filters, and other unit components, and service space clearances.

Retain "Air-Handling Unit Acoustical Performance" paragraph below only for sound-sensitive applications that require special attention to acoustical performance.

* + - * 1. Air-Handling Unit Acoustical Performance:

Radiated Noise: Noise radiated from air-handling unit casing**[ and openings not ducted]** shall not exceed following sound pressure levels when measured **[3 feet] <Insert distance>** away from any exterior surface of unit. Sound pressure levels indicated in each octave band are in decibels (dB) (reference 20 µPa).

63 Hz: **<Insert value>** dB.

125 Hz: **<Insert value>** dB.

250 Hz: **<Insert value>** dB.

500 Hz: **<Insert value>** dB.

1000 Hz: **<Insert value>** dB.

2000 Hz: **<Insert value>** dB.

4000 Hz: **<Insert value>** dB.

Retain "Casing Acoustical Performance" paragraph below only for sound-sensitive applications that require special attention to acoustical performance.

* + - * 1. Casing Acoustical Performance:

Retain "Sound Absorption" subparagraph below to require independent testing of perforated casing assemblies. Independent testing provides some assurance of performance for proposed construction. Consult air-handling unit manufacturers for performance information to compare against Project requirements.

Sound Absorption: Minimum acceptable sound absorption coefficient and noise reduction coefficient (NRC) of perforated inside casing assemblies when tested by an independent testing laboratory in accordance with ASTM C423 and ASTM E795:

125 Hz: **<Insert value>** dB.

250 Hz: **<Insert value>** dB.

500 Hz: **<Insert value>** dB.

1000 Hz: **<Insert value>** dB.

2000 Hz: **<Insert value>** dB.

4000 Hz: **<Insert value>** dB.

NRC: **<Insert value>**.

Retain "Durability Performance" paragraph below for applications with a long equipment life expectancy.

* + - * 1. Durability Performance: Design and manufacture air-handling units with underlying requirement to provide a highly durable piece of equipment.

Unit Life Expectancy: **[25] <Insert number>** years.

Supporting Documentation: Submit documentation showing proposed products to consider and include design features, components, and materials to satisfy requirement.

Retain "Extreme Operating Conditions" paragraph below, as applicable, to require air-handling unit manufacturer to further evaluate and address the potential operating condition the air-handling units may encounter.

* + - * 1. Extreme Operating Conditions:

Corrosive Environments: Air-handling unit manufacturer shall evaluate the quality and potential corrosiveness of air passing through air-handling units and propose additional protective finishes and better-quality materials of a heavier thickness if required to comply with requirements indicated.

Unless otherwise indicated, air-handling units for HVAC applications may use up to 100 percent of outdoor air or a mix of outdoor air with return air from habitable areas served.**[ Projects located in coastal and industrial areas may require added protection.]**

Air-handling units circulating **[Class 3] [and] [Class 4]** exhaust air in accordance with ASHRAE 62.1 could potentially be hot, humid, and corrosive and may require added protection.

Humidity and Temperatures: Materials and components of air-handling units shall be suitable for use in low and high humidity and temperature extremes when operating under normal and abnormal conditions without permanent degradation or loss in material performance.

* + - * 1. Outdoor Environment:

Air-handling units specially designed to withstand effects of wind, rain, ice, snow, seismic, air quality, sun, and other influences associated with outdoor installations.

Comply with requirements of air-handling unit and governing codes.

* + - * 1. Safety:

Comply with OSHA regulations.

Exposed sharp edges and corners of metal shall be protected or rounded to prevent injury to personnel not wearing gloves.

Cover exposed ends of screws with plastic or metal covers to prevent injury to personnel coming in contact with screws.

* + - * 1. Serviceability:

Hoisting Provisions: Fans and motors weighing more than **[200 lb] <Insert weight>** shall have full-length hoist rails mounted over the equipment to facilitate service, removal, and replacement.

Mounting Location: Install internal components in readily accessible locations to facilitate ease of service and replacement.

Service Access:

Internal components shall be serviceable through access sections with doors indicated on Drawings.

Internal components shall be removable and replaceable through access doors or panels.

Review requirements for access doors and panels indicated and recommend additional access doors and panels if required for uninhabited service, removal, and replacement of components.

Tripping Hazards: Floors in accessible sections of air-handling unit shall be free of standing seams, reinforcing, supports, or section splits located in the walking path that is capable of causing a tripping hazard. Locate section splits immediately adjacent to internal walls.

* + - * 1. Quality: Type and thickness of materials indicated are the minimum acceptable. Provide better-quality materials of a heavier thickness if required to comply with performance requirements indicated.

If manufacturer's standard construction exceeds requirements indicated, use manufacturer's standard construction.

If manufacturer's standard construction does not comply with requirements indicated, modify manufacturer's standard construction to comply with requirements.

Retain "Seismic Performance" paragraph below with "Seismic Qualification Data" paragraph in "Informational Submittals" Article for projects requiring seismic design. Delete paragraph if performance requirements are indicated on Drawings. Model building codes and ASCE/SEI 7 establish criteria for buildings subject to earthquake motions. Coordinate requirements with structural engineer.

* + - * 1. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7] <Insert requirement>**.

Retain first subparagraph below to define the term "withstand" as it applies to this Project. Definition varies with type of building and occupancy and is critical to valid certification. Option is used for essential facilities where equipment must operate immediately after an earthquake.

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]**."

For life-safety components required to function after an earthquake (such as fire-sprinkler systems, components that contain hazardous content, and storage racks in structures open to the public), the Component Importance Factor is 1.5. For other components, the Component Importance Factor is 1.0 unless the structure is in Seismic Use Group III and component is necessary for continued operation of facility or failure of component could impair continued operation of facility, in which case the Component Importance Factor is 1.5.

Component Importance Factor: **[1.5] [1.0]**.

See ASCE/SEI 7, Coefficients for Architectural Component Table and Seismic Coefficients for Mechanical and Electrical Components Table for requirements to be inserted in subparagraph below.

**<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

* + - * 1. Vibration Performance: Air-handling unit manufacturer shall evaluate vibration of internal components installed inside of air-handling units and include internal vibration isolation required to limit the vibration transmitted to the building at a low enough level that vibration is not perceived by building occupants.
      1. CAPACITIES AND CHARACTERISTICS

This custom class of air-handling unit equipment requires capacity, performance, and other characteristics to be indicated in equipment schedules on Drawings.

* + - * 1. See equipment schedules on Drawings.
      1. SOURCE LIMITATIONS

Retain any of first three paragraphs below as applicable.

* + - * 1. Source all outdoor **[and indoor ]**custom air-handling units from same manufacturer.
        2. Like components furnished with air-handling units shall be from same manufacturer.
        3. Air-handling units shall be manufactured in **[United States] [United States or Canada] [North America] <Insert requirement>**.
      1. MANUFACTURERS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Ventrol

Air Enterprises, LLC.

Buffalo Air Handling.

Climate Craft.

Engineered Air.

Environmental Air Systems.

Haakon Industries.

HUNTAIR; A Nortek Air Solutions Company.

Temtrol; A Nortek Air Solutions Company.

Trane; An Ingersoll Rand Company.

[YORK; a Johnson Controls company](http://www.specagent.com/Lookup?uid=123457148354).

Approved equivalent

* + - 1. UNIT ARRANGEMENT AND CONFIGURATION
         1. Arrangement: Project-specific arrangement and configuration of air-handling units indicated on Drawings. Do not deviate from requirements indicated**[ without submitting a formal request clearly describing each deviation and reason for each deviation, and only after receiving Architect's written acceptance]**.

Retain only one of six options in "Mounting Requirements" paragraph below. If multiple mounting requirements apply to different air-handling units, indicate requirements on Drawings.

* + - * 1. Mounting Requirements: **[Indicated on Drawings] [Units mounted on concrete housekeeping pads] [Units mounted on structural floor] [Units mounted on structural-steel frame] [Units suspended from structure] [Units mounted on roof curbs]**.

Retain "Multiple Sections" or "Multiple Sections, Splits" paragraph below as applicable.

* + - * 1. Multiple Sections: Each air-handling unit shall consist of multiple sections for field assembly to comply with requirements indicated on Drawings.
        2. Multiple Sections, Splits: Air-handling unit manufacturer to determine number of sections and location of section splits required for each air-handling unit in accordance with the following criteria:

Physical size and weight of each section, on-site path of travel, and methods for erection and installation. Air-handling manufacturer to review criteria with Installer before preparing Shop Drawings.

Maximize physical size of each air-handling unit section considering, shipping, moving, erecting, and installation.

Minimize the number of air-handling unit sections requiring field assembly. Preference is for single-piece air-handling units where possible.

* + - 1. AIR-HANDLING UNIT BASE
         1. Performance:

Air-handling unit manufacturer shall design and assemble air-handing unit casing and internal components for attachment and support by air-handling unit structural base.

Design air-handling units to be lifted from only the air-handling unit structural base and not the casing.

Support air-handling units from only the perimeter base unless otherwise indicated on Drawings.

Air-handling unit manufacturer to size and locate intermediate structural base supports as required to comply with structural performance indicated for air-handling unit floors.

Level base before factory assembly of air-handling unit casing and internal components to ensure proper fit and alignment.

* + - * 1. Structural Member Size:

Air-handling unit manufacturer shall select size of base members and construction of base to withstand the rigors of loading, unloading, shipping, and rigging without damage to air-handling unit components or misalignment of factory-assembled components.

Depth and weight of structural members shall be selected by air-handling unit manufacturer to comply with performance requirements indicated.

Retain subparagraph below to dictate minimum depth of base. Retain only one of three options.

Depth of perimeter base members is not less than **[size indicated on Drawings] [1/10 of the unit width] [8 inches deep] <Insert requirement>**.

* + - * 1. Structural Member Spacing: Positioned as required to comply with requirements indicated, but not to exceed **[24 inches] <Insert requirement>**.

See the Evaluations for discussion of structural base materials. If Project requires different materials for different units, retain applicable option in "Materials" paragraph below and indicate materials on Drawings.

* + - * 1. Materials: **[Structural aluminum, ASTM B209, Alloy 6061 T6] [structural carbon steel, ASTM A36] [structural stainless steel, ASTM A276, Type304L] [or] [structural stainless steel, ASTM A276, Type 316L] [as indicated on Drawings]**.

Retain any of "Perimeter Members," "Intermediate Members (Spanning Full Width of Unit)," and "Cross Members (Spanning Intermediate Members)" subparagraphs below and revise text options to restrict structural shapes. Coordinate shapes selected below with material selected in "Materials" paragraph above. Not all shapes are available with all materials. Channel is the most common shape used for perimeter and intermediate members. Angle is also a common shape used for cross members.

Perimeter Members: **[Angle] [channel] [I or W beam shapes] [or] [tube]**.

Intermediate Members (Spanning Full Width of Unit): **[Angle] [channel] [or] [I or W beam shapes] [or] [tube]**.

Cross Members (Spanning Intermediate Members): **[Angle] [channel] [or] [tube]**.

Retain "Carbon-Steel Finish, Mill Galvanized" or "Carbon-Steel Finish" paragraph below only if retaining "Structural carbon steel, ASTM A36" option in "Materials" paragraph above.

* + - * 1. Carbon-Steel Finish, Mill Galvanized: Mill-galvanized carbon steel with weld-damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.
        2. Carbon-Steel Finish: Carbon-steel bases shall be shot-blasted, cleaned, prepared, and **[painted] [or] [hot-dip galvanized]** after fabrication.
        3. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.

Use welding materials with corrosion properties equal to material being welded.

* + - * 1. Welding Procedures:

Coordinate retained options in "Structural Welding Codes" subparagraph below with base materials retained in "Materials" paragraph.

Structural Welding Codes: **[AWS D1.1 for carbon steel] [AWS D1.2 for aluminum] [AWS D1.6 for stainless steel]**.

Join structural members to one another using **[continuous] [or] [stitch]** welds.

After welding and fabrication, deburr and grind exposed welds to provide smooth surfaces free of sharp edges.

* + - * 1. Penetrations through Base Perimeter: Seal **[weld]** pipe, tubing, and conduit penetrations through base perimeter members to provide a watertight assembly.

Retain "Section Joints" paragraph below unless all air-handling units are single piece.

* + - * 1. Section Joints: Air-handling units consisting of multiple sections for field assembly shall be joined with structural joining plates.

Joining plate material type to match base.

Joining plate of thickness required to join sections without resulting in a permanent deflection, minimum **[1/2 inch] <Insert dimension>** thick.

Continuously weld joining plates to each mating end of base.

Joining plates shall not extend beyond outer edge of adjoining base.

Plates to include at least three equally spaced holes for field connection using factory-furnished threaded hardware of a nominal diameter of at least **[1/2 inch] <Insert diameter>**.

* + - * 1. Lifting Provisions: Air-handling unit manufacturer to design and install lifting lugs of size and location required to comply with performance requirements indicated.**[ Lifting lugs extending beyond the base shall be easily removable in the field after unit is installed.]**

Retain "Curb Cap" paragraph below to include base with integral curb cap for installations on curbs.

* + - * 1. Curb Cap:

For air-handling units installed on a continuous perimeter curb, provide air-handling unit base with a continuous structural angle counterflashing.

Angle shall extend down vertical face of curb to completely cover wood nailer.

Coordinate inside dimension of angle counterflashing with curb dimension and roofing. Provide adequate clearance between angle counterflashing and roofing over curb.

* + - 1. UNIT CASINGS

See the Evaluations for discussion of casings.

* + - * 1. Casing Assembly:

Retain "Appearance" subparagraph below for applications requiring a more refined and finished appearance. Not all manufacturers may be able to comply with this requirement. Consult custom air-handling unit manufacturers.

Appearance:

Exposed exterior surfaces of casing shall have a neat and finished appearance free of standing seams, exposed reinforcing, and other casing protrusions more than **[0.25 inch] [0.5 inch] <Insert dimension>** beyond the exterior skin surface.

Retain first subparagraph below for elevated air-handling units requiring a finished underside appearance.

Underside of air-handling units with finished installation exposed to view shall have finished appearance matching casing walls. Casing shall be recessed within the perimeter structural base to provide a single contiguous plane.

Interior surfaces of casing shall have a neat and finished appearance free of standing seams, exposed reinforcing, and other casing protrusions more than **[0.25 inch] [0.5 inch] <Insert dimension>** beyond the skin surface.

Dissimilar Metals: Isolate dissimilar metals that are in contact to prevent galvanic action and corrosion.

Framing and Supports: Interconnect and support individual casing wall and roof panels using either formed panel construction or framed construction with structural support members. For framed casing construction, materials used to construct casing of structural support members shall be as follows:

Casings with Aluminum Outer and Inner Skins: Aluminum extrusions in accordance with ASTM B211 Alloy 6063 T6.

Casings with Galvanized-Steel Outer and Inner Skins: Galvanized steel.

Casings with Galvanized-Steel Outer Skin and Aluminum or Stainless Steel Inner Skins: Stainless steel.

Casings with Stainless Steel Outer and Inner Skins: Stainless steel.

Seals: Seal interior and exterior joints and seams to make casing air- and watertight. Trim factory-applied sealant flush with adjacent surface.

Double-Wall Casings: Consisting of insulation sandwiched between an outer and inner metal wall. Use double-wall casings to construct air-handling units unless septum casings are required.

Septum Casings: Triple-wall construction consisting of a solid metal inner wall sandwiched between insulation layers that are covered with metal walls. Use septum casings for applications having performance requirements that are not achievable with double-wall casings.

Penetrations: Seal voids around conduit, piping and tubing penetrations.

Walls and Roofs:

Conduit, Pipe, and Tube Sizes **[NPS 3] <Insert pipe size>** and Smaller:

Seal void through casing with a nonhardening vapor-barrier caulk covered by an escutcheon on both interior and exterior sides of casing. Back caulk using formed insulation within a sheet metal sleeve.

Seal void using a friction fit neoprene or EPDM sheet material attached to casing using a bed of adhesive.

Cover penetration and sealing sheet material with metal escutcheon matching adjacent casing material.

Larger Conduit, Pipe, and Tube Sizes: Seal annular void using an adjustable compression-type sealing sleeve.

Floors: Route conduit, pipe, and tube within a floor-mounted pipe sleeve.

Sleeve:

Fabricate sleeve of aluminum**[, galvanized-steel,]** or stainless steel pipe.

Extend top of sleeve above adjacent floor surface to prevent standing water on floor from entering annular space of sleeve.

Seal**[ weld]** sleeve to top of floor for an air- and watertight seal.

Seal annular void of sleeve using an adjustable compression seal **[or] [nonhardening packing material]**.

Retain "Floor Openings with Metal Grating" subparagraph below to include factory-installed grating over air-handling unit floor openings.

Floor Openings with Metal Grating:

Factory install walk-on safety gratings over any floor opening large enough to create a safety hazard for operators including, but not be limited to, supply-, return-, and exhaust-air openings.

Bar Grating:

Materials: Use **[stainless steel grating for aluminum] [stainless steel grating for stainless steel] [hot-dip galvanized-steel grating for galvanized-steel] [painted steel grating for painted steel]** floors.

Air-handling unit manufacturer shall select depth and thickness of grating bars to limit deflection to 1/360 of span when subjected to a dynamic load of not less than **[500 lb] <Insert weight>**.

Industry-standard welded grating with bars at least 1-1/2 inches deep by at least 3/16 inch thick with nominal 1-3/16-inch main bar spacing and 4-inch cross bar spacing.

Source: Product manufacturer specializing in metal gratings.

Grating bearing surface shall extend beyond clear opening in floor at least **[2 inches] [3 inches] <Insert dimension>**.

Mounting Frame:

Mount grating in a continuous structural angle or bar frame so no ends of grating bars are exposed. Top of frame to be flush with top of grating.

Secure grating to frame with threaded hardware so grating does not move when walked on but can be easily removed from top to gain access behind grating.

Retain one of first two subparagraphs below.

Continuously weld mounting frame to air-handling unit floor.

Fasten mounting frame to air-handling unit floor with hardware and seal attachment air- and watertight.

For applications with automatic dampers installed at floor openings, elevate height of mounting frame and grating to enclose entire damper assembly including jackshaft so walk-on surface of grating is above damper assembly.

Retain "Waterproof Floors" subparagraph below to create a waterproof floor capable of holding standing water.

Waterproof Floors: Continuously weld floor joints, seams, and penetrations to completely seal floor. Roll all edges of floor up at least **[1 inch] <Insert dimension>** to create a shallow tub capable of holding standing water.

Retain "Duct Connections - Direct to Casing" or "Duct Connections - Elevated Off Casing" subparagraph below.

Duct connections that are direct to casing cost less to manufacturer than duct connections that are elevated off the casing surface.

Duct Connections - Direct to Casing: Frame and reinforce unit casing around perimeter of unit duct openings to accommodate direct attachment of field-installed ductwork. Coordinate requirements with Installer to accommodate field connection.

Retain "Duct Connections - Elevated Off Casing" subparagraph below to minimize field penetrations to air-handling unit casing.

Duct Connections - Elevated Off Casing:

Terminate with angle flange face elevated **[3 inches] <Insert dimension>** from exterior surface of casing.

Flange Thickness: **[0.25 inch] <Insert dimension>**.

Flange face with holes located not more than **[4 inches] <Insert dimension>** o.c., starting at corners, and sized for **[0.375-inch-]** diameter, field-installed hardware.

Size flange face to mate to full face of duct flange.

Clear inside dimension of unit connection to match clear inside dimension of duct.

For connections to acoustically lined ducts, increase unit flange face to accommodate thickness of liner so end of duct liner is concealed by air-handling unit flange.

**<Insert requirements>**.

* + - * 1. Materials for Outer Skin of Casing Walls and Roofs:

Retain any of "Galvanized-Steel Solid Sheet," "Aluminum Solid Sheet," and "Stainless Steel Solid Sheet" subparagraphs below.

Galvanized-Steel Solid Sheet: ASTM A653; **[G90] <Insert coating> coating; minimum (nominal) [18 gauge] [16 gauge] [14 gauge] <Insert value>** thick.

Aluminum Solid Sheet: ASTM B209; Alloy 3003-H14, **[smooth] [stucco-embossed texture] [or] [leather-grain texture] <Insert finish>** finish; minimum (nominal) **[0.063 inch] [0.080 inch] <Insert value>** thick.

Stainless Steel Solid Sheet: ASTM A240 or ASTM A480, **[Type 304] [Type 304L] [Type 316] [Type 316L] <Insert type>**; No. **[2D] [or] [4] <Insert finish>** finish; minimum (nominal) **[18 gauge] [16 gauge] [14 gauge] <Insert value>** thick.

Retain "Application" subparagraph below if more than one material type is required and indicate material requirements on Drawings.

Application: See Drawings for application of different materials indicated.

* + - * 1. Materials for Inner Skin of Casing Walls and Roofs:

Retain any of "Galvanized-Steel Solid (and Perforated) Sheet," "Aluminum Solid (and Perforated) Sheet," and "Stainless Steel Solid (and Perforated) Sheet" subparagraphs below.

Galvanized-Steel Solid**[ and Perforated]** Sheet: ASTM A653; **[G90] <Insert coating>** coating, minimum (nominal) **[20 gauge] [18 gauge] [16 gauge] <Insert value>** thick.

Aluminum Solid**[ and Perforated]** Sheet: ASTM B209; Alloy 3003-H14, **[smooth] <Insert finish>** finish; minimum (nominal) **[0.032 inch] [0.040 inch] [0.063 inch] [0.080 inch] <Insert value>** thick.

Stainless Steel Solid**[ and Perforated]** Sheet: ASTM A240 or ASTM A480; **[Type 304] [Type 304L] [Type 316] [Type 316L] <Insert type>**; No. **[2D] <Insert finish>** finish; minimum (nominal) **[20 gauge] [18 gauge] [16 gauge] <Insert value>** thick.

Retain "Application" subparagraph below if more than one material type is required and indicate material requirements on Drawings.

Application: See Drawings for application of different materials indicated.

* + - * 1. Materials for Floor Walking Surface:

Retain any of "Galvanized-Steel Solid Sheet," "Stainless Steel Solid Sheet," "Carbon-Steel Diamond Treadplate," "Aluminum Diamond Treadplate," and "Stainless Steel Diamond Treadplate" subparagraphs below.

Galvanized-Steel Solid Sheet: ASTM A653; **[G90] <Insert coating>** coating; minimum (nominal) **[14 gauge] [12 gauge] [10 gauge] <Insert value>** thick.

Stainless Steel Solid Sheet: ASTM A240 or ASTM A480, **[Type 304] [Type 304L] [Type 316] [Type 316L] <Insert type>**; No. [2D] **<Insert finish>** finish; minimum (nominal) **[14 gauge] [12 gauge] [10 gauge] <Insert value>** thick.

Carbon-Steel Diamond Treadplate: ASTM A786, painted finish; minimum (nominal) **[0.125 inch] [0.1875 inch] <Insert value>** thick.

Aluminum Diamond Treadplate: ASTM B632, Alloy 6061 T6; mill finish; minimum (nominal) **[0.125 inch] [0.1875 inch] <Insert value>** thick.

Stainless Steel Diamond Treadplate: ASTM A793; **[Type 304] [Type 304L] [Type 316] [Type 316L] <Insert type>**; mill finish; minimum (nominal) **[0.125 inch] [0.1875 inch] <Insert value>** thick.

Retain "Application" subparagraph below if more than one material type is required and indicate material requirements on Drawings.

Application: See Drawings for application of different materials indicated.

* + - * 1. Materials for Underside of Floor Insulation:

Retain any of "Galvanized-Steel Solid Sheet," "Aluminum Solid Sheet," and "Stainless Steel Solid Sheet" subparagraphs below.

Galvanized-Steel Solid Sheet: ASTM A653; **[G90] <Insert coating>** coating, minimum (nominal) **[18 gauge] [16 gauge] <Insert value>** thick.

Aluminum Solid Sheet: ASTM B209; Alloy 3003-H14, **[smooth] <Insert finish>** finish; minimum (nominal) **[0.040 inch] [0.063 inch] [0.080 inch] <Insert value>** thick.

Stainless Steel Solid Sheet: ASTM A240 or ASTM A480; **[Type 304] [Type 304L] [Type 316] [Type 316L] <Insert type>**; No. **[2D] [4] <Insert finish>** finish; minimum (nominal) **[18 gauge] [16 gauge] <Insert value>** thick.

Retain "Application" subparagraph below if more than one material type is required and indicate material requirements on Drawings.

Application: See Drawings for application of different materials indicated.

* + - * 1. Materials for Internal Walls:

Retain any of "Galvanized-Steel Solid Sheet," "Aluminum Solid Sheet," and "Stainless Steel Solid Sheet" subparagraphs below.

Galvanized-Steel Solid Sheet: ASTM A653; **[G90] <Insert coating>** coating; minimum (nominal) **[16 gauge] [14 gauge] <Insert value>** thick.

Aluminum Solid Sheet: ASTM B209; Alloy 3003-H14, smooth finish; minimum (nominal) **[0.063 inch] [0.080 inch] <Insert value>** thick.

Stainless Steel Solid Sheet: ASTM A240 or ASTM A480, **[Type 304] [Type 304L] [Type 316] [Type 316L] <Insert type>**; No. 2D finish; minimum (nominal) **[16 gauge] [14 gauge] <Insert value>** thick.

Retain "Application" subparagraph below if more than one material type is required and indicate material requirements on Drawings.

Application: See Drawings for application of different materials indicated.

* + - * 1. Surfaces in Contact with Airstream:

Comply with ASHRAE 62.1 and NFPA 90A.

Glass or mineral-fiber insulation installed behind perforated metal shall be encapsulated to prevent insulation fibers from entering the airstream by using a **[polymer sheet material] [or] [tightly woven glass cloth material that does not impact the acoustical absorption properties of insulation]**.

* + - * 1. Insulation for Casing Walls and Roofs Not Exposed to Airstream:

Many manufacturers use injected or spray foam insulation as standard casing construction for applications where insulation is not exposed to the airstream. Glass or mineral-fiber insulation is also common and regularly used for applications with insulation exposed to the airstream. See the Evaluations.

Materials Not Exposed to Airstream: **[Glass or mineral-fiber board] [injected or sprayed polyurethane foam] [or] [polyurethane foam board]** insulation with a minimum nominal density of **[2 lb/cu. ft.] [3 lb/cu. ft.] <Insert density>**.

Carefully coordinate and confirm insulation options if retaining both "R-Value" and "Thickness" subparagraphs below to ensure that insulating value can be achieved within the thickness indicated. R-values indicated are based on a conservative R-value of R-4 per inch of thickness to accommodate mineral- or glass-fiber insulation. Foam insulation R-valves are approximately R-6+ per inch of thickness.

R-Value: Minimum **[R-8] [R-10] [R-12] [R-16] <Insert value>**.

Thickness: Minimum **[2 inches] [2.5 inches] [3 inches] [4 inches] <Insert dimension>**.

Insulation shall completely fill the casing cavity so no voids exist.

* + - * 1. Insulation for Casing Walls and Roofs Exposed to Airstream:

Materials Exposed to Airstream: Glass or mineral-fiber board insulation with a minimum density of **[2 lb/cu. ft.] [3 lb/cu. ft.] [6 lb/cu. ft.] <Insert density>**.

Carefully coordinate if retaining both "R-Value" and "Thickness" subparagraphs below to ensure that insulating value can be achieved within the thickness indicated. R-values indicated are based on a conservative R-value of R-4 per inch of thickness.

R-Value: Minimum **[R-8] [R-10] [R-12] [R-16] <Insert value>**.

Thickness: Minimum **[2 inches] [2.5 inches] [3 inches] [4 inches] <Insert dimension>.**

Insulation shall completely fill the casing cavity so no voids exist.

* + - * 1. Insulation for Casing Floors:

Injected or spray foam insulation offers a rigid air-handling unit floor assembly that is less likely to deflect when walked on. It should be listed as an insulation option unless rare Project circumstances exclude use.

Materials: **[Glass or mineral-fiber board insulation] [injected or sprayed polyurethane foam] [or] [polyurethane foam board]** insulation with a minimum nominal density of **[2 lb/cu. ft.] [3 lb/cu. ft.] <Insert density>**.

Carefully coordinate and confirm insulation options if retaining both "R-Value" and "Thickness" subparagraphs below to ensure that insulating value can be achieved within the thickness indicated. R-values indicated are based on a conservative R-value of R-4 per inch (25 mm) of thickness to accommodate mineral- or glass-fiber insulation. Foam insulation R-valves are approximately R-6+ per inch of thickness.

R-Value: Minimum **[R-8] [R-10] [R-12] [R-16] <Insert value>**.

Thickness: Minimum **[2 inches] [2.5 inches] [3 inches] [4 inches] <Insert dimension>**.

Insulation shall completely fill the casing cavity so no voids exist.

* + - * 1. Access Doors:

ASHRAE 62.1, Section "Systems and Equipment," Topic "Access for Inspection, Cleaning, and Maintenance," indicates requirements for equipment access.

Application: **[Install access doors in air-handling units at locations indicated on Drawings] [Install access doors downstream and upstream of all internal components] <Insert requirement>**.

Adjustment: Design doors for field adjustment capable of maintaining specified leakage rate.

Mounting Height: Install bottom of door frame within **[2 inches] <Insert dimension>** of air-handling unit floor walking surface.**[ Where internal conditions require access doors to be mounted higher above air-handling unit floor, include permanent retractable stairs inside and outside of air-handling unit to limit stair risers to 6 inches.]**

Performance: Leakage as required to satisfy overall unit leakage performance indicated, but not more than **[1.0 cfm] <Insert leakage rate>** per door when tested at 10 inches wg.

Fabrication: Formed and reinforced, constructed of same materials and thicknesses as casing.**[ Where doors are installed in casing walls with perforated interior, install doors with solid interior.]**

Swing: Arrange doors to be opened against pressure, unless otherwise indicated on Drawings.

Frame: **[Extruded aluminum with thermal break] [galvanized steel] [or] [stainless steel]** with **[welded ]**mitered corners.

Handles:

Secure door closed using not less than two **[roller-style ]**latches with handles located at quarter points along door height.

If three latches with handles are included, install one at midpoint of door height and equally space others.

Air-handling unit manufacturer has option to use a multipoint latching mechanism that is operable from a single door handle located at midpoint of door height, but secures door to frame at top, bottom, and handle location.

Include door handles on outside and inside of door to allow operator access to open and close door from outside and inside of unit.

Field adjustable to accommodate changes to fit and gasket compression.

Durable product capable of withstanding repeated opening and closing of door while operating under design pressure without damage.

Hinges: **[Minimum of two hinges] [minimum of three hinges] [or] [full-length, concealed, stainless steel piano hinge]**.

Gasket:

Design: Specially formed with an internal air chamber specifically designed to seal on two surfaces without taking a permanent set.

Dual Gaskets: Primary and secondary gasket.

Location: Install gaskets around entire perimeter of doors or frames.

Material: EPDM, neoprene, or santoprene.

Protection: Seat gasket in a protective metal ribbed chamber integral to door or door frame to protect gasket from damage by operator incidental contact.

Service: Field replaceable.

Adhesive-backed tape-type gaskets adhered to a single flat surface are unacceptable.

Size of Door Frame Clear Opening: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.

Retain "Width" and "Height" subparagraphs below if doors are all the same size. Retain third subparagraph and delete first two subparagraphs if multiple doors sizes are required.

Width: At least **[18 inches] [24 inches] <Insert dimension>** clear inside of door frame.

Height: Full clear height of unit casing up to a maximum height of **[60 inches] [72 inches] <Insert dimension>** clear inside of door frame.

Door sizes indicated on Drawings.

Safety Latches and Stops:

Safety Latches: Install safety latch with retainers on outward swing doors that do not open against pressure to allow restricted travel for purpose of pressure relief and so that doors do not open uncontrollably due to inside pressure.

Stops: Install cushioned door stops on inward swinging doors where necessary to limit door travel that could potentially damage the door or internal components.

Retain "Tie-Backs" subparagraph below to include enhanced service feature. Consult Owner to determine if this feature is desired.

Tie-Backs: Install tie-backs with retainers on**[ outward-swinging]** access doors to hold doors in an open position during service.

Retain "Locks" subparagraph below to limit unauthorized access inside air-handling units during shipping, storage, and installation and after unit is placed into service. Locks are sometimes used to deter abuse of all types before Owner's beneficial use.

Locks: Include each access door with an integral key lock. Pad locks are unacceptable.

Incorporate key lock into door handle where feature is available.

A common key shall be used to lock and unlock access doors of **[each] [all]** air-handling unit(s).

Include **[two] <Insert value>** keys**[ for each air-handling unit]**.

Lock access doors at factory to ensure that unauthorized access is in place before air-handling unit packaging and shipment.

Retain "Windows" subparagraph below to add windows in access doors.

Windows:

Construction: Fabricate windows with frame mounted in access doors of double-glazed safety glass with an airspace between panes and interior and exterior seals.

Condensation Control: Install desiccant material in airspace between panes if necessary to prevent condensation from forming on glazing.

Clear Viewing Size: Minimum **[6 inches] [8 inches] [12 inches] <Insert dimension>**, square**[ or round]**.

Mounting Location: Center window in door width. For doors up to **[60 inches] <Insert dimension>** high, locate top of window **[6 inches] <Insert dimension>** below top of door. For taller doors, locate center of windows at optimal viewing height, approximately **[60 inches] <Insert dimension>** above floor adjacent to unit.

Application: Install windows in **[all access doors] [only access doors servicing fans]** **[only access doors servicing fans and filters] [only access doors servicing coils, dampers, heat wheels, fans, filters, and UV-C lamps] <Insert requirement>**.

Retain "Nameplates" subparagraph below to add nameplates on exterior surface of access doors. Nameplates make it easy for service personnel to more quickly find internal components.

Nameplates:

On each access door, include a nameplate defining the access to service within. Nameplates shall be included for, but not be limited to, the following:

Retain any of first 16 subparagraphs below as applicable.

Dampers.

Filters.

Gas-Phase Filters.

Cooling Coils.

Heating Coils.

Electric Heaters.

Duct Silencers.

Heat Wheels.

Fixed Plate Exchangers.

Heat Pipe Heat Exchangers.

UV-C Lamp Systems.

Supply Fans.

Exhaust Fans.

Return Fans.

Humidifiers.

Air Blenders.

<Insert items>.

Air-handling unit designation.

Where door access is to multiple components, list all components accessed. For example: Filter/Cooling Coil.

For each door that does not open against static pressure, include a warning sign stating: "DANGER: DOOR UNDER PRESSURE. DO NOT OPEN WITH FAN ON."

Lettering Size and Style: At least **[1-inch-] <Insert dimension>** high, block style.

Material: Lettering engraved in black plastic on a white plastic back. Engraving shall penetrate through black plastic so lettering reads white.

Attachment: Attach nameplates to door using high-strength bonding cement and **[stainless steel ]**screws.

Mounting Location:

Retain one of first two subparagraphs below, or both. Coordinate with "Windows" subparagraph above.

For access doors without windows, locate top of nameplate **[6 inches] <Insert dimension>** from top of door and center in door width.

For access doors with windows, locate nameplate directly **[above] [or] [below]** window frame and center in door width.

Align nameplates of all doors for uniform placement.

Retain "Access Door Gutters (and Downspouts)" paragraph below to include additional access doors with additional rain protection.

* + - * 1. Access Door Gutters**[ and Downspouts]**: Install rain gutters directly above each access door to deflect rain away from doors.

Construct gutters of same materials and finish as casing exterior.

Extend gutters beyond vertical edge of doors at least **[3 inches] <Insert dimension>**.

Retain subparagraph below to include gutters with downspouts.

Install gutter with a downspout located adjacent to access door frame. Construct downspout of **[aluminum] [or] [stainless steel]** pipe **[or] [copper tube]** of a size determined by unit manufacturer. Terminate downspout at a height below unit floor.

* + - * 1. Access Panels:

Performance: Leakage as required to satisfy overall unit leakage performance indicated.

Fabrication: Formed and reinforced panels of same material and thickness as casing.

Fasteners: Adjustable, reusable type for multiple operations without degradation due to reuse.**[ Do not use screws capable of stripping.]**

Arrangement: Panels removable from exterior side of casing.

Gasket: EPDM, neoprene, or santoprene similar to access doors, applied around entire perimeter of panels or frames.

Location and Size:

Coils**[ and Electric Heaters]**: Oversized access panel to allow removal and replacement without impacting adjacent casing.

Fans: Oversized access panel to allow removal and replacement of entire fan assembly **[including base ]**without impacting adjacent casing.

Retain "Heat Wheels and Heat Exchangers" or "Humidifiers" subparagraph below, or both, as applicable.

Heat Wheels and Heat Exchangers: Oversized access panel to allow removal and replacement of internal components without impacting adjacent casing.

Humidifiers: Oversized access panel to allow removal and replacement without impacting adjacent casing.

**<Insert component>**.

Retain "Nameplates" subparagraph below to add nameplates on exterior surface of access panels.

Nameplates:

On each access panel, include a nameplate defining the access to service within. Nameplates shall be included for, but not be limited to, the following:

Retain any of first 10 subparagraphs below as applicable.

Cooling Coils.

Heating Coils.

Electric Heaters.

Heat Wheels.

Fixed Plate Exchangers.

Heat Pipe Heat Exchangers.

Humidifiers.

Supply Fans.

Exhaust Fans.

Return Fans.

**<Insert description>.**

Retain any of "Standing-Seam Metal Roof," "Roofing Membrane," and "Liquid-Applied Roofing" paragraphs below for air-handling unit roofing. Retaining more than one paragraph gives air-handling unit manufacturer the choice. Not all options are available from all manufacturers. Consult air-handling unit manufacturers for availability of different options.

* + - * 1. Standing-Seam Metal Roof: Construct air-handling unit roof casing with standing seams designed for waterproof roofing applications.

Construct air-handling unit roof using same materials and finish as walls.

Slope roof away from primary access side of unit at not less than **[1] [2] <Insert number>** percent.

For air-handling units shipped in multiple sections, include standing-seam joiners at each split with adhesive, hardware, and cover strips for field joining by Installer.

* + - * 1. Roofing Membrane:

Cover entire roof with a roofing membrane. Extend membrane down sides of unit a sufficient distance to provide a waterproof roof assembly and secure in place with a metal flashing matching casing material and finish.

Roofing membrane shall have an elongation of at least 450 percent when tested in accordance with ASTM D412.

Roofing membrane shall not become brittle at temperatures down to minus 40 deg F.

Slope unit roof away from primary access side of unit at a slope in accordance with roofing manufacturer's written instructions, but not less than **[1] [2] <Insert number>** percent.

Application: Factory or field applied as determined by air-handling unit manufacturer; in accordance with roof manufacturer's written instructions.

Field-applied roofing to be supervised by an air-handling unit manufacturer's factory service representative.

* + - * 1. Liquid-Applied Roofing:

Cover entire roof with a liquid-applied roofing. Extend liquid-applied roofing down sides of unit a sufficient distance to provide a waterproof roof assembly and cover sides with a metal flashing matching casing material and finish.

Cured roofing shall have an elongation of at least 500 percent at 77 deg F and at least 300 percent at 0 deg F, when tested in accordance with ASTM D412.

Roofing shall not become brittle at temperatures down to minus 40 deg F.

Slope unit roof away from primary access side of unit at a slope in accordance with roofing manufacturer's written instructions, but not less than **[1] [2] <Insert number>** percent.

Application: Factory or field applied as determined by air-handling unit manufacturer; in accordance with roof manufacturer's written instructions.

Field-applied roofing to be supervised by an air-handling unit manufacturer's factory service representative.

Retain "Service Corridors" below to include an enclosed temperature-controlled indoor environment and enhanced weather protection for service.

* + - * 1. Service Corridors:

Description: Integral walk-in service corridors with **[heated] [and] [cooled] [ventilated]** temperature-controlled indoor environment for weather-protected service access to unit access doors and factory-installed **[piping] [electrical] [and] [controls]**.

Size and Arrangement: **[As indicated on Drawings] [Full length of unit by 6 feet deep] <Insert requirements>**.

Construction: Base, floor, walls, and roof to match air-handling unit.

Access Doors:

Width: Minimum **[36-inch] [42-inch] <Insert dimension>** clear inside frame opening.

For double-door applications, include door frames with removable center mullions for unrestricted access.

Electrical: Factory install and wire **[service lights with switches] [and] [receptacles]**.

Indoor Environmental Control: Factory install **[self-contained, packaged ]**HVAC equipment required to thermostatically controlled indoor environment to maintain following indoor conditions:

Minimum Temperature: **<Insert temperature>**.

Maximum Temperature: **<Insert temperature>**.

Maximum Coincident Relative Humidity: **[60] <Insert number>** percent.

Field Connections to Factory-Installed Piping, Electrical, and Controls: Arranged to make field connections to factory terminations inside of service corridor and within **<Insert distance>** of floor walking surface. Frame openings in air-handling unit floor to accommodate field connections.

Retain "Piping Enclosures" paragraph below to include weather-protected enclosure for field-installed piping.

* + - * 1. Piping Enclosures:

Description: Integral accessible enclosure(s) to house field-installed piping from below and connecting to hydronic **[and steam ]**coils**[ and steam humidifiers]**.

Size: Adequate clearance for field installation of piping, valves, accessories, and associated insulation.

Maintain at least **[6 inches] <Insert dimension>** of clearance between inside of enclosure and face of pipe insulation at most restricted point.

Construction:

Base, Walls, and Roof: Match air-handling unit.

Floor: Not required, open to below.

Access Doors:

Size for full front access to piping, valves, and accessories installed within enclosure.

Double-door applications with removable center mullions for unrestricted access.

Electrical: Factory install and wire **[service light with switch] [and] [receptacle]** for each enclosure.

* + - 1. WALL LOUVERS

Retain any of "Wall Louvers, Drainable Blade"; "Wall Louvers, Wind-Driven Rain"; and "Wall Louvers, Hurricane Rated" paragraphs below as applicable.

* + - * 1. Wall Louvers, Drainable Blade:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Greenheck Fan Corporation.

Pottorff.

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain louvers from single source from single manufacturer.

Performance:

Air Pressure Drop, Design: Less than **[0.1 inch wg] <Insert pressure drop>** at airflow indicated on Drawings.

Air Pressure Drop, Rating: Less than 0.1 inch wg at free area intake face velocity of 700 fpm.

Face Velocity: If louver size is not indicated on Drawings, size louver for **[500-fpm] <Insert value>** velocity across louver free area.

Free Area: 54 percent or more for a 48-by-48-inch representative sample.

AMCA 500-L: Beginning point of water penetration at 870 fpm.

Features:

Depth: 4 inches.

Frame: 0.080 inch thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy.

Blades: 0.080 inch thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy; stationary in horizontal position, drainable.

Stationary vertically positioned blades.

Bird Screen: 0.5-by-0.040-inch expanded flattened aluminum attached to back of louver.

Finish: Match exterior casing.

Air-Handling Unit Factory Assembly:

Install louver face flush with exterior of casing and seal to provide a weathertight installation.

Secure louver in casing and include additional bracing if required to handle loading of extreme outdoor environmental performance indicated.

Application: Factory install louvers in air-handling casing **[at locations indicated on Drawings] [for each outdoor intake] [for each outdoor intake and exhaust discharge]**.

* + - * 1. Wall Louvers, Wind-Driven Rain:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

[Greenheck Fan Corporation](http://www.specagent.com/Lookup?uid=123457148358).

Pottorff.

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain louvers from single source from single manufacturer.

Performance:

Air Pressure Drop, Design: Less than **[0.1 inch wg] <Insert pressure drop>** at airflow indicated on Drawings.

Air Pressure Drop, Rating: Less than 0.1 inch wg at free area intake face velocity of 800 fpm.

Face Velocity: If louver size is not indicated on Drawings, size louver for **[500-fpm] <Insert value>** velocity across louver free area.

Free Area: 47 percent or more for a 48-by-48-inch representative sample.

AMCA 500-L:

Wind-Driven Rain Penetration Class: Class A, with wind-driven rain penetration effectiveness of 99 percent at core velocity up to **[408 fpm] <Insert velocity>** with 50-mph wind and rainfall of 8 inches per hour.

Intake Discharge Loss Class: Class 2.

Features:

Depth: 5 inches.

Frame: 0.080 inch thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy.

Blades: 0.063 inch thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy; stationary in horizontal position, double drainable, and sight proof.

Stationary vertically positioned blades.

Bird Screen: 0.5-by-0.040-inch expanded flattened aluminum attached to back of louver.

Finish: Match exterior casing.

Air-Handling Unit Factory Assembly:

Install louver face flush with exterior of casing and seal to provide a weathertight installation.

Secure louver in casing and include additional bracing if required to handle loading of extreme outdoor environmental performance indicated.

Application: Factory install louvers in air-handling casing **[at locations indicated on Drawings] [for each outdoor intake] [for each outdoor intake and exhaust discharge]**.

* + - * 1. Wall Louvers, Hurricane Rated:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Greenheck Fan Corporation.

Pottorff.

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain louvers from single source from single manufacturer.

Certification: Miami-Dade Notice of Acceptance.

Performance:

Air Pressure Drop, Design: Less than **[0.1 inch wg] <Insert pressure drop>** at airflow indicated on Drawings.

Air Pressure Drop, Rating: Less than 0.1 inch wg at free area face velocity of 1500 fpm.

Face Velocity: If louver size is not indicated on Drawings, size louver for **[500-fpm] <Insert value>** velocity across louver free area.

Free Area: 33 percent for a 48-by-48-inch representative sample.

AMCA 500-L, Wind-Driven Rain Penetration Class: Class A, with wind-driven rain penetration effectiveness of 100 percent at core velocity up to **[960 fpm] <Insert velocity>** with 50-mph wind and rainfall of 8 inches per hour.

AMCA 540 and AMCA 550: Listed.

Wind Loading: Positive 160 psf, negative 140 psf.

Features:

Depth: 6 inches nominal.

Frame: 0.095 inch thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy.

Blades: 0.080 inch thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy; stationary in vertical position.

Bird Screen: 0.5-by-0.063-inch expanded flattened aluminum attached to back of louver in a removable frame.

Finish: Match exterior casing.

Air-Handling Unit Factory Assembly:

Install louver face flush with exterior of casing and seal to provide a weathertight installation.

Secure louver in casing and include additional bracing if required to handle loading of extreme outdoor environmental performance indicated.

Application: Factory install louvers in air-handling casing **[at locations indicated on Drawings] [for each outdoor intake] [for each outdoor intake and exhaust discharge]**.

* + - 1. INTERNAL STRUCTURAL SUPPORTS
         1. General:

Air-handling unit manufacturer shall design and assemble air-handing unit internal structural supports for attachment and support by air-handling unit structural base.

Factory install structural supports for internal support casing if required to comply with casing structural performance.

Factory install hoist beams and rails over equipment to comply with performance requirements for service.

* + - * 1. Structural Member Size and Spacing:

Size: Air-handling unit manufacturer shall select size of members and construction to do the following:

Withstand the rigors of loading, unloading, shipping and rigging without damage to air-handling unit components or misalignment of factory-assembled casing and components.

Comply with performance requirements indicated.

Spacing: Positioned as required to comply with requirements.

* + - * 1. Materials: **[Structural aluminum, ASTM B209, Alloy 6061 T6]** **[structural carbon steel, ASTM A36/A36M] [structural stainless steel, ASTM A276, Type 304L] [or] [structural stainless steel, ASTM A276, Type 316L] [as indicated on Drawings]**.

Structural Supports: **[Angle] [channel] [I or W beam shapes] [or] [tube]** shapes selected by air-handling unit manufacturer for application.

Hoist Beams for Internal Components (Spanning Full Width of Unit): I or W beam shapes.

Retain "Carbon-Steel Finish, Mill Galvanized" or "Carbon-Steel Finish" paragraph below only if retaining "Structural carbon steel, ASTM A36" option in "Materials" paragraph above.

* + - * 1. Carbon-Steel Finish, Mill Galvanized: Mill-galvanized carbon steel with weld damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.
        2. Carbon-Steel Finish: Carbon-steel bases shall be shot-blasted, cleaned, prepared, and **[painted] [or] [hot-dip galvanized]** after fabrication.
      1. FACTORY-MANUFACTURED ROOF CURBS

Retain this article for factory-manufactured curbs to be included with air-handling units by air-handling unit manufacturer.

* + - * 1. General:

Air-handling unit manufacturer shall furnish a continuous perimeter curb for **[each] [each roof-mounted] <Insert requirement>** air-handling unit.

Design curb to support operating air-handling unit from its base with attachments to withstand environmental forces. Curbs with intermediate reinforcing as required.

Frame curb for ductwork, piping, and conduit located within curb.

Fabricate curb to maintain top of curb level even where installed on sloping substrate.

Furnish top of curb to provide for field attachment of unit base to curb.

Furnish curb with a fully mitered and raised cant where required by adjacent insulation and roofing.

Include bottom of curb with attachment flange that extends beyond base of curb and is suitable for attachment to substrate.

Furnish curb with integral crickets if required by roof installation.

* + - * 1. Size:

Size curb to provide continuous support of unit base and to fit within footprint of unit perimeter base.

Retain one of two "Height" subparagraphs below.

Height: See Drawings.

Height: **[12 inches] [18 inches] <Insert dimension>** from top of curb to finished roofing surface at highest point along perimeter of curb.

* + - * 1. Materials:

Retain "Galvanized-Steel Solid Sheet" or "Stainless Steel Solid Sheet" subparagraph below, or both.

Galvanized-Steel Solid Sheet: ASTM A653; **[**G90**] <Insert coating>** coating; minimum (nominal) **[14 gauge] [12 gauge] [10 gauge] <Insert value>** thick. Treat welded areas to protect against corrosion with a zinc-rich coating.

Stainless Steel Solid Sheet: ASTM A240 or ASTM A480, **[Type 304] [Type 304L] [Type 316] [Type 316L] <Insert grade>** grade; No. **[2D] <Insert finish>** finish; minimum (nominal) **[14 gauge] [12 gauge] [10 gauge] <Insert value>** thick.

* + - * 1. Insulation:

Insulate curb to provide thermal performance equal to unit casing.

Completely encapsulate insulation within metal curb.

* + - * 1. Gaskets:

Include a continuous gasket between air-handling unit base and top of curb for an air and watertight seal.

Select gasket materials suitable for installation while complying with requirements indicated.

Furnish gasket materials with air-handling units and curbs for field installation.

Air-handling unit manufacturer to provide instruction to installer on proper installation techniques.

* + - 1. CENTRIFUGAL FAN ARRAYS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

See the Evaluations for discussion. Fan arrays are available in individually stackable units and panel-mounted units. Some fan manufacturers offer fans with electronically commutated (EC) motors.

[ebm-papst Inc](http://www.specagent.com/Lookup?uid=123457148364).

Greenheck Fan Corporation.

Lau Fan.

Loren Cook Company.

Rosenberg USA, Inc.

Twin City Fan & Blower.

ZIEHL-ABEGG Inc.

Approved equivalent.

Retain "Sourcing Option" paragraph below to give air-handling unit manufacturer the option of using its fan array products or sourcing fan arrays from a specialty fan manufacturer. Not all custom air-handling unit manufacturers build fan products. Consult custom air-handling unit manufacturers to review product availability and options.

* + - * 1. Sourcing Option: In lieu of sourcing fan array assemblies from a specialty fan manufacturer, air-handling unit manufacturer has option to furnish in-house fan array assemblies that achieve equal or better performance while complying with other requirements indicated.
        2. Operating Performance:

Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.

Add additional static pressure to fan scheduled total static pressure.

If fan motor horsepower is increased, notify Architect.

Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.

Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.

Scheduled motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.

At a minimum, fans shall have AMCA class indicated on Drawings.

Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.

If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.

AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.

Motor starting torque shall exceed fan speed-torque requirements.

Airflow Profile:

Fan arrangement within fan array shall produce a uniform airflow and velocity profile across air-handling unit air tunnel when measured **[12 inches] <Insert dimension>** upstream of fan inlet and **[48 inches] <Insert dimension>** downstream of fan inlet.

* + - * 1. Vibration Balance:

Balance options in first subparagraph below may not be available from all fan manufacturers. BV-5 is a better balance grade than BV-4 and BV-3. Most common HVAC applications default to BV-3. Some applications require better balance. Consult fan manufacturers for balance options and cost. If balance requirements for fans vary, indicate requirements on Drawings.

Each fan/motor assembly shall be factory balanced to AMCA 204, **[BV-5, Balance Quality Grade G1.0] [BV-4, Balance Quality Grade G2.5] [BV-3, Balance Quality Grade G6.3] [Balance Quality Grade indicated on Drawings] <Insert fan vibration balance requirements>** or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be **[10] [20] <Insert number>** percent of design speed.

Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.

Submit test reports as an informational submittal for Project record.

* + - * 1. Vibration Isolation: Install vibration isolation on each fan/motor assembly in the fan array, except vibration isolation may be omitted on fans/motor assemblies balanced to AMCA 204, BV-5, with a maximum residual imbalance of 0.22-in./s peak, filter in.
        2. Operation and Service Requirements:

Remaining fans in array shall continue to operate with one or multiple failed fans.

Each fan/motor assembly of fan array shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in the array.

Each fan/motor assembly shall be controlled through a variable-frequency controller, except for fans with electronically commutated (EC) motors having integral motor controls.

Retain one of two subparagraphs below, or both, to improve operating reliability. If requirements vary by air-handling unit indicate requirements on Drawings.

Include a dedicated variable-frequency controller for each fan/motor assembly in the fan array.

If fan array is served from a single variable-frequency controller, include a redundant variable-frequency controller with automatic switchover in event of primary variable-frequency controller failure.

A single mechanical, electrical, and control device failure shall not result in a fan array available capacity of less than **[33] <Insert number>** percent of air-handling unit total scheduled airflow capacity.

Fan wheel/motor assembly shall pass through the air-handling unit access door servicing fans. Entire individual fan assembly shall pass through the door to the room where air-handling unit is located.

Design and incorporate features to permit safe, rapid, and economical maintenance.

Retain "Airflow Measurement, Local Indication, and Remote Monitoring" paragraph below to include as integral part of air-handling unit.

* + - * 1. Airflow Measurement, Local Indication, and Remote Monitoring:

Each fan within fan array shall include airflow measurement indication in cfm.

Include airflow totalization of all operating fans in fan array.

Airflow measurement instrumentation shall not restrict or deflect air travel through fan and shall not impact fan air and sound performance.

Include digital display of individual fan airflow and total fan array airflow on face of fan control panel.

Include a 4- to 20-mAoutput signal for remote monitoring of total fan array airflow.

* + - * 1. Fan Array Local Control:

Include fan control panel with operator interface to control fan array locally through the fan control panel and to switch to control of fan array through a remote-control source.

Local control shall include on/off operation **[and speed adjustment ]**for entire fan array and each individual fan/motor in fan array.

* + - * 1. Fan Array Remote Control:

Include fan control panel with control interface for remote control.

Fan array on/off operation shall be remotely controlled through a single hardwired digital output signal.

Fan array speed shall be remotely controlled through a single hardwired analog (4- to 20-mA) output signal.

* + - * 1. Fan Base, Stackable Fan Units:

Mount fan/motor on **[aluminum] [galvanized-steel] [or] [powder-coated steel]** base.

Include base and vibration isolators in accordance with requirements indicated.

Weld structural members to form a rigid base.

Size and design the base construction to withstand the rigors of shipping and rigging.

Include the base with lifting lugs or holes.

* + - * 1. Fan Frame:

Construct frame of **[aluminum] [galvanized steel] [or] [powder-coated steel]**.

Reinforce and brace frame to prevent excessive deflection and pulsation.

Include stiffeners to form a rigid frame that is free of structural resonance and vibration.

* + - * 1. Fan Panel:

Construct fan panel of **[continuously welded] [aluminum] [galvanized steel] [or] [powder-coated steel]**.

Reinforce and brace fan panel to prevent excessive deflection and pulsation.

Include stiffeners to form a rigid panel that is free of structural resonance and vibration.

* + - * 1. Fan Inlet Cone:

Include a precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of fan blades.

Inlet cone shall be a smooth hyperbolic shape.

Inlet cone shall be a single piece, constructed of aluminum or powder-coated steel.

Fasten inlet cone to fan panel using bolts, nuts, and washers to provide a positive and secure attachment that can be field removable.

* + - * 1. Fan Wheel:

Fan blades shall be a true hollow airfoil shape, welded to backplate and wheel cone.

Construct blades of aluminum, reinforced for AMCA fan class.

Design blades to provide smooth airflow over all surfaces of blade.

Construct fan hubs of aluminum with integral bracing for extra strength and stiffness.

Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.

Clean surfaces of castings by blasting, pickling, or any other standard method.

Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.

Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.

Hubs shall be keyed and set screwed to motor shaft for positive attachment.

Construct wheel backplates of aluminum.

Select entire rotating assembly so first critical speed is at least **[30] <Insert number>** percent greater than fan design speed and at least **[20] <Insert number>** percent greater than maximum speed in AMCA fan class.

* + - * 1. Fan Drive:

Direct drive, arrangement 4 in accordance with AMCA 99.

Adjust wheel width and diameter to match motor speed while providing performance scheduled.

Fasten fan wheel directly to motor shaft using a key in motor shaft and setscrew.

Construct motor base and pedestal supports of **[aluminum] [galvanized steel] [or] [powder-coated steel]**.

Retain "Fan Speed Limitation" subparagraph below to restrict fan operation at speeds exceeding motor nameplate. Coordinate requirement with fan performance indicated on Drawings.

Fan Speed Limitation:

Fan speed at design conditions indicated shall not exceed speed on motor nameplate.

Do not select fans to operate at motor speeds greater than motor nameplate.

Retain "Fan Motors" or "Fan Motors, Electronically Commutated (EC)" paragraph below. EC motors are only available on fan arrays.

* + - * 1. Fan Motors: See "Fan Motors" Article for ac motors.
        2. Fan Motors, Electronically Commutated (EC):

Description: EC, variable-speed, dc, programmable brushless motor.

Features:

Integral controller/inverter operates wound stator and senses rotor position to electronically commutate the stator.

Controller shall control motor speed either through manual adjustment locally at fan array control panel or through a remote 0- to 10-V-dc control signal.

Motor Mounting: Coordinate with driven equipment; suitable for mounting with motor shaft in either horizontal or vertical position.

Performance:

Altitude: Suitable for operation at site altitude.

Electrical Characteristics: Suitable for operation with field power source. Coordinate with electrical Installer.

Energy Efficiency: Complying with governing energy codes; **[80] <Insert number>** percent or higher maintained throughout entire operating range.

Power Factor: **[0.9] <Insert value>** or higher at full load.

Service Factor: 1.0 or higher.

Speed Control: Variable, zero to 100 percent.

Synchronous speed rotation with no slip losses.

Gradual ramp-up to set point upon receiving a start signal.

Soft speed change ramps.

Able to overcome reverse rotation without impact.

Control airflow within 5 percent of set point regardless of static pressure.

Temperature: Suitable for operation in ambient temperature range encountered.

Thermal Protection:

Automatically breaks electrical power to motor when temperature exceeds a safe value.

Automatically resets and restores power when temperature returns to normal range.

Bearings: Sealed and permanently lubricated ball bearings.

Enclosure: ODP or TEFC.

Insulation: Class B or Class F.

Rotor: Permanent magnet with near zero rotor losses that operates independent of motor current.

Materials and Construction:

Enclosure and Frame: Aluminum, painted steel, or stainless steel.

End Brackets: Cast aluminum.

Shaft: Steel or stainless steel.

Motor Leads: Pin or screw terminals.

Nameplates: Manufacturer's standard.

Paint: Manufacturer's standard.

Retain "Fan Enclosure" paragraph below to add fan discharge enclosure for physical separation between operating fans without sound attenuation.

* + - * 1. Fan Enclosure:

Include each fan in fan array with integral single-wall enclosure constructed of solid **[aluminum] [galvanized-steel] [or] [powder-coated steel]** sheet.

Enclosure shall not increase fan array length beyond size indicated on Drawings.

Enclosure shall not add static pressure loss.

Enclosure shall provide a physical separation between operating adjacent fans to prevent negative performance.

Retain "Fan Sound Silencing Enclosure" paragraph below to add fan discharge sound attenuation. Consult manufacturers about expected sound attenuating performance.

* + - * 1. Fan Sound Silencing Enclosure:

Include each fan of fan array with integral sound silencer enclosure to reduce the bare fan discharge sound levels by at least **[8] [15] <Insert value>** dB through octave band frequencies from 125 to 8000 Hz.

Enclosure shall not increase the fan array length beyond size indicated on Drawings.

Silencing enclosure shall not add static pressure loss.

Double-wall construction consisting of sound absorbing insulation sandwiched between a solid metal outer skin and perforated metal inner skin.

Outer Skin Material: **[Aluminum] [Galvanized steel] [Powder-coated steel]**.

Inner Skin: Material **[Aluminum] [Galvanized steel] [Powder-coated steel]**.

Insulation Material: **[Mineral fiber] [mineral fiber wrapped in a tight woven fiberglass cloth or polymer sheet] [or] [fiberfree]**.

Enclosure shall provide a physical separation between operating adjacent fans to prevent a negative performance.

Retain "Backdraft Damper" paragraph below to include backdraft dampers on fans.

* + - * 1. Backdraft Damper:

Include each fan in the fan array with a backdraft damper at the fan **[inlet] [or] [outlet]** to prevent air circulation through a fan that is not operating.

Open backdraft damper when fan is operating and close when fan is not operating.

Design backdraft damper assembly to operate with little to no static pressure loss with fan operating throughout entire operating range from design to minimum airflow.

Add damper pressure loss shall to fan scheduled total static pressure.

If pressure loss requires a change field electrical power, air-handling unit manufacturer shall be responsible for associated cost of change.

Fasten backdraft damper assembly to fan panel or enclosure using hardware designed for easy removal by maintenance personnel.

Dampers shall not create measurable additional noise above the sound level of fan.

Dampers shall not vibrate or rattle.

Construct dampers of extruded aluminum, stainless steel, or powder-coated steel.

Retain "Blank-off Panels" paragraph below to include blank-off panels to prevent bypass airflow through individual fans that are not operating. Coordinate with "Backdraft Damper" paragraph above. Fan arrays with backdraft dampers do not require blank-off panels.

* + - * 1. Blank-off Panels:

Include **[one] [two] [10 percent of] <Insert number>** blank-off panel(s) with each air-handling unit fan array for use by operators in the field to prevent air circulation through any of the fans in fan array that are not operating.

Design blank-off panels for attachment to fan panels using easily removable and reusable hardware.

Construct blank-offs of aluminum, stainless steel, or powder-coated steel sheets, not less than **[0.07 inch] <Insert dimension>** thick.

Mount fan blank-off panels in the fan inlet access section for convenient operator access and use in the future.

Retain "Protective Screens" paragraph below to enhance operating safety. Consult Director’s Representative to determine operating protocols and need for screens.

* + - * 1. Protective Screens:

Include easily removable safety screens where fan inlet and outlet are exposed to maintenance personnel, including walk-in air-handling unit plenums.

Safety screens are not required on fan inlets and outlets with backdraft dampers.

Expanded-metal or wire screens, fastened to a flat bar perimeter frame.

Screens shall comply with OSHA requirements.

Screens and frame shall be constructed of aluminum, stainless steel, or powder-coated steel.

Fasten screens to fan using removable and reusable hardware designed for easy removal by maintenance personnel.

* + - * 1. Hardware: Hex-head, high-strength **[carbon steel with corrosion-resistant coating] [or] [300 series stainless steel]**.
        2. Nameplates:

Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.

Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.

Locate nameplates in a highly visible location on motor side of fan.

**[Engrave] [stamp] [or] [label]** the following information on nameplate:

Retain any of firsts 10 subparagraphs below.

Manufacturer, address, phone number, and website address.

Manufacturer model number.

Serial number.

Manufacturing date.

Fan size.

Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).

Design airflow.

Design static pressure.

Design fan speed.

AMCA fan class.

**<Insert requirement>**.

* + - * 1. Air-Handling Unit Factory Assembly:

Internal Access: Include each fan with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Removal and Replacement: Each fan wheel and motor shall be independently removable and replaceable through a removable access door installed in air-handling unit casing.

Stackable Fan Arrays: Construct frame work from aluminum**[, galvanized steel,] [, painted steel,]** or stainless steel.

Panel-Mounted Fan Array Supports:

Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.

Construct frame work from aluminum**[, galvanized steel,] [, painted steel,]** or stainless steel.

* + - 1. CENTRIFUGAL PLENUM FANS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Greenheck Fan Corporation.

Loren Cook Company.

New York Blower Company (The).

Twin City Fan & Blower.

Approved equivalent.

* + - * 1. Source Limitations: Obtain fans from single source from single manufacturer.
        2. Operating Performance:

Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.

Add additional static pressure to fan scheduled total static pressure.

If fan motor horsepower is increased, notify Architect.

Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.

Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.

Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.

Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.

Base fans sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.

At a minimum, fans shall have AMCA class indicated on Drawings.

Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.

If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.

AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.

Motor starting torque shall exceed fans speed-torque requirements.

* + - * 1. Vibration Balance:

Balance options in first subparagraph below may not be available from all fan manufacturers. BV-5 is a better balance grade than BV-4 and BV-3. Most common HVAC applications default to BV-3. Some applications require better balance. Consult fan manufacturers for balance options and cost. If balance requirements for fans vary, indicate requirements on Drawings.

Each fan/motor assembly shall be factory balanced to AMCA 204, **[BV-5, Balance Quality Grade G1.0] [BV-4, Balance Quality Grade G2.5] [BV-3, Balance Quality Grade G6.3] [Balance Quality Grade indicated on Drawings] <Insert fan vibration balance requirements>** or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be **[10] [20] <Insert number>** percent of design speed.

Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.

Submit test reports as an information submittal for Project record.

* + - * 1. Operation and Service Requirements:

Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.

Design and incorporate features to permit safe, rapid, and economical maintenance.

* + - * 1. Fan Base:

Mount fan, motor, and drive on a structural-steel or an aluminum base; except, where indicated on Drawings, install fan on a concrete-filled inertia base.

Include base and vibration isolators in accordance with requirements indicated.

Electrically weld the base.

Size and design the base construction to withstand the rigors of shipping and rigging.

Include the base with lifting lugs or holes.

Construct base with gusseted brackets to accommodate spring isolators indicated.

* + - * 1. Fan Panel:

Construct fan panel of aluminum or powder-coated steel.

Support fan wheel and bearings from a structural aluminum or powder-coated steel framework.

Reinforce and brace fan panel to prevent vibration and pulsation.

Include stiffeners to form a rigid panel that is free of structural resonance and vibration.

* + - * 1. Fan Inlet and Wheel Cone:

Precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of blades.

Inlet and wheel cones shall be hyperbolic.

Inlet cone shall be a single piece, constructed of aluminum or powder-coated carbon steel.

Fasten inlet cone to fan panel using bolts, nuts and washers to provide a positive and secure attachment that can be field removable.

Inlet cones that are held in place using retaining clips are unacceptable.

* + - * 1. Fan Wheel:

Fan blades shall be a true hollow airfoil shape,**[ continuously]** welded to backplate and wheel cone.

Construct blades of aluminum, reinforced for AMCA fan class and operating conditions scheduled.

Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.

Construct fan hubs of cast aluminum or cast-iron ASTM A48 Class 20A and better, with integral bracing for extra strength and stiffness.

Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.

Clean surfaces of castings by blasting, pickling, or other standard method.

Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.

Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.

Hubs shall be keyed and set screwed to shaft for positive attachment.

Construct the wheel backplates of aluminum.

Statically and dynamically balance fan wheel before fan is assembled.

Select entire rotating assembly so first critical speed is at least **[30] <Insert number>** percent greater than fan design speed and at least **[20] <Insert number>** percent greater than maximum AMCA class speed.

* + - * 1. Fan Drive:

Only direct drives are indicated. If applications require belt-drive plenums fans, copy requirements for belt drives indicated in "Housed Centrifugal Fans" Article below and revise to suit application.

Direct drive, arrangement 4 in accordance with AMCA 99 for single-width, single-inlet fans.

Adjust wheel width and diameter to match motor speed while providing performance scheduled.

Fasten fan wheel directly to motor shaft using a key and setscrew as previously specified.

Construct motor base and pedestal of aluminum or powder-coated carbon-steel plate.

Retain "Fan Speed Limitation" subparagraph below to restrict fan operation in excess of motor nameplate speed. Coordinate with performance indicated on Drawings.

Fan Speed Limitation: Fan speed at design conditions indicated shall not exceed speed on motor nameplate for direct-drive applications. Do not select fans to operate at motor speeds greater than motor nameplate.

* + - * 1. Protective Screens: Factory furnish and install protective screens on fan inlet and discharge.

**[Expanded metal] [or] [welded wire]** welded to a **[painted carbon-steel] [or] [stainless steel]** frame.

Screens shall comply with OSHA requirements.

Screens shall be constructed of **[painted carbon] [or] [stainless]** steel.

Fasten screens to fan frame for easy removal by maintenance personnel.

* + - * 1. Welding:

Use AWS- or ASME-certified welders to weld materials required by application.

Retain subparagraph below to require continuous welds. Requirement for continuous welding is not required for most fan applications and will increase fan cost. Consult fan manufacturers for additional requirements.

**[Where indicated on Drawings, ][All ]**welds shall be continuous full penetration welds.

* + - * 1. Hardware: Hex-head, high-strength **[carbon steel] [or] [300 series stainless steel]**.
        2. Nameplates:

Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.

Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.

Locate nameplates in a highly visible location on motor side of fan.

**[Engrave] [stamp] [or] [label]** the following information on nameplate:

Retain any of first 10 subparagraphs below.

Manufacturer, address, phone number, and website address.

Manufacturer model number.

Serial number.

Manufacturing date.

Fan size.

Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).

Design airflow.

Design static pressure.

Design fan speed.

AMCA fan class.

**<Insert requirement>**.

* + - * 1. Air-Handling Unit Factory Assembly:

Internal Access: Include each fan with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.

Fan Supports:

Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.

Construct frame work from aluminum**[, galvanized steel,] [, painted steel,]** or stainless steel.

* + - 1. HOUSED CENTRIFUGAL FANS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Greenheck Fan Corporation.

Loren Cook Company.

Approved equivalent.

* + - * 1. Source Limitations: Obtain fans from single source from single manufacturer.
        2. Operating Performance:

Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.

Add additional static pressure to fan scheduled total static pressure.

If fan motor horsepower is increased, notify Director’s Representative.

Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.

Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.

Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.

Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.

Base fans sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.

At a minimum, fans shall have AMCA class indicated on Drawings.

Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.

If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.

AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.

Motor starting torque shall exceed fan speed-torque requirements.

* + - * 1. Vibration Balance:

Balance options in first subparagraph below may not be available from all fan manufacturers. BV-5 is a better balance grade than BV-4 and BV-3. Most common HVAC applications default to BV-3. Some applications require better balance. Consult fan manufacturers for balance options and cost. If balance requirements for fans vary, indicate requirements on Drawings.

Each fan/motor assembly shall be factory balanced to AMCA 204, **[BV-5, Balance Quality Grade G1.0] [BV-4, Balance Quality Grade G2.5] [BV-3, Balance Quality Grade G6.3] [Balance Quality Grade indicated on Drawings] <Insert fan vibration balance requirements>** or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be **[10] [20] <Insert number>** percent of design speed.

Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.

Submit test reports as an information submittal for Project record.

* + - * 1. Operation and Service Requirements:

Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.

Design and incorporate features to permit safe, rapid, and economical maintenance.

* + - * 1. Fan Base:

Mount fan, motor, and drive assembly on an open structural base, except where Drawings indicate an inertia base.

Continuously weld base structural members constructed of **[aluminum] [carbon steel] [or] [stainless steel]**.

**[Air-handling unit] [or] [fan]** manufacturer to size and design the fan base construction to withstand the rigors of shipping and rigging.

Fabricate base with lifting lugs or holes and gusseted brackets to accommodate spring isolators indicated.

* + - * 1. Fan Housing:

Continuously weld housing constructed of **[aluminum] [carbon-steel] [or] [stainless steel]** sheets, plates, and structural shapes.

Support fan housing and shaft bearings from a rigid structural framework.

Brace fan housing to prevent vibration and pulsation with external stiffeners to form a rigid housing that is free of operating resonance.

Extend fan housing side sheets not more than **[1/2 inch] <Insert dimension>** past fan scroll.

Fan Cut-off: Designed for pressure distribution required by the application.

Fan Blast Area: At least **[80] <Insert number>** percent of fan outlet area.

Wheel Removal: Construct fan housing for fan wheel(s) removal through the inlet opening when the inlet cone is removed.

Retain "Split-Housings" subparagraph below to require split housings on large fans for enhanced access.

Split Housings: For fans with wheel diameters nominal **[49 inches] <Insert dimension>** and larger, include diagonally flanged, gasketed and bolted split housings.

Retain "Access Doors" subparagraph below to require access doors for enhanced access.

Access Doors: Quick-opening, gasketed, with heavy-duty latches.

Conform to housing contour.

Locate in 5 o'clock or 7 o'clock position about the end of the shaft and position to gain internal access.

Maximize size of square access door up to **[24 inches] <Insert dimension>**.

Retain "Drains" subparagraph below to require drains on fans capable of accumulating moisture.

Drains: **[NPS 1] <Insert pipe size>** female NPT threaded half coupling welded to lowest point of fan housing. Position the drain connection to accommodate field-installed drain piping. Include each drain coupling with a stainless steel threaded plug.

Retain "Flanged Discharge Connections" subparagraph below to require fans with flanged discharge connections.

Flanged Discharge Connections: Welded flanged discharge with a matching companion flange having evenly spaced holes for threaded hardware.

Retain "Flanged Inlet Connections" subparagraph below to require fans with flanged inlet connections.

Flanged Inlet Connections: Welded flanged inlet with a matching companion flange having evenly spaced holes for threaded hardware.

* + - * 1. Fan Inlet and Wheel Cones:

Precision-spun or die-formed, matched inlet and wheel cones with hyperbolic shape to ensure streamlined airflow into the wheel and fully load the blades for efficient aerodynamic performance.

Inlet cone shall be a single piece, constructed of **[aluminum] [carbon steel] [or] [stainless steel]**.

Fasten inlet cone to fan housing using bolts, nuts, and washers to provide a positive and secure attachment that can be removed and replaced in the field.

* + - * 1. Fan Wheel:

Fan blades with true hollow airfoil shape, continuously welded to backplate or centerplate and wheel cone(s).

Construct blades of **[aluminum] [carbon steel] [or] [stainless steel]**, reinforced for AMCA fan class.

Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.

Construct fan hubs of **[cast aluminum] [cast iron, ASTM A48 Class 20A and better] [or] [stainless steel]**, with integral bracing for extra strength and stiffness.

Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.

Clean surfaces of castings by blasting, pickling, or other standard method.

Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.

Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.

Key and setscrew hubs to shaft for positive attachment.

Construct wheel backplates or centerplates of **[aluminum] [carbon steel] [or] [stainless steel]**.

Statically and dynamically balance fan wheel before fan is assembled.

Select entire rotating assembly so first critical speed is at least **[30] <Insert number>** percent greater than fan design speed and at least **[20] <Insert number>** percent greater than maximum AMCA class speed.

Retain "Fan Shafts" paragraph below for belt-drive fan applications and for direct-drive fan applications with a drive coupling. paragraph is not required for applications where fan wheel is directly connected to motor shaft.

* + - * 1. Fan Shafts:

Fan shaft shall be one piece, solid **[carbon] [or] [stainless]** steel, accurately turned, ground, polished, and inspected.

Polish shafts at the point of bearing contact to comply with bearing manufacturer's recommended tolerances.

Inspect shafts for straightness after the keyways are cut.

Coat carbon-steel shafts with a rust-inhibitive coating.

Retain "Fan Shaft Bearings" paragraph below if retaining "Fan Shafts" paragraph above.

* + - * 1. Fan Shaft Bearings:

Fan bearings shall be foot-mounted type, bolted on a rigid welded steel framework that is integral with, or independent of, the housing.

Size bearings for L-10 life of at least **[200,000] <Insert value>** hours, a DN factor less than **[200,000] <Insert value>** and a load factor less than **[2,700,000] <Insert value>** at the maximum fan class load limit horsepower, including belt pull.

Select bearings in accordance with **[ABMA 9] [and] [or] [ABMA 11]**.

Types:

Bearings for Fans with Motor Horsepower up to **[10 HP] <Insert size>**: Single-row ball or spherical bearings, self-aligning, grease lubricated, and housed in a pillow block housing.

Bearings for Larger-Size Fans: Double-row spherical, self-aligning, grease lubricated, and housed in a horizontally split pillow block housing.

Grease Fittings:

Extend **[copper] [or] [plastic]** grease lines to an accessible location within sight of bearing for greasing the bearings without removing guards, inlet screens, linkages, and other appurtenances.

Terminate bearings and extended grease lines with grease gun fittings.

* + - * 1. Fan Drives: Fan-drive type, belt or direct, as indicated on Drawings.

Retain "Direct Drives" subparagraph below for direct-drive fan applications.

Direct Drives:

Double Width, Double Inlet: Arrangement 7 in accordance with AMCA 99.

Single Width, Single Inlet: Arrangement **[4] [or] [5]** in accordance with AMCA 99.

For AMCA arrangements 4 and 5, fasten fan wheel directly to motor shaft using a key and setscrew indicated.

Construct motor base and pedestal for AMCA arrangement 4 and 7 fans of **[aluminum] [carbon-steel] [stainless steel]** plate.

Retain "Belt Drives" subparagraph below for belt-drive fan applications.

Belt Drives:

Multiple V-Belt Design:

Size two belt drives for at least **[2.0] <Insert value>** times the fan motor horsepower.

Size belt drives with more than two belts, for at least **[1.5] <Insert value>** times the fan motor horsepower.

Coordinate, with motor manufacturer, the size and location of motor sheave required to satisfy the motor L-10 bearing life using motor manufacturer's written instructions.

Sheave and V-belt selections shall be in accordance with manufacturer's published data.

Sheaves:

Constant-Speed Applications: Fixed or variable sheaves for applications up to **[5 hp] <Insert size>** and fixed sheaves for applications with larger horsepower.

Variable-Speed Applications: Fixed sheaves.

Profile machined to Mechanical Power Transmission Association Standards.

Construct sheaves of high-strength cast iron having a minimum tensile strength of **[25,000 psi] <Insert value>**.

Sheave rim speeds shall not exceed **[5000 fpm] <Insert value>**.

Sheave side wobble and runout, and eccentricity shall be within Mechanical Power Transmission Association and Rubber Manufacturers Association (RMA) tolerances.

Balance sheaves to satisfy vibration performance requirements.

Mount sheaves on the shaft using a taperlock split and keyed bushing or an integral keyed bushing.

V-Belts:

V-belts shall be oil resistant, non-static conducting, and high quality in accordance with RMA standards.

Classic A, B, C, D, and E, non-cogged, cross sections.

Multiple belt drives shall be a matched set with belt tolerances in accordance with RMA standards.

Tension belts in accordance with manufacturer's written instructions.

Drive Guards: Furnish and factory install fan drive guard(s) for bearing assemblies, rotating shafts, sheaves, belts, couplings, and heat slingers.

Arrangement 3 fans do not require guards for bearings on the side opposite the drive.

Make provision for motor and fan rpm measurement without removing the guard.

Construct the guard of flattened expanded aluminum or steel wrapped around a channel frame, suitably braced to prevent vibration.

Paint guards using the same coating as fan, except color shall be safety yellow.

Design attachment to fan for easy removal by maintenance personnel using a clamp and latch.

Where discharge dampers are required, retain "Discharge Damper, Counterbalanced Backdraft" or "Discharge Damper, Motorized" paragraph below, or both. Energy codes may dictate the use of low-leakage motorized dampers for some applications.

* + - * 1. Discharge Damper, Counterbalanced Backdraft:

Requirements in "Performance," "Construction," "Mounting," and "Seals" subparagraphs below are based on Ruskin's "CBS8 Series."

Performance:

Velocity and Pressure Rating: Suitable for a face velocity of up to **[4000 fpm] <Insert value>** and a static pressure differential of **[8.0 inches wg] <Insert value>**.

Leakage: Not to exceed **[15 cfm/sq. ft.] <Insert value>** at a static pressure differential of **[1.0 inch wg] <Insert value>**.

Construction:

Frame: Minimum **[10-gauge-] <Insert thickness>** thick, **[galvanized-steel] [or] [stainless steel]** channel frame. Frame to extend beyond blade in open position.

Blades: Double-skin airfoil-type parallel blades, constructed of minimum **[18-gauge-] <Insert thickness>** thick, **[galvanized] [or] [stainless]** steel. Include dividers and bracing to form a rigid framework.

Axles: **[Steel] [or] [stainless steel]**; full length of blade and supported by lubricated ball bearings.

Mounting:

Mount blade axle linkage **[in] [or] [out]** of airstream.

Seals:

Blades: EPDM.

Jambs: Stainless steel, compression-type seals.

* + - * 1. Discharge Damper, Motorized: Where indicated on Drawings, furnish fans with factory-installed automatic dampers assembled complete in all respects to functions intended.

Requirements in "Performance," "Construction," "Mounting," and "Seals" subparagraphs below are based on Ruskin's "CD80AF Series."

Performance:

Velocity and Pressure Rating: Suitable for a face velocity of at least **[5000 fpm] <Insert value>** and a static pressure differential of **[8.5 inches wg] <Insert value>**.

Leakage: Not to exceed **[8 cfm/sq. ft.] <Insert value>** at a static pressure differential of **[4.0 inches wg] <Insert value>**.

Construction:

Frame: Minimum **[10-gauge-] <Insert thickness>** thick, **[galvanized-steel] [or] [stainless steel]** channel frame. Frame to extend beyond blade in open position.

Blades: Double-skin airfoil-type parallel blades, constructed of minimum **[14-gauge-] <Insert thickness> thick, [galvanized] [or] [stainless]** steel. Include dividers and bracing to form a rigid framework.

Axles: Each blade with full length axle supported by lubricated ball bearings. Include thrust bearings for dampers mounted in the vertical orientation.

Mounting:

Mount blade axle linkage out of airstream.

Mount damper to fan discharge so damper blades are perpendicular to fan shaft.

Configure linkage assembly to interface with single electric actuator.

Seals:

Blades: EPDM.

Jambs: Stainless steel, compression-type, double seals. Jamb seal shall use an outer standard width seal and a narrow inner seal for maximum compression and minimum leakage when blade is in closed position.

Damper Electric Actuator:

Furnish and factory install an electric actuator for each automated fan discharge damper.

Mount actuator on damper frame.

Construct interconnecting linkages, lever, and brackets of **[aluminum] [carbon steel] [or] [stainless steel]**. Paint interconnecting linkages, lever, and brackets to match the fan coating.

Action, either modulating or two position, as indicated on Drawings.

Fail-safe operation (open, closed, or last position) as indicated on Drawings.

Size actuators to do the following:

Shut off against fan maximum pressure on fan curve at design speed.

Operate the damper with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which damper is subjected.

Actuator to include the following:

Indicator and graduated scale on each actuator to show open and closed positions at travel limits.

Adjustable stops for both maximum and minimum positions.

Coordinate control interface requirements with external controls to comply with operation indicated.

Retain "Shaft Seals" paragraph below for exhaust applications requiring a seal to minimize leakage.

* + - * 1. Shaft Seals:

Provide single-width, single-inlet fans with shaft seal(s) where indicated on Drawings.

Shaft seal(s) shall minimize fan leakage when operating and not operating.

Construct shaft seal of an aluminum or split stainless steel plate with non-asbestos material fitted under the split metal plate and seated around the shaft.

Secure split plates to housing using threaded hex-head hardware.

Shaft seals shall be replaceable from outside the housing without disturbing the shaft or bearings.

Select shaft seal clearances and materials for operating temperature, pressure, and air quality encountered.

Shaft seals, including labyrinth, floating bushing, or close clearance annulus, are acceptable alternatives.

* + - * 1. Protective Screens: Factory furnish and install safety screens on unducted fan inlets and discharge openings.

**[Expanded metal] [or] [welded wire]** welded to a **[painted carbon-steel] [or] [stainless steel]** frame.

Screens shall comply with OSHA requirements.

Screens shall be constructed of **[painted carbon steel] [or] [stainless steel]**.

Fasten screens to fan for easy removal by maintenance personnel.

Retain "Piezometer Ring" paragraph below for airflow measurement integral to fan inlet.

* + - * 1. Piezometer Ring: Mount at fan inlet cone for airflow measurement.
        2. Welding:

Use AWS- or ASME-certified welders to weld materials required by application.

Retain subparagraph below to require continuous welds. Requirement for continuous welding is not required for most fan applications and will increase fan cost. Consult fan manufacturers for additional requirements.

**[Where indicated on Drawings, ][All ]**welds shall be continuous full-penetration welds.

* + - * 1. Hardware: Hex-head, high-strength **[carbon steel] [or] [Type 304 or Type 316 stainless steel]**.
        2. Nameplates:

Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.

Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.

Locate nameplates in a highly visible location on motor side of fan.

**[Engrave] [stamp] [or] [label]** the following information on nameplate:

Retain any of first 10 subparagraphs below.

Manufacturer, address, phone number, and website address.

Manufacturer model number.

Serial number.

Manufacturing date.

Fan size.

Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).

Design airflow.

Design static pressure.

Design fan speed.

AMCA fan class.

**<Insert requirement>**.

* + - * 1. Special Fan Construction: Where indicated on Drawings, construct individual fans with the following additional features.

Retain any of "Spark-Resistant Construction," "Heat Slinger," and "Corrosion-Resistant Coating" subparagraphs below as applicable.

Spark-Resistant Construction: Construct fans in accordance with AMCA 99 **[Type A] [Type B] [Type C]** spark-resistant construction**[ where indicated on Drawings]**.

Heat Slinger: Provide for fans handling air with temperatures exceeding **[150 deg F] <Insert temperature>**.

Cast aluminum, split-design, internally-finned rotor to create a strong circulation of air over the shaft and inboard bearing, and reduce heat conduction along the shaft to bearings.

Secure the split halves together using at least two stainless steel bolts and use a setscrew to secure the assembly to fan shaft.

Corrosion-Resistant Coating:

Baked phenolic,**[ equal to Heresite's "P-4403 Brown Baked Phenolic Coating."] <Insert manufacturer's name and product name or designation.>**

Total Dry Film Thickness: **[7] <Insert value>** mils.

Application in accordance with manufacturer's written instructions and the following:

Mist bonding pass and allow to flash off for several minutes, but not long enough to allow film to completely dry.

Not less than three crisscross multipasses maintaining a wet-appearing film.

Air dry approximately 45 to 60 minutes with ventilation before applying heat.

After air dry period has elapsed, raise temperature in recommended increments of 30 minutes until desired temperature is reached.

Bake intermediate coats at approximately half the final temperature for 10 to 20 minutes.

Final Bake: **[400 deg F] <Insert temperature>** for 1-1/2 hours.

**<Insert requirements>**.

* + - * 1. Air-Handling Unit Factory Assembly:

Internal Access: Include each fan with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.

Fan Supports:

Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.

Construct frame work from aluminum**[, galvanized steel,] [, painted steel,]** or stainless steel.

* + - 1. FAN MOTORS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Siemens Industry, Inc., Building Technologies Division.

Toshiba Corporation.

US Motors; Nidec Motor Corporation; Nidec Corporation.

Approved equivalent.

* + - * 1. Source Limitations: Obtain motors from single source from single manufacturer.
        2. Standard: Comply with NEMA MG 1 unless more stringent requirements are indicated.
        3. Description: NEMA MG 1, **[Design B] <Insert design>**, as required to comply with capacity and torque characteristics; medium-induction motor.

Performance:

Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

Efficiency: NEMA Premium Efficiency rating complying with NEMA MG 1.

Motor Horsepower: Minimum size as indicated on Drawings. Motor shall operate fan under all conditions indicated without exceeding motor nameplate and without use of motor service factor.

Inverter-Duty Rating: Comply with minimum requirements of Class F or Class H insulation, suitable for "inverter-duty" or "drive-duty" applications in accordance with NEMA MG 1. Motor operation through a variable-frequency controller shall not adversely affect the motor performance, operation, useful life, and warranty.

Service Factor: **[1.15] <Insert value>**.

Temperature Rise: **[Match] [One class lower than] <Insert requirements>** insulation rating.

* + - * 1. Enclosure Type: **[See Drawings for motor enclosure type] [ODP] [or] [TEFC]**.
        2. Shaft Grounding System:

Shaft grounding system to protect bearings from induced voltage.

Shaft grounding system shall have low drag (less than 0.05 percent of motor horsepower), and shall operate for a minimum of three years without periodic maintenance or adjustments.

Mounting: External **[or internal ]**to motor enclosure.

* + - * 1. Frame:

Frames with integrally cast feet unless other requirements of driven equipment require a different arrangement.

Frame, front and back end brackets, and front and back end bearing intercaps constructed of cast iron, ASTM A48, Class 25 or better.

* + - * 1. Rotor:

Fabricate rotor frame from die-cast aluminum, copper, or associated alloys.

Key rotors to motor shaft.

Rotating assembly shall be dynamically balanced to within limits defined in NEMA MG 1.

Motors shall have the entire rotating assembly between bearing inner caps coated with a corrosion-resistant coating.

* + - * 1. Stator:

Copper windings shall be spike resistant to withstand 1600 peak V.

Entire wound and insulated stator coated with a coating to protect against moisture and corrosion.

* + - * 1. Shaft:

Solid shaft fabricated of **[carbon] [Type 304 stainless] [Type 316 stainless] [Type 416 stainless]** steel, accurately turned, ground and polished, and inspected for accuracy.

End of shaft with drilled hole for use in field measurements.

* + - * 1. Bearings:

Grease-lubricated ball or roller bearings.

ABMA 11 L-10 motor bearing life of **[100,000] <Insert value>** hours.

Bearing Lubrication:

Factory lubricate motor bearings using a premium moisture-resistant polyurea thickened grease with rust inhibitors suitable for extreme operating temperatures encountered.

Coordinate special requirements that may impact lubrication and include appropriate lubrication.

Grease Fittings:

Equip each bearing housing with an easily accessible grease inlet.

Fit grease inlets with a grease fitting and protective fitting cap.

Equip inlets with an automatic grease relief fitting to prevent excessive greasing.

Equip each bearing housing with grease drain and threaded plug.

* + - * 1. Conduit Box:

Material same as frame.

For motor frames 365T and below, furnish conduit boxes sized with internal volumes in accordance with NEMA MG 1.

For motor frames larger than 365T, furnish conduit boxes one size larger than NEMA MG 1.

Coordinate the location and mounting of conduit box with driven equipment manufacturer.

Factory mount conduit box on motor.

* + - * 1. Grounding: NRTL-listed clamp-type grounding lug mounted in conduit box.
        2. Motor Leads:

Non-wicking type, Class F temperature rating or better and permanently numbered over entire length for identification.

Lead terminals shall be manufacturer's standard.

* + - * 1. Condensate Drains:

Motor with drain holes at the lowest point for drainage of condensate.

Each drain hole with a threaded removable plug.

Retain "TEFC Motor Fans" paragraph below for TEFC motors.

* + - * 1. TEFC Motor Fans: Corrosion-resistant construction, non-sparking, metallic or non-metallic, bi-directional, and keyed to shaft.

Motor Fan Cover: **[Steel] [Same material as frame]**.

* + - * 1. Hardware: Hex-head, high-strength, zinc-plated carbon steel or stainless steel.
        2. Lifting Eyebolts: Eyebolt threaded into frame receptacle and design to prevent moisture and other foreign material from entering motor cavity when eyebolt is removed.
        3. Nameplates:

Construct nameplates of aluminum or stainless steel and attach to motor frame with aluminum, stainless steel, or brass drive pins.

Engrave or stamp data on the nameplate.

At a minimum, include nameplate data in accordance with NEMA MG 1.**[ Also include ABMA bearing designation for the drive and opposite end bearing.]**

* + - * 1. Paint: Successfully pass **[500] [1000] [2000] <Insert value>**-hour salt spray test for corrosion in accordance with ASTM B117.
      1. VIBRATION ISOLATION
         1. General:

Provide fans inside air-handling units with base and vibration isolation indicated on Drawings.

* + - * 1. Inertia Bases:

Description: Reinforced structural base designed for concrete infill with integral bolting provisions for fan mounting.

Design and Performance:

Weight of inertia base including concrete infill a minimum of 1.5 times the operating weight of fan.

Base thickness not less than 1/12 of longest span.

Minimum base thickness is as follows:

Up to 15 HP: **[6 inches] <Insert thickness>**.

20 to 50 HP: **[8 inches] <Insert thickness>**.

60 to 75 HP: **[10 inches] <Insert thickness>**.

100 HP and Larger: **[12 inches] <Insert thickness>**.

Construction:

Base Materials: **[Structural carbon steel, ASTM A36] [structural stainless steel, ASTM A276, Type 304L] [or] [structural stainless steel, ASTM A276, Type 316L]**.

Retain "Carbon-Steel Finish, Mill Galvanized" or "Carbon-Steel Base Finish" subparagraph below only if retaining "Structural carbon steel, ASTM A36" option in "Base Materials" subparagraph above.

Carbon-Steel Finish, Mill Galvanized: Mill-galvanized carbon-steel bases with weld-damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.

Carbon-Steel Base Finish: Carbon-steel bases cleaned in accordance with SSPC SP-1, **[SSPC SP-6/NACE No. 3] [SSPC SP-10/NACE No. 5] and [painted] [or] [hot-dip galvanized]** after fabrication.

Base Structural Members:

Retain any of "Perimeter Members," "Intermediate Members (Spanning Full-Width Base)," and "Cross Members (Spanning Intermediate Members)" subparagraphs below and revise options to restrict structural shapes. Coordinate shapes selected below with material selected above. Not all shapes are available in with all materials. Channel is the most common shape used for perimeter and intermediate members. Angle is also a common shape used for cross members.

Perimeter Members: **[Channel] [I or W beam shapes] [or] [tube]**.

Intermediate Members (Spanning Full-Width Base): **[Channel] [or] [I or W beam shapes] [or] [tube]**.

Cross Members (Spanning Intermediate Members): **[Angle] [channel] [or] [tube]**.

Reinforcing Bars: Carbon steel, ASTM A615, sized for a maximum stress of 20,000 psi when subjected to both static and dynamic loads, and welded in place.

Floor: Design inertia base with solid floor in bottom for concrete placement after base installation. Seal to prevent leakage or seepage.

Retain "Galvanized-Steel Solid Sheet" or "Stainless Steel Solid Sheet" subparagraph below. Coordinate with inertia base materials.

Galvanized-Steel Solid Sheet: ASTM A653; **[G90] <Insert coating>** coating, minimum (nominal) **[18 gauge] [16 gauge] <Insert value>** thick.

Stainless Steel Solid Sheet: ASTM A240 or ASTM A480; **[Type 304] [Type 304L] [Type 316] [Type 316L] <Insert type>**; No.**[2D] [4] <Insert finish>** finish; minimum (nominal) **[18 gauge] [16 gauge] <Insert value>** thick.

Isolator Brackets: Gusseted, height-saving brackets.

Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.

Air-Handling Unit Factory Assembly: Install fans with inertia bases where indicated on Drawings.

Coordinate placement of inertia bases with design of air-handling unit structural base. Make provisions for attachment and support.

Coordinate inertia base mounting provisions with spring isolators.

* + - * 1. Spring Isolators:

Performance:

Deflection: Minimum deflection indicated on Drawings. Use a greater deflection if required to maintain an isolator efficiency of at least **[98] <Insert number>** percent under all operating conditions encountered. Calculate isolator efficiency using actual support conditions considering the rigidity of structure.

Laterally stable freestanding open-spring mounting.

Spring diameter not less than 0.8 of compressed spring height at rated load and in the installed and operating condition.

Reserve travel to solid shall be equal to a minimum of 50 percent of rated deflection and in no case less than 25 percent of rated deflection in an installed and operating condition.

Ratio of horizontal stiffness to vertical stiffness equal to approximately one.

Design and install so that ends of springs remain parallel.

Select springs that are non-resonant with equipment related frequencies and natural frequencies of support structure.

Springs shall not take a permanent set when compressed to coil bind.

Seismic restraints to limit motion under seismic forces to **[1/4 inch] <Insert dimension>**.

Construction:

Coat springs with PVC or neoprene. Color-code springs to allow positive identification after installation.

Construct baseplates, spring retainers, and other components of **[aluminum]** **[galvanized carbon steel] [or] [stainless steel]**. Etch and paint aluminum components.

Use nuts, bolts, and washers and other associated hardware constructed of **[zinc-electroplated carbon steel] [or] [stainless steel]**.

Isolators with integral leveling bolts.

Baseplates with holes and isolation grommets for bolting.

Bond nominal **[1/4-inch-] <Insert dimension>** thick, neoprene friction pad to baseplate.

* + - * 1. Thrust Restraints:

In sets of two or more, thrust restraints shall consist of springs in series with neoprene isolators.

Coordinate and select deflection of thrust restrains with equipment being restrained.

Thrust restraints complete with rods and adjustment nuts, plus angle brackets and backing plates for attachment to substrate and equipment being restrained.

* + - * 1. Elastomeric Grommets:

Elastomeric grommets shall be a combination of neoprene washer and bushing.

Elastomer shall be 56-durometer maximum.

Grommets formed to prevent bolts from directly contacting the secured item.

* + - * 1. Flexible Connections:

Construct flexible connection **[galvanized-steel] [or] [stainless steel]** edges firmly attached to waterproof and fire-retardant fabric.

Fabric shall be **[6 inches] <Insert dimension>** wide or more.

Suitable for operation in extreme temperatures encountered.

NRTL listed for application and complying with NFPA 90A.

* + - * 1. Air-Handling Unit Factory Assembly:

Use precompression -type height-saving brackets with isolators having **[2-1/2 inch] <Insert dimension>** deflection or greater, to limit exposed bolt length.

Install spring isolators plumb and adjust isolators that are not plumb under operating conditions to make plumb.

Adjust isolators to prevent stress transfer to equipment.

Verify that installed isolators and mounting systems permit equipment motion in all directions.

Restraint fans with isolated thrust resistors to limit displacement to **[1/4 inch] <Insert dimension>**. Design for the maximum lateral thrust the fan can develop.

Adjust or include additional resilient restraints to flexibly limit fan lateral motion to **[1/4 inch] <Insert dimension>**during startup and operation of equipment.

Anchor restraints to fixed supports having a stiffness greater than the thrust encountered.

Include at least **[2-inch] <Insert dimension>** operating clearance between fan bases and walking surface of air-handling unit floor. Before startup, clean out foreign matter between bases and equipment to prevent short circuit.

Flexible Connections:

Install flexible connections at connections to fans.

Install flexible connections in accordance with SMACNA standards and manufacturer's written instructions.

Make fabric joints on the flat run, not the corners, with overlap to provide an area sufficient to make a positive seal.

Apply adhesive between fabric layers.

Attach connections using screws or bolts.

Reinforce fabric if required to keep fabric from collapsing and impacting airflow into fan.

* + - 1. HYDRONIC COILS

See the Evaluations for discussion.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Aerofin.

Coilmaster Corporation.

Approved equivalent.

Retain "Sourcing Option" paragraph below to give air-handling unit manufacturer the option of using its hydronic coil products or sourcing hydronic coils from a specialty coil manufacturer. Not all custom air-handling unit manufacturers build hydronic coil products. Consult custom air-handling unit manufacturers to review product availability and options.

* + - * 1. Sourcing Option: In lieu of sourcing hydronic coils from a specialty coil manufacturer, air-handling unit manufacturer has option to furnish in-house hydronic coils that achieve equal or better performance while complying with other requirements indicated.
        2. General: Provide air-handling units with hydronic coils where indicated on Drawings.
        3. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die formed into plate fins.
        4. Design and Performance:

Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.

Air pressure drop, water pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.

Coils shall be counterflow design, air to fluid. Fluid supply shall enter air leaving side of coil and exit air entering side.

Design coils to be drainable.

Coils shall have all circuits drainable when coils are installed in horizontal position and level.

Coil supply **[and return ]**header shall be furnished with a drain connection at lowest point on header.

Design coils to be self-venting.

Supply connection near bottom of supply header.

Return connection near top of return header.

Furnish coil return **[and supply ]**header with a vent connection at highest point on header.

Coils supply and return piping connections on same end of coil.

Coils shall be rated for system operating pressures and temperatures encountered by installation, but not less than **[200 psig] [300 psig] <Insert pressure>**.

Coil selection criteria, unless otherwise indicated on Drawings, are as follows:

Face Velocity: Maximum of **[500 fpm] <Insert value>**.

Fluid Tube Velocity (at Design Flow Rate):

Maximum: **[6 fps] <Insert velocity>**.

Minimum: **[3 fps] <Insert velocity>**.

Fluid Header Velocity: Maximum of **[6 fps] <Insert velocity>**.

Fin Height: Maximum of **[48 inches] <Insert dimension>**.

Fin Spacing: Maximum of **[12 fins per inch] <Insert spacing>**.

Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.

* + - * 1. Casing and Tube Sheets:

Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch] <Insert dimension>** beyond face of fins on both entering and leaving side.

Casing and Tube Sheet Materials:

Cooling Coils: Stainless steel, ASTM A240 or ASTM A480, **[Type 304L] [or] [Type 316L]**, No. 2D finish.

Heating Coils:

Retain one of first two subparagraphs below, or both.

Stainless steel, ASTM A240 or ASTM A480, **[Type 304L] [or] [Type 316L]**, No. 2D finish.

Galvanized steel, ASTM A653, G90 coating.

Top and Bottom Casings:

Flange face minimum of **[1-1/2 inches] <Insert dimension>**; double flange edge for rigidity and ease of removal with secondary flange face minimum of **[1/2 inch] <Insert dimension>**.

Thickness:

Coils with Fin Length of up to **[72 Inches] <Insert dimension>:** Minimum of **[16 gauge] [14 gauge] [12 gauge]** thick.

Coils with Fin Length Exceeding **[72 Inches] <Insert dimension>**: Minimum of **[16 gauge] [14 gauge] [12 gauge]** thick.

End Tube Sheets:

Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.

Flange face minimum of **[1-1/2 inches] <Insert dimension>**.

Thickness: Minimum of **[16 gauge] [14 gauge] [12 gauge]** thick.

Intermediate Tube Sheets:

Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.

Space intermediate tube sheets a maximum of **[48 inches] <Insert dimension>** o.c. and locate to provide equal spacing between tube sheet across coil tube length.

Flange face minimum of **[1/2 inch] <Insert dimension>**.

Thickness: Minimum of **[16 gauge] <Insert thickness>** thick.

Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

* + - * 1. Fins:

Materials:

Retain any of "Aluminum," "Copper," and "90/10 Cupronickel" subparagraphs below. Aluminum is most common fin material for HVAC applications. Copper and cupronickel are used in applications with corrosive environments. Indicate requirements on Drawings if materials vary by application.

Aluminum: **[0.0060 inch] [0.0075 inch] [0.0095 inch] <Insert dimension>** thick.

Copper: **[0.0060 inch] [0.0075 inch] [0.0095 inch] <Insert dimension>** thick.

90/10 Cupronickel: **[0.0060 inch] [0.0075 inch] [0.0095 inch] <Insert dimension>** thick.

Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.

Fin Configuration: **[Flat face fins without ripples] [Flat face or enhanced ripple fins as required by performance]**.

* + - * 1. Headers:

Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.

Tube-to Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness, to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than 0.12 inch.

Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.

Drains: Include low point of **[supply] [supply and return]** header with a **[NPS 1/2] <Insert pipe size>** drain connection. Extend copper or **[red brass] [carbon-steel] [stainless steel] <Insert material>** pipe through air-handling unit casing and terminate end with male national pipe threads (MNPT). Pipe shall be threaded on both ends to facilitate easy field removal and replacement.

Vents: Include high point of **[return] [supply and return]** header with a **[NPS 1/2] <Insert pipe size>** vent connection. Extend copper or **[red brass] [carbon-steel] [stainless steel] <Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.

Supply and Return Connections:

Terminate ends with MNPT.

Connections to header shall be either copper tube with brazed ASME B16.18 threaded male adapters or **[red brass] [carbon-steel] [stainless steel] <Insert material>** pipe with machine-threaded MNPT connections. Pipe shall extend through air-handling unit casing and be threaded on both ends to facilitate easy field removal and replacement.

Connections **[NPS 2-1/2] <Insert pipe size>** and larger shall have a bronze ASME 16.24 threaded flanges attached to threaded connections to provide for a flanged field connection. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.

Protect openings of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into the coil.

* + - * 1. Tubes:

Material: Copper, ASTM B75 annealed temper or ASTM B280 drawn temper; **[90/10 cupronickel alloy, ASTM B122]**.

Tube Nominal Diameter: 1/2 or 5/8 inch before expanding, selected to provide performance indicated.

Available tube thickness varies by tube material and diameter. Consult coil manufacturers.

Tube Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch] [0.025 inch] [0.035 inch] <Insert dimension>** thick.

* + - * 1. Tube Return Bends: 180-degree bends brazed to tubes; material**[, wall thickness,]** and nominal diameter to match tubes.

Retain "Tube Return Bend Nominal Wall Thickness" subparagraph below if requiring a heavier wall thickness than tube. Retain option in "Tube Return Bends" paragraph above if same wall thickness is required.

Tube Return Bend Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch] [0.025 inch] [0.035 inch] <Insert dimension** thick.

* + - * 1. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.

Retain first paragraph below if corrosion-resistant coating is desired and is specified in Section 230546 "Coatings for HVAC." If retaining below, consult coil manufacturers to confirm that the coatings included in the referenced Section are available as a factory-applied coating.

* + - * 1. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.

Retain "Coatings" paragraph below if corrosion-resistant coating is desired and is specified in this Section. Indicate coating location requirements on Drawings.

* + - * 1. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:

Retain any of first four subparagraphs below. Coordinate with Drawings.

Baked phenolic.

Cathodic epoxy.

Water-based flexible epoxy polymer.

Water-based synthetic flexible polymer.

**<Insert coating type>**.

* + - * 1. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304] [or] [Type 316]** stainless steel.
        2. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:

Retain any of first 12 subparagraphs below.

Manufacturer name, address, telephone number, and website address.

Manufacturer model number.

Serial number.

Manufacturing date.

Coil identification (indicated on Drawings).

Coil fin length.

Coil fin height.

Coil weight with fluid/without fluid.

Coil casing material and thickness.

Coil fin material and thickness.

Coil tube material and thickness.

Coil header material and thickness.

**<Insert requirements>**.

* + - * 1. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
        2. Air-Handling Unit Factory Assembly:

Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches] <Insert dimension>** beyond exterior face of access panel, and seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.

Internal Access: Include each coil with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.

Supports for Coils:

Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.

Construct framework for cooling coils, from aluminum or stainless steel**[ structural shapes]**.

Construct frame work for heating coils from aluminum**[, galvanized steel,]** or stainless steel**[ structural shapes]**.

* + - 1. REFRIGERANT COILS

See the Evaluations for discussion.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Aerofin.

Coilmaster Corporation.

Approved equivalent.

* + - * 1. Source Limitations: Obtain coils from single source from single manufacturer.
        2. General: Provide air-handling units with refrigerant coils where indicated on Drawings.
        3. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die formed into plate fins. Coils shall be counterflow circuited and equipped with pressure-type distributors. Distributor tubes shall be of equal length to ensure equal distribution of refrigerant to each circuit.

Coordinate circuiting options in "Circuiting" paragraph below with DX system serving coil. If more than one option applies, indicate coil circuiting on Drawings.

* + - * 1. Circuiting: **[Face] [Row] [Interlaced] [Interlaced and face control] [Indicated on Drawings] <Insert circuiting type>**.
        2. Performance:

Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.

Air pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.

Rate coils in accordance with AHRI 410 when tested in accordance with ASHRAE 33.

Coil performance variables and selection procedures shall be in accordance with AHRI 410.

Coils piping connections on same end of coil.

Coils shall be rated for system operating flows, pressures, and temperatures encountered by installation.

Coil selection criteria, unless otherwise indicated on Drawings, are as follows:

Face Velocity: Maximum of **[500 fpm] <Insert value>**.

Fin Height: Maximum of **[48 inches] <Insert dimension>**.

Fin Spacing: Maximum of **[12 fins per inch] <Insert spacing>**.

Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.

* + - * 1. Casing and Tube Sheets:

Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch] <Insert dimension>** beyond face of fins on both entering and leaving side.

Casing and Tube Sheet Materials: Stainless steel, ASTM A240 or ASTM A480, **[Type 304L] [or] [Type 316L]**, No. 2D finish.

Top and Bottom Casings:

Flange face minimum of **[1-1/2 inches] <Insert dimension>**; double flange edge for rigidity and ease of removal with secondary flange face minimum of **[1/2 inch] <Insert dimension>**.

Thickness: Minimum of **[16 gauge] [14 gauge] [12 gauge]** thick.

End Tube Sheets:

Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.

Flange face minimum of **[1-1/2 inches] <Insert dimension>**.

Thickness: Minimum of **[16 gauge] [14 gauge] [12 gauge]** thick.

Intermediate Tube Sheets:

Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.

Space intermediate tube sheets a maximum of **[48 inches] <Insert dimension>** o.c. and locate to provide equal spacing between tube sheet across coil tube length.

Flange face minimum of **[1/2 inch] <Insert dimension>**.

Thickness: Minimum of **[16 gauge] <Insert thickness>** thick.

Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

* + - * 1. Fins:

Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.

Configuration: **[Flat face fins without ripples] [Flat face or enhanced ripple fins as required by performance]**.

Materials:

Retain any of "Aluminum," "Copper," and "90/10 Cupronickel" subparagraphs below. Aluminum is most common fin material for HVAC applications. Copper and cupronickel are used in applications with corrosive environments. Indicate requirements on Drawings if materials vary by application.

Aluminum: **[0.0060 inch] [0.0075 inch] [0.0095 inch] <Insert dimension>** thick.

Copper: **[0.0060 inch] [0.0075 inch] [0.0095 inch] <Insert dimension>** thick.

90/10 Cupronickel: **[0.0060 inch] [0.0075 inch] [0.0095 inch] <Insert dimension>** thick.

* + - * 1. Headers:

Construct header of seamless copper, ASTM B75 drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.

Tube-to Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than 0.12 inch.

Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.

Protect openings to prevent entry of dirt into the coil.

* + - * 1. Tubes:

Material: Copper, ASTM B75 annealed temper or ASTM B280 drawn temper.

Tube Nominal Diameter: Selected for performance indicated.

Available tube thickness varies by tube material and diameter. Consult coil manufacturers.

Tube Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch] [0.025 inch] [0.035 inch] <Insert dimension>** thick.

* + - * 1. Tube Return Bends: 180-degree bends brazed to tubes; material, wall thickness, and nominal diameter to match tubes.
        2. Brazing: High-temperature brazing alloy with not less than 5 percent silver.

Retain first paragraph below if corrosion-resistant coating is desired and is specified in Section 230546 "Coatings for HVAC." If retaining below, consult coil manufacturers to confirm that the coatings included in the referenced Section are available as a factory-applied coating.

* + - * 1. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.

Retain "Coatings" paragraph below if corrosion-resistant coating is desired and is specified in this Section. Indicate coating location requirements on Drawings.

* + - * 1. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:

Retain any of first four subparagraphs below. Coordinate with Drawings.

Baked phenolic.

Cathodic epoxy.

Water-based flexible epoxy polymer.

Water-based synthetic flexible polymer.

**<Insert coating type>**.

* + - * 1. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304] [or] [Type 316]** stainless steel.
        2. Nameplates: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:

Retain any of first 12 subparagraphs below.

Manufacturer name, address, telephone number, and website address.

Manufacturer model number.

Serial number.

Manufacturing date.

Coil identification (indicated on Drawings).

Coil fin length.

Coil fin height.

Coil weight.

Coil casing material and thickness.

Coil fin material and thickness.

Coil tube material and thickness.

Coil header material and thickness.

**<Insert requirements>**.

* + - * 1. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
        2. Air-Handling Unit Factory Assembly:

Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches] <Insert distance>** beyond exterior face of the access panel, and seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.

Internal Access: Provide each coil with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.

Supports for Coils:

Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.

Construct framework for cooling from aluminum or stainless steel**[ structural shapes]**.

* + - 1. STEAM COILS

See the Evaluations for discussion.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Aerofin.

Coilmaster Corporation.

Approved equivalent.

* + - * 1. Source Limitations: Obtain coils from single source from single manufacturer.
        2. General: Provide air-handling units with refrigerant coils where indicated on Drawings.
        3. Description: Plate fin coils constructed of tubes mechanically expanded into continuous collars that are die formed into plate fins and specially designed for thermal expansion and contraction of the tubes during coil operation.

Retain one of two subparagraphs below, or both. "Distributing" type coils are better suited for heating applications with low-temperature air capable of freezing. "Non-distributing" type coils are more economical and better suited for heating applications having a low risk of freezing. Indicate requirements on Drawings if type varies by application.

Distributing-type steam coils of a tube-in-tube design for uniform steam distribution along the entire length of each tube to ensure a consistent temperature rise across the full coil face and accelerate condensate removal.

Non-distributing-type steam coils of a single tube design for uniform steam distribution across the entire header and each tube.

* + - * 1. Design and Performance:

Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.

Air pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.

Design coils to be drainable.

Coils shall have all circuits drainable when coils are installed in horizontal position and level.

Coil headers shall be furnished with a drain connection at lowest point on header.

Vents: Vent connection at highest point on header.

Coils supply and return piping connections on same end of coil.

Coils shall be rated for system operating pressures and temperatures encountered by installation, but not less than **<Insert pressure>**.

Coil selection criteria, unless otherwise indicated on Drawings, are as follows:

Face Velocity: Maximum of **[500 fpm] <Insert value>**.

Fin Height: Maximum of **[48 inches] <Insert dimension>**.

Fin Spacing: Maximum of **[12 fins per inch] <Insert spacing>**.

* + - * 1. Casing and Tube Sheets:

Depth: Extend coil casing and tube sheets a minimum of **[1/2 inch] <Insert dimension>** beyond face of fins on both entering and leaving side.

Casing and Tube Sheet Materials:

Retain one of first two subparagraphs below, or both.

Stainless steel, ASTM A240 or ASTM A480, **[Type 304L] [or] [Type 316L]**, No. 2D finish.

Galvanized steel, ASTM A653, G90 coating.

Top and Bottom Casings:

Flange face minimum of **[1-1/2 inches] <Insert dimension>**; double flange edge for rigidity and ease of removal with secondary flange face minimum of **[1/2 inch] <Insert dimension>**.

Thickness:

Coils with Fin Length of up to **[72 Inches] <Insert dimension>**: Minimum of **[16 gauge] [14 gauge] [12 gauge]** thick.

Coils with Fin Length Exceeding **[72 Inches] <Insert dimension>**: Minimum of **[16 gauge] [14 gauge] [12 gauge]** thick.

End Tube Sheets:

Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.

Flange face minimum of **[1-1/2 inches] <Insert dimension>**.

Thickness: Minimum of **[16 gauge] [14 gauge] [12 gauge]** thick.

Intermediate Tube Sheets:

Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.

Space intermediate tube sheets a maximum of **[48 inches] <Insert dimension>** o.c. and locate to provide equal spacing between tube sheet across coil tube length.

Flange face minimum of **[1/2 inch] <Insert dimension>**.

Thickness: Minimum of **[16 gauge] <Insert thickness>** thick.

Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

* + - * 1. Fins:

Materials:

Retain any of "Aluminum," "Copper," and "90/10 Cupronickel" subparagraphs below. Aluminum is most common fin material for HVAC applications. Copper and cupronickel are used in applications with corrosive environments. Fin thicknesses vary by tube diameter. Coils with larger tubes are only available with heavier fins. Indicate requirements on Drawings if materials vary by application. Consult coil manufacturers for availability.

Aluminum: **[0.0060 inch] [0.0075 inch] [0.0095 inch] <Insert dimension>** thick.

Copper: **[0.0060 inch] [0.0075 inch] [0.0095 inch] <Insert dimension>** thick.

90/10 Cupronickel: **[0.0060 inch] [0.0075 inch] [0.0095 inch] <Insert dimension>** thick.

Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.

Fin Configuration: **[Flat face fins without ripples] [Flat face or enhanced ripple fins as required by performance]**.

* + - * 1. Headers:

Construct header of seamless copper, ASTM B75 drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.

Tube-to Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than 0.12 inch.

Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.

Drains: Include low point of headers with a **[NPS 1/2] <Insert pipe size>** drain connection. Extend copper or **[red brass] [carbon-steel] [stainless steel] <Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.

Vents: Include high point of headers with a **[NPS 1/2] <Insert pipe size>** vent connection. Extend copper or **[red brass] [carbon-steel] [stainless steel] <Insert material>** pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.

Supply and Return Connections:

Terminate ends with MNPT.

Connections to header shall be either copper tube with brazed ASME B16.18 threaded male adapters or **[red brass] [carbon-steel] [stainless steel] <Insert material>** pipe with machine-threaded MNPT connections. Pipe shall extend through air-handling unit casing and be threaded on both ends to facilitate easy field removal and replacement.

Connections **[NPS 2-1/2] <Insert pipe size>** and larger shall have a bronze ASME 16.24 threaded flanges attached to threaded connections to provide for a flanged field connection. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.

Protect openings of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into the coil.

* + - * 1. Tubes:

Material: Copper, ASTM B75 annealed temper or ASTM B280 drawn temper; **[90/10 cupronickel alloy, ASTM B122]**.

Tube Nominal Diameter: 5/8 or 1 inch before expanding, selected to provide performance indicated.

Available tube thickness varies by tube material and diameter. Consult coil manufacturers.

Tube Nominal Wall Thickness: As required by performance, minimum of **[0.035 inch] [0.049 inch] <Insert dimension>** thick.

* + - * 1. Tube Return Bends: 180-degree bends brazed to tubes; material**[, wall thickness,]** and nominal diameter to match tubes.

Retain "Tube Return Bend Nominal Wall Thickness" subparagraph below if requiring a heavier wall thickness than tube. Retain option in "Tube Return Bends" paragraph above if same wall thickness is required.

Tube Return Bend Nominal Wall Thickness: As required by performance, minimum of **[0.020 inch] [0.025 inch] [0.035 inch] <Insert dimension>** thick.

* + - * 1. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.

Retain first paragraph below if corrosion-resistant coating is desired and is specified in Section 230546 "Coatings for HVAC." If retaining below, consult coil manufacturers to confirm that the coatings included in the referenced Section are available as a factory-applied coating.

* + - * 1. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.

Retain "Coatings" paragraph below if corrosion-resistant coating is desired and is specified in this Section. Indicate coating location requirements on Drawings.

* + - * 1. Coatings: Where indicated on Drawings, coat coils with one of the following coatings for additional corrosion protection:

Retain any of first four subparagraphs below. Coordinate with Drawings.

Baked phenolic.

Cathodic epoxy.

Water-based flexible epoxy polymer.

Water-based synthetic flexible polymer.

**<Insert coating type>**.

* + - * 1. Hardware: Use hex-head bolts, nuts, and washers constructed of **[Type 304] [or] [Type 316]** stainless steel.
        2. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:

Retain any of first 12 subparagraphs below.

Manufacturer name, address, telephone number, and website address.

Manufacturer model number.

Serial number.

Manufacturing date.

Coil identification (indicated on Drawings).

Coil fin length.

Coil fin height.

Coil weight with fluid/without fluid.

Coil casing material and thickness.

Coil fin material and thickness.

Coil tube material and thickness.

Coil header material and thickness.

**<Insert requirements>**.

* + - * 1. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
        2. Air-Handling Unit Factory Assembly:

Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches] <Insert dimension>** beyond exterior face of the access panel as seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.

Internal Access: Include each coil with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.

Supports for Coils:

Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.

Construct frame work from aluminum**[, galvanized steel,]** or stainless steel**[ structural shapes]**.

* + - 1. HEATING COILS WITH INTEGRAL FACE-AND-BYPASS DAMPERS

See the Evaluations for discussion.

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=13582) Subject to compliance with requirements, provide products by the following:

[DRS Marlo Coil; part of DRS Technologies, Inc](http://www.specagent.com/Lookup?uid=123457148399).

Approved equivalent.

* + - * 1. Source Limitations: Obtain coils from single source from single manufacturer.
        2. General: Provide air-handling units with cheating coils with integral face-and-bypass dampers where indicated on Drawings.
        3. Description: Horizontal or vertical tube arrangement as indicated on Drawings with integral face-and-bypass dampers and controls installed to control modulating dampers to achieve discharge air temperature set point.

Each coil consisting of multiple finned heating elements, each with bypasses and interlocking dampers controlled by electric actuators and a discharge airstream thermostat.

* + - * 1. Performance:

Each coil able to maintain constant discharge air temperature regardless of variations in entering-air temperature with constant **[steam] [and] [water]** flow through coil.

Portioning of air across and around the heating element shall result in a uniform temperature within 5 deg F of average temperature when measured anywhere across a vertical plane located **[24 inches] [36 inches]** downstream of leaving face of coil.

* + - * 1. Casing: **[Galvanized steel] [or] [Type 304 stainless steel]**, minimum of 16 gauge thick. Standard casing shall be extended if required air-handling unit manufacturer to accommodate installation arrangement inside of the air-handling unit.
        2. Fins: Rectangular shape, constructed of 0.010-inch- thick aluminum with spacing not closer than 12 fins per inch
        3. Headers: **[Carbon steel] [or] [copper]**, of thickness selected by manufacturer for flow, pressure, and temperature encountered; drain connections at low points, vent connections at high points, and supply and return connections located on discharge face of coil.

Retain "Insulation" subparagraph below to require insulation on headers. Insulation reduces energy loss and improves stability of air temperatures.

Insulation: Insulate headers with mineral-fiber insulation covered by a metal jacket.

Supply and Return Connections:

Terminate ends with MNPT.

Connections **[NPS 2-1/2] <Insert pipe size>** and larger shall have thread-on flanges. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.

* + - * 1. Tubes:

Materials: **[Copper] [90/10 cupronickel] [or] [carbon steel]**.

Nominal Diameter: 5/8 inch.

Nominal Tube Wall Thickness: As required by performance, minimum of **[0.035 inch] [0.049 inch]** thick.

* + - * 1. Dampers: Clamshell design arranged to modulate airflow across or around individual heating elements. Constructed of **[galvanized steel] [or] [Type 304 stainless steel]**, minimum of 16 gauge thick.
        2. Damper Actuators: **[Face] [or side]** mounted; electric motor for proportional control, failing in last position.
        3. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.

Retain first paragraph below if corrosion-resistant coating is desired and is specified in Section 230546 "Coatings for HVAC." If retaining below, consult coil manufacturers to confirm that the coatings included in the referenced Section are available as a factory-applied coating. Retain "Coatings" paragraph below if corrosion-resistant coating is desired and is specified in this Section. Indicate coating location requirements on Drawings.

* + - * 1. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.

Retain "Coatings" paragraph below if corrosion-resistant coating is desired and is specified in this Section. Indicate coating location requirements on Drawings. The "air-dried alkyd enamel" option below is standard coating for galvanized-steel material. The "baked-epoxy" option is better suited for applications in a corrosive environment.

* + - * 1. Coating: Where indicated on Drawings, coat coil casings and damper assemblies with **[air-dried alkyd enamel] [or] [baked-epoxy]** corrosion-resistant coating.
        2. Hardware: Use hex-head bolts, nuts, and washers constructed of **[zinc-plated carbon steel] [or] [Type 304 stainless steel]**.
        3. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:

Retain any of first five subparagraphs below.

Manufacturer name, address, telephone number, and website address.

Manufacturer model number.

Serial number.

Manufacturing date.

Coil identification (indicated on Drawings).

**<Insert requirements>**.

* + - * 1. Air-Handling Unit Factory Assembly:

Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately **[4 inches] <Insert dimension>** beyond exterior face of the access panel as seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.

Internal Access: Include each coil with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.

Supports for Coils:

Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.

Construct frame work from aluminum**[, galvanized steel,]** or stainless steel**[ structural shapes]**.

* + - 1. DRAIN PANS
         1. General:

Include a drain pan for each cooling**[ and heating]** coil and at other locations indicated.

Continuously weld drain pan seams, joints, and mitered corners to make the assembled drain pan watertight.

Drain pans shall be located under the entire coil and provide full coil coverage including coil return bends and headers.

Slope drain pans in multiple directions toward low point drain connection at a uniform slope of at least **[1] [2]** percent from high point to low point.

Include stainless steel blank-offs to prevent air from bypassing around coil.

Retain "Intermediate Drain Pans" paragraph below for air-handling units with stacked coils.

* + - * 1. Intermediate Drain Pans:

Where multiple individual horizontally mounted coils are vertically stacked to make a coil bank, install intermediate drain pans under each stacked coil in the coil bank.

Material: **[Type 304L] [Type 316L] [300 series]** stainless steel ASTM A240 or ASTM A480, a minimum of **[16 gauge] <Insert value>** thick.

Minimum Depth: **[1.0 inch] [1.5 inches] <Insert dimension>**.

Retain first subparagraph below to require drain pan to extend upstream of coil. Not all manufacturers extend drain pans beyond air entering face as standard practice. Consult manufacturers.

Extend drain pan beyond air entering face of coil casing at least **[3 inches] <Insert distance>**.

Extend drain pan beyond air leaving face of coil casing at least **[6 inches] <Insert distance>**.

Where moisture eliminators are required to prevent moisture carryover, extend drain pan beyond leaving face of moisture eliminator in lieu of leaving face of coil.

Drain Pan Connection:

Stainless steel threaded coupling welded to underside of drain pan at lowest point.

Minimum Nominal Connection Size: **[NPS 1] [NPS 1.5] [NPS 2] <Insert pipe size>**.

Drain Pipe:

Air-handling unit manufacturer to connect full-size drain pipe to each drain pan connection. Option to use one of following pipe materials:

Retain any of first three subparagraphs below.

Copper tube with a bronze threaded male adapter, brazed or solder to end.

Aluminum pipe with threaded MNPT ends.

Stainless steel pipe with threaded MNPT ends.

Extend drain pipe to top of drain pan immediately below.

Include a removable stainless steel support to secure bottom of drain pipe from drain pan below to prevent lateral movement.

In applications where multiple drain pans are stacked, align stacked drains pan connections and pipes for clear vertical flow.

* + - * 1. Bottom Drain Pans:

Retain "Mounting Location, Recessed in Floor" or "Mounting Location, Above Floor" subparagraph below. "Mounting Location, Above Floor" subparagraph requires the drain pan to be located on top of the floor. Many custom air-handling unit manufacturers recess drain pans into the floor and structural base as standard practice. Consult manufacturers if retaining second subparagraph. Review height available to install a trap during design if allowing a recessed drain pan.

Mounting Location, Recessed in Floor: Air-handling unit manufacturer has option to recess bottom drain pan into the floor or install drain pan above air-handling unit floor walking surface.

Mounting Location, Above Floor: Bottom drain pan shall be installed above air-handling unit floor walking surface. Do not recess drain pan into unit base.

Retain "Grating" subparagraph below to require grating over the drain pan. Grating allows for service inside of the unit without having to step in the drain pan.

Grating: Install removable stainless steel grating on top of drain pan.

Retain "Double-Wall Construction" subparagraph below to require double-wall insulated drain pans in applications where drain pans are recessed into floor. Consult air-handling unit manufacturers to determine the need for double-wall construction.

Double-Wall Construction: Double-wall sheet with space between walls filled with **[1-inch] <Insert thickness>** insulation.

Material: **[Type 304L] [Type 316L] [300 series]** stainless steel ASTM A240/A240M or ASTM A480/A480M, a minimum of **[16 gauge] <Insert value>** thick.

Minimum Depth: **[1.5 inches] <Insert depth>**.

Retain first subparagraph below to require drain pan to extend upstream of coil. Not all manufacturers extend drain pans beyond air entering face as standard practice. Consult manufacturers.

Extend drain pan beyond air entering face of coil casing at least **[3 inches] <Insert distance>**.

Extend drain pan beyond air leaving face of coil casing at least **[12 inches] <Insert distance>**.

Where moisture eliminators are required to prevent moisture carryover, extend drain pan beyond leaving face of moisture eliminator in lieu of the leaving face of coil.

Drain Pan Connection:

Stainless steel threaded half-coupling welded to lowest point of drain pan.

Retain "See Drawings" option in "Location" subparagraph below if requirements for air-handling units vary, or if physical drain location must be indicated.

Location: **[One end] [Both ends] [See Drawings] <Insert requirement>**.

Minimum Nominal Connection Size: **[NPS 1] [NPS 1.5] [NPS 2] <Insert pipe size>**.

Drain Pipe:

Air-handling unit manufacturer to connect full size drain pipe to each drain pan connection. Option to use one of following pipe materials:

Retain any of first three subparagraphs below.

Copper tube with threaded male adapter, brazed or soldered to ends.

Aluminum pipe with threaded MNPT ends.

Stainless steel pipe with threaded MNPT ends.

Extend drain pipe and terminate **[3 inches] <Insert distance>** beyond exterior face of casing.

* + - 1. ELECTRIC HEATERS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Brasch Manufacturing Co., Inc.

INDEECO.

Approved equivalent.

* + - * 1. Source Limitations: Obtain heaters from single source from single manufacturer.
        2. General:

Provide air-handling units with electric heaters where indicated on Drawings.

NRTL listed for zero clearance to combustible surface, regardless of heater capacity.

* + - * 1. Design and Performance:

Heaters and installation shall comply with NFPA 70.

Scheduled capacity (kW) is minimum acceptable.

Air pressure drop and face velocity are maximum acceptable.

Rate heaters output capacity at voltage, phase, and hertz indicated on Drawings.

Arrange capacity control to minimize stratification.

Equally balance heater electrical load for each step across all three phases.

Retain "Part-Load Operation" subparagraph below for variable airflow applications where uninterrupted heater operation cannot be accomplished with a single heater. Consult heater manufacturers for heater operating limitations. Coordinate options below with Drawings. Series arrangements require more airway length than parallel arrangements.

Part-Load Operation: Include multiple heaters configured in a **[series] [or] [parallel]** arrangement with operation staged if required for uninterrupted heater operation over the full range of air-handling unit airflow down to the minimum airflow indicated.

Where multiple heaters positioned in a parallel arrangement are required for operation over the full range of air-handling unit airflow, include an automatic isolation damper at the **[inlet] [or] [discharge]** of inactive heaters to isolate airflow across inactive heaters while other heaters are operating.

* + - * 1. Heating Elements:

Retain "Open Elements" or "Finned Tubular Elements" subparagraph below. If more than one heater type is required, indicate the heater types on Drawings. Finned tubular heaters are more durable, but they come at a higher cost than open element heaters.

Open Elements:

Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in a frame.

Safety Screens: Install safety screens to protect operators from accidentally coming in direct connect with elements.

Finned Tubular Elements:

Coiled resistance wire of 80 percent nickel and 20 percent chromium; center-mounted and surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.

Finish finned tubular elements with a baked-on aluminum paint, and mount in a frame.

Each element individually removable from terminal box.

Use threaded stainless steel element terminals and hardware.

* + - * 1. Frame: **[Galvanized] [or] [stainless]** steel; include intermediate element support brackets equally spaced at a maximum of **[36 inches] <Insert distance>** o.c. across heater element length.

Retain "Unit or remote mounting arrangement indicated on Drawings" option in "Terminal Box/Control Panel" paragraph below where mounting arrangements vary by air-handling unit.

* + - * 1. Terminal Box/Control Panel: **[Unit mounted] [Remote mounted] [Unit or remote mounting arrangement indicated on Drawings]**; with disconnection means and overcurrent protection.

Enclosure: NEMA 250, **[Type 1] [or] [Type 12]** enclosure complying with UL 50.

Full face hinged door**[ with lock and key latching device(s)]**.

Factory insulate base of terminal box to prevent condensation from occurring within box.

Mount terminal box control panel on exterior surface of air-handling unit casing. Gasket and seal air-handling unit cabinet penetrations.

Install a laminated elementary wiring diagram on inside face of heater control panel door or in another protected location than visible be service personnel. Wiring diagram shall match installation.

* + - * 1. Controls:

Safety Controls: Each heater with following factory-mounted safety controls:

Disk-type thermal cutout switch with automatic reset.

Primary linear thermal limit cutout switch with automatic reset.

Secondary linear thermal limit cutout switch with local manual reset.

Airflow Proving Switch: Diaphragm-operated pressure differential type; with pressure range selected to ensure reliable operation throughout full range of air-handling unit airflow down to minimum airflow indicated.

Staging Control: Magnetic contactors for switching stages of heat except for air-handling units located in occupied spaces, include mercury contactors for switching stages of heat.

Retain "SCR Control" subparagraph below to require a proportional heat output for more refined temperature control. For large-capacity heaters, SCR control is included in conjunction with stage control to provide stepless operation.

SCR Control: Silicon-controlled rectifier (SCR) for 100 percent stepless capacity control.

Remote Monitoring and Control: Include control devices necessary to interface with remote-control signals including the following:

Retain any of first five subparagraphs below.

Heater on/off control.

Monitoring heater on/off status.

High-temperature alarm.

Low-airflow alarm.

Heater capacity control.

**<Insert requirements>**.

* + - * 1. Electrical:

Single-Point Field Power Connection: Install and wire the heater to accommodate a single field electrical connection for electrical power.

Disconnecting Means: Provide each heater with a main electrical power, door mounted and interlocking, and disconnecting means to prevent access into panel, unless switched in the off position.

**[Fused disconnect switch] [Nonfused disconnect switch] [Circuit breaker]** with lockable handle.

Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000] [65,000] <Insert value>** A.

Factory install and wire branch circuit fusing, or circuit breakers in accordance with NFPA 70.

Pilot Lights: Include labeled pilot lights on face of control panel for the following:

Retain any of first four subparagraphs below.

Power on.

Low-airflow alarm.

High-temperature alarm.

One for each stage on.

**<Insert requirement>**.

Terminations: Wire terminations and field interface terminations to labeled terminal strips.

Control Transformer: Size control circuit transformer for required load, plus 75 VA.

Labeling: Label each electrical device with a laminated phenolic tag.

Use only NRTL-labeled electrical components.

* + - * 1. Nameplate: Include the following data:

Retain any of first five subparagraphs below.

Manufacturer name, address, telephone number, and website address.

Manufacturer model number.

Serial number.

Manufacturing date.

Coil identification (indicated on Drawings).

**<Insert requirements>**.

* + - * 1. Air-Handling Unit Factory Assembly:

Support individual heater assemblies within unit from a structural framework constructed of **[aluminum] [galvanized steel] [or] [stainless steel]**.

Provide each heater assembly with access from **[downstream] [and] [or] [upstream]** sides.

Make provisions in arrangement and installation to mitigate uneven airflow patterns within unit for proper heater operation.

* + - 1. DIRECT-STEAM-INJECTION PANEL DISTRIBUTION MANIFOLD HUMIDIFIERS

The Section Text includes only humidifiers of the direct-steam-injection panel distribution manifold type for purposes of humidification because it is most common. If wetted element, atomizing, direct-steam-injection distributer tube, self-contained, or heat exchanger humidifiers are required for humidification and are to be part of the air-handling units, copy and revise the Section Text from the respective humidifier Sections: Section 238413.16 "Wetted Element Humidifiers," Section 238413.19 "Atomizing Humidifiers," Section 238413.23 "Direct-Steam-Injection Humidifiers," Section 238413.29 "Self-Contained Humidifiers," or Section 238413.36 "Heat Exchanger Humidifiers." See the Evaluations for discussion.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

DriSteem.

Nortec Industries Inc.

Approved equivalent.

* + - * 1. Source Limitations: Obtain humidifiers from single source from single manufacturer.
        2. Description: Prefabricated, direct-steam panel distribution manifold specially designed for steam dispersion in a short distance.

Not all manufacturers offer each configuration combination. Coordinate with manufacturers. If retaining horizontal headers, vertical tubes are applicable. If retaining vertical headers, horizontal tubes are applicable. If either configuration is acceptable, retain both and "or" option.

**[Horizontal] [or] [vertical]** header with multiple **[vertical] [or] [horizontal]**, **[nonsteam] [steam]**-jacketed tubes.

**[Nozzles/metered orifices in conjunction with nonsteam-jacketed manifolds] [or] [punched orifices/no nozzles in conjunction with steam-jacketed manifolds]** spaced evenly along manifold tubes and providing dry and uniform steam distribution.

* + - * 1. Design and Performance:

Absorption distance within **[12 inches] [18 inches] [24 inches] <Insert dimension>**.

Air Pressure Drop: Less than 0.1 inch wg at design velocity.

Suitable for pressurized steam applications.

* + - * 1. Headers and Distribution Tubes:

If specific type of stainless steel is not desired, retaining first option in "Material" subparagraph below will allow for the greatest number of manufacturers to comply. Consider Type 316 stainless steel for steam generated from deionized or reverse osmosis water. Not all manufacturers offer a Type 316 stainless steel option. Coordinate with manufacturers.

Material: **[Stainless steel] [Stainless steel, Type 304] [Stainless steel, Type 316]**.

Retain one of three options in "Insulation" subparagraph below. ASHRAE/IES 90.1-2013 requires minimum R-0.5 insulation of humidifier distribution tubes, with certain exceptions; however, most manufacturers do not publish specific R-value information for the insulation they offer. If retaining the specific R-value option, verify specific availability with manufacturers. Some manufacturers consider airspace between double tube walls to be insulation. Coordinate with manufacturers.

Insulation: **[Uninsulated] [Insulated] [Insulated, minimum R-0.5]**.

* + - * 1. Steam Separator: External separator, or separator/baffles integral to header, to provide condensate-free steam to the distribution tubes.

If specific type of stainless steel is not desired, retaining first option in "Material" subparagraph below will allow for the greatest number of manufacturers to comply. Consider Type 316 stainless steel for steam generated from deionized or reverse osmosis water. Not all manufacturers offer a Type 316 stainless steel option. Coordinate with manufacturers.

Material: **[Stainless steel] [Stainless steel, Type 304] [Stainless steel, Type 316]**.

* + - * 1. Steam Trap:

Consider Type 316 stainless steel for steam generated from deionized or reverse osmosis water. Not all manufacturers offer a Type 316 stainless steel option. If stainless steel is desired but specific type of stainless steel is not required, retaining first stainless steel option in "Material" subparagraph below will allow for the greatest number of manufacturers to comply. Coordinate with manufacturers.

Material: **[Cast iron] [Stainless steel] [Stainless steel, Type 304] [Stainless steel, Type 316]**.

If specific type of trap is not desired, retaining all three options in "Type" subparagraph below will allow for the greatest number of manufacturers to comply. Manufacturers do not offer both trap options. Coordinate with manufacturers.

Type: **[Inverted bucket] [or] [float and thermostatic]**.

Capacity: Sized for a minimum of **[3] <Insert number>** times the maximum rated condensate flow of humidifier at **[1/2-psig] <Insert value>** differential pressure.

* + - * 1. Air-Handling Unit Factory Installation:

Air-handling unit manufacturer shall furnish and install humidifiers with the size and capacities indicated on Drawings.

Extend humidifier piping through the air-handling unit casing and terminate the connections approximately **[4 inches] <Insert distance>** beyond the exterior face.

Drain Pans: Install condensate drain pans to collect and drain water to exterior of air-handling unit casing.

Provide each humidifier with access for inspection, service, and replacement.

Each humidifier shall be removable for replacement through a removable access panel in the air-handling unit casing or an access door.

Include a freestanding and self-supporting structural **[aluminum or ]**stainless steel framework to support each humidifier.

* + - 1. BAG FILTERS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Flanders Corporation.

Koch Filter Corporation.

Approved equivalent.

* + - * 1. Source Limitations: Obtain filters from single source from single manufacturer.
        2. Description: Factory-fabricated, dry, extended-surface, unsupported filters with header frames.
        3. Performance:

Retain "See Drawings" option in "Filtration Efficiency, ASHRAE 52.2 MERV Rating" subparagraph below if efficiency varies by air-handling unit.

Filtration Efficiency, ASHRAE 52.2 MERV Rating: **[11] [11A] [13] [13A] [14] [14A] [15] [15A] [See Drawings]**.

Retain "Energy Cost Index" subparagraph below to include energy cost performance rating. Only some filter manufacturers publish an energy cost index. Consult filter manufacturers for additional information.

Energy Cost Index: Five star rating.

Retain "Initial Air Pressure Drop" subparagraph below to include initial air pressure drop performance requirements, or indicate requirements on Drawings.

Initial Air Pressure Drop: With face velocity of 500 fpm, pressure drop shall not exceed the following:

Retain any of four MERV subparagraphs and any of four depth subparagraphs below.

MERV 11 and MERV 11A:

Depth 12 Inches: 0.28 inch wg.

Depth 15 Inches: 0.26 inch wg.

Depth 22 Inches: 0.24 inch wg .

Depth 30 Inches: 0.23 inch wg.

MERV 13 and MERV 13A:

Depth 12 Inches: 0.52 inch wg.

Depth 15 Inches: 0.48 inch wg.

Depth 22 Inches: 0.38 inch wg.

Depth 30 Inches: 0.34 inch wg.

MERV 14 and MERV 14A:

Depth 12 Inches: 0.67 inch wg.

Depth 15 Inches : 0.55 inch wg.

Depth 22 Inches: 0.45 inch wg.

Depth 30 Inches: 0.41 inch wg.

MERV 15 and MERV 15A:

Depth 15 Inches: 0.81 inch wg.

Depth 22 Inches: 0.62 inch wg.

Depth 30 Inches: 0.53 inch wg.

Manufacturer-Recommended Final Air Pressure Drop: **[1.0 inch wg] <Insert pressure drop>**.

Pressure Differential without Failure: **[10 inches wg] <Insert pressure drop>**.

Temperature Rating: **[158 deg F] <Insert temperature>**.

* + - * 1. Certification:

AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).

ASHRAE: Tested and rated in accordance with ASHRAE 52.2.

UL: UL 900 listed.

* + - * 1. Size:

Retain one of first two subparagraphs below.

Nominal size of individual filters indicated on Drawings:

Nominal Filter Size:

Face: **[24 by 24 inches] <Insert dimensions>**.

All options indicated in "Depth" subparagraph below may not be available for all MERV ratings. Consult filter manufacturers for availability.

Depth: **[12 inches] [15 inches] [22 inches] [30 inches] <Insert dimension>**.

Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.

* + - * 1. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal 24-by-24-inch face:

Retain any of four depth subparagraphs below.

Depth 12 Inches: 39 sq. ft..

Depth 15 Inches: 49 sq. ft..

Depth 22 Inches: 71 sq. ft..

Depth 30 Inches: 97 sq. ft..

* + - * 1. Construction:

Media: Glass-fiber material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports.**[ Coat media with an antimicrobial agent.]**

Synthetic mesh backing to provide media protection and support.

Multiple stitched pockets sealed to eliminate air bypass through stitch points.

Header: Filter face with ABS plastic or corrosion-resistant metal header designed for rigidity and to eliminate racking.

Adhesive: Fire-retardant bonding adhesive where bonding media to header.

* + - 1. CARTRIDGE FILTERS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Flanders Corporation.

Koch Filter Corporation.

Approved equivalent.

* + - * 1. Source Limitations: Obtain filters from single source from single manufacturer.
        2. Description: Factory-fabricated, dry, extended-surface, disposable, air filters with media formed in mini-pleats and arranged in a V-shape pattern.
        3. Performance:

Retain "See Drawings" option in "Filtration Efficiency, ASHRAE 52.2 MERV Rating" subparagraph below if efficiency varies by air-handling unit.

Filtration Efficiency, ASHRAE 52.2 MERV Rating: **[11] [11A] [13] [13A] [14] [14A] [16] [16A] [See Drawings]**.

Retain "Energy Cost Index" subparagraph below to include energy cost performance rating. Only some filter manufacturers publish an energy cost index. Consult filter manufacturers for additional information.

Energy Cost Index: Five star rating.

Retain "Initial Air Pressure Drop" subparagraph below to include initial air pressure drop performance requirements, or indicate requirements on Drawings.

Initial Air Pressure Drop: With face velocity of 500 fpm, clean filter pressure drop shall not exceed the following:

Retain any of four MERV subparagraphs below.

MERV 11 and MERV 11A: 0.21 inch wg.

MERV 13 and MERV 13A: 0.25 inch wg.

MERV 14 and MERV 15A: 0.27 inch wg.

MERV 16 and MERV 16A: 0.60 inch wg.

Manufacturer-Recommended Final Air Pressure Drop: **[1.5 inches wg] <Insert pressure drop>**.

Pressure Differential without Failure: **[10 inches wg] <Insert pressure drop>**.

Temperature Rating: **[175 deg. F] <Insert temperature>**.

* + - * 1. Certification:

AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).

ASHRAE: Tested and rated in accordance with ASHRAE 52.2.

UL: UL 900 listed.

* + - * 1. Size:

Retain one of first two subparagraphs below.

Nominal size of individual filters indicated on Drawings:

Nominal Filter Size:

Face: **[24 by 24 inches] <Insert dimensions>**.

Depth: 12 inches.

Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.

* + - * 1. Filter Media Surface Area: Each filter shall contain at least **[200 sq. ft. <Insert area>** for a filter with a nominal 24-by-24-inch face.
        2. Construction:

Media: Microfine glass media formed into mini-pleats and arranged in V-shape patterns.

Media Frame: Plastic or corrosion-resistant metal.

Adhesive: Fire-retardant bonding adhesive where bonding media to frame.

* + - 1. PLEATED PANEL FILTERS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=13587) Subject to compliance with requirements, provide products by one of the following:

[Flanders Corporation](http://www.specagent.com/Lookup?uid=123457148417).

[Koch Filter Corporation](http://www.specagent.com/Lookup?uid=123457148418).

Approved equivalent.

* + - * 1. Source Limitations: Obtain filters from single source from single manufacturer.
        2. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters.
        3. Performance:

Retain "See Drawings" option in "Filtration Efficiency, ASHRAE 52.2 MERV Rating" subparagraph below if efficiency varies by air-handling unit.

Filtration Efficiency, ASHRAE 52.2 MERV Rating: **[8] [8A] [9] [9A] [See Drawings]**.

Retain "Energy Cost Index" subparagraph below to include energy cost performance rating. Only some filter manufacturers publish an energy cost index. Consult filter manufacturers for additional information.

Energy Cost Index: Five star rating.

Retain "Initial Air Pressure Drop" subparagraph below to include initial air pressure drop performance requirements, or indicate requirements on Drawings.

Initial Air Pressure Drop: With face velocity of 500 fpm, clean filter pressure drop shall not exceed the following:

Retain any of two MERV subparagraphs and any of three depth subparagraphs below.

MERV 8 and MERV 8A:

Depth 1 Inch: 0.23 inch wg.

Depth 2 Inches: 0.31 inch wg.

Depth 4 Inches: 0.27 inch wg.

MERV 9 and MERV 9A:

Depth 2 Inches: 0.30 inch wg.

Depth 4 Inches: 0.27 inch wg.

Manufacturer-Recommended Final Air Pressure Drop: **[1.0 inch wg] <Insert pressure drop>**.

Pressure Differential without Failure: **[2 inches wg] <Insert pressure drop>**.

Temperature Rating: **[200 deg F] <Insert temperature>**.

* + - * 1. Certification:

AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).

ASHRAE: Tested and rated in accordance with ASHRAE 52.2.

UL: UL 900 listed.

* + - * 1. Size:

Retain one of first two subparagraphs below.

Nominal size of individual filters indicated on Drawings:

Nominal Filter Size:

Face: **[24 by 24 inches] <Insert dimensions>**.

Depth: **[1 inch] [2 inches] [4 inches]**.

Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.

* + - * 1. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal 24-by-24-inch face:

Retain any of three subparagraphs below.

Depth 1 Inch: 9.8 sq. ft..

Depth 2 Inches: 17.3 sq. ft..

Depth 4 Inches: 27.7 sq. ft..

* + - * 1. Construction:

Media: **[Glass or] [Cotton and]** synthetic blend of fibers arranged in a series of pleats attached to and supported by a corrosion-resistant welded-wire grid.**[ Coat media with an antimicrobial agent.]**

Filter Media Casing: High wet strength (28-point) beverage board that is bonded around the periphery to eliminate air bypass.

Diagonal support members across upstream and downstream filter face constructed of same material as casing shall ensure pleat spacing and stability.

Adhesive: Fire-retardant bonding adhesive where bonding media to casing.

* + - 1. ASHRAE-RATED FILTER HOLDING FRAMES
         1. Filter Holding Frames for ASHRAE-Rated Filters:

Fabricate filter holding frames with mitered corners and reinforce frame to maintain a durable, rugged, true square shape.

Construct frames of **[galvanized] [or] [stainless]** steel. Use stainless steel frames in applications exposed to corrosive airstreams.

For applications with pre-filter and final filters sharing the same filter holding frame, frames shall be suitable for supporting and holding both pre-filter and final filters in frame with both filters serviceable from upstream (entering air) side.

Frame Depth: At least **[2.75 inches] <Insert dimension>**.

Gaskets: Continuous, suitable for same operating temperature as filters.

Filter Clips: Each filter holding frame with spring clip fasteners at each corner. Spring clips shall allow filters to be removed and replaced without use of tools.

Frames shall be industry-standard size to provide interchangeability of filters from other manufacturers.

* + - * 1. Air-Handling Unit Factory Installation:

Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.

Furnish filter quantity, size, type, and performance indicated on Drawings.

Install filter frames in a flat vertical position for horizontal airflow.

Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.

Secure individual holding frames together to build a multiple filter bank.

Construct **[aluminum] [galvanized-steel] [or] [stainless steel]** support structure to hold frames and filters.

Design support structure for maximum system operating pressures encountered equal to fan shutoff pressure.

Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[200-lb] <Insert value>** lateral force applied at any point on the filter holding frame assembly.

* + - 1. ABSOLUTE FILTERS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

AAF International.

Flanders Corporation.

Approved equivalent.

* + - * 1. Source Limitations: Obtain filters from single source from single manufacturer.
        2. Description: Factory-fabricated, disposable, packaged high-efficiency particulate air filters consisting of an anodized aluminum hold frame with media formed into mini-pleats and arranged in a V-shape pattern.
        3. Performance:

Filtration Efficiency:

Retain one of first two subparagraphs below.

Rating indicated on Drawings.

IEST Rating at 0.3-micron Size: **[95] [99.99] [99.999] <Insert number>** percent.

Retain "Energy Cost Index" subparagraph below to include energy cost performance rating. Only some filter manufacturers publish an energy cost index. Consult filter manufacturers for additional information.

Energy Cost Index: Five star rating.

Retain "Initial Air Pressure Drop" subparagraph below to include initial air pressure drop performance requirements, or indicate requirements on Drawings.

Initial Air Pressure Drop: With face velocity of 500-fpm, clean filter pressure drop shall not exceed the following:

Retain "Gasket Seal Filters" or "Gel Seal Filters subparagraph below, or both.

Gasket Seal Filters:

Retain any of "95 Percent Efficiency," "99.99 Percent Efficiency," and "99.999 Percent Efficiency" subparagraphs below.

95 Percent Efficiency: 0.50 inch wg.

99.99 Percent Efficiency: 1.0 inch wg.

99.999 Percent Efficiency: 1.1 inches wg.

Gel Seal Filters:

Retain any of "95 Percent Efficiency," "99.99 Percent Efficiency," and "99.999 Percent Efficiency" subparagraphs below.

95 Percent Efficiency: 0.70 inch wg.

99.99 Percent Efficiency: 0.9 inch wg.

99.999 Percent Efficiency: 1.1 inches wg.

Manufacturer-Recommended Final Air Pressure Drop: **[2.0 inches wg] <Insert pressure drop>**.

Pressure Differential without Failure: **[10 inches wg] <Insert pressure drop>**.

Temperature Rating:

Retain "Gasket Seal" or "Gel Seal" subparagraphs below, or both.

Gasket Seal: **[175 deg F] <Insert temperature>**.

Gel Seal: **[155 deg F] <Insert temperature>**.

* + - * 1. Certification:

IEST: Tested and rated in accordance with IEST's "Recommended Practice for Testing HEPA Filters."

Comply with IEST-RP-CC001.6.

Comply with IEST-RP-CC034.

UL: UL 900 listed.

* + - * 1. Size:

Nominal Face Size: **[24 by 24 inches] [See Drawings] <Insert size>**.

Depth: 12 inches.

Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.

* + - * 1. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal 24-by-24-inch face:

Retain "Gasket Seal" or "Gel Seal" subparagraph below, or both.

Gasket Seal:

Retain any of "95 Percent Efficiency," "99.99 Percent Efficiency," and "99.999 Percent Efficiency" subparagraphs below.

95 Percent Efficiency: 390 sq. ft..

99.99 Percent Efficiency: 390 sq. ft..

99.999 Percent Efficiency: 431 sq. ft..

Gel Seal:

Retain any of "95 Percent Efficiency," "99.99 Percent Efficiency," and "99.999 Percent Efficiency" subparagraphs below.

95 Percent Efficiency: 401 sq. ft..

99.99 Percent Efficiency: 401 sq. ft..

99.999 Percent Efficiency: 401 sq. ft..

Retain "Construction for Gasket Seal Filters" paragraph below for filters with gasket seal.

* + - * 1. Construction for Gasket Seal Filters:

Media: Microfine glass media formed into mini-pleats and arranged in a V-shape pattern.

Internal Separators: **[None] <Insert type>**.

Media to Filter Frame Seal Material: **[Polyurethane] <Insert material>**.

In "Faceguard Material" subparagraph below, not all manufacturers offer each material type; consult manufacturers.

Faceguard Material: **[Aluminum] [Stainless steel] <Insert material>**.

Faceguard Location: **[None] [upstream] [and] [downstream]**.

Media-Holding Frame: Anodized aluminum enclosing frame with continuous seamless perimeter **[neoprene] <Insert gasket material>** gasket.

Filter Frame to Mounting Frame Seal Location: **[Upstream] [Downstream]**.

Adhesive: Fire-retardant bonding adhesive where bonding media to frame.

Retain "Construction for Gel Seal Filters" paragraph below for filters seal with knife edge embedded in a gel seal track.

* + - * 1. Construction for Gel Seal Filters:

Media: Microfine glass media formed into mini-pleats and arranged in a V-shape pattern.

Internal Separators: **[None] <Insert type>**.

Media to Filter Frame Seal Material: **[Polyurethane] <Insert material>**.

In "Faceguard Material" subparagraph below, not all manufacturers offer each material type; consult manufacturers.

Faceguard Material: **[Aluminum] [Stainless steel] <Insert material>**.

Faceguard Location: **[None] [upstream] [and] [downstream]**.

Media-Holding Frame: Anodized aluminum enclosing frame with gel seal track and elastic **[silicone] [urethane] <Insert material>** gel sealant.

Adhesive: Fire-retardant bonding adhesive where bonding media to frame.

* + - 1. ABSOLUTE FILTER HOLDING FRAME ASSEMBLY
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

AAF International.

Flanders Corporation.

Approved equivalent.

* + - * 1. Source Limitations: Obtain holding frame assembly from absolute filter manufacturer.
        2. Description: Holding frame assembly with access for upstream (front) or downstream (back) filter servicing as indicated, specifically designed for absolute filter banks.

Retain "Gasket Seal" or "Gel Seal" subparagraph below, or both. Coordinate with seal types retained in absolute filter holder.

Gasket Seal: Positive-sealing device to ensure seal between each gasket filter to prevent bypass of unfiltered air. Filter latching mechanism to seat each filter firmly against holding frame surface.

Gel Seal: Knife-edge to mate to each filter to prevent bypass of unfiltered air. Positive-locking mechanism for each filter to seat the knife edge into the gel during installation and to remove the filter from the knife edge during filter replacement.

* + - * 1. Construction:

Each filter bank with a factory-assembled filter holding framework consisting of a framework superstructure, a base, bracing, and removable swing bolt assemblies designed to accommodate the scheduled sizes and configuration of absolute filters.

Framework:

Nominal 4 inches, minimum 11-gauge- thick, **[galvanized-steel] [or] [stainless steel]** channels or tube.

Continuously weld members. After assembly, grind and polish welds to provide a smooth uniform sealing surface.

Base:

Continuously weld the framework to a minimum 11-gauge- thick, **[galvanized-steel] [or] [stainless steel]** base.

Filter Attachment:

Equip framework with four swing bolts for each filter.

Include each swing bolt with a bearing clamp and hex nut designed for applying a sufficiently uniform sealing pressure against the periphery of each filter.

Swing bolts shall be constructed of at least 5/16-inch **[zinc electroplated] [galvanized] [or] [stainless]** steel.

Hex nuts shall be capable of being torqued to provide at least 50 percent gasket compression.

Swing bolt assembly shall provide individual sealing of filters.

Pre-Filter Frames:

For filter banks with pre-filters attached on the air entering side of absolute filter, include an ASHRAE-rated filter holding frame.

Pre-filter holding frames shall be held in place by swing bolts and allow for installation and removal of pre-filters without disturbing absolute filter seal.

* + - * 1. Air-Handling Unit Factory Installation:

Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.

Furnish filter quantity, size, type, and performance indicated on Drawings.

Install filter frames in a flat vertical position for horizontal airflow.

Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.

Construct aluminum**[, galvanized-steel,]** or stainless steel support structure to hold frames and filters.

Design support structure for maximum system operating pressures encountered equal to fan shutoff pressure.

Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[400-lb] <Insert value>** lateral force applied at any point on the filter holding frame assembly.

* + - 1. GAS-PHASE FILTERS

See Section 234200 "Gas-Phase Air Filtration" for other gas-phase filter types if the gas-phase filter types included in this article are unsuited for the application. Copy and insert Section Text from Section 234200 "Gas-Phase Air Filtration" and revise as applicable.

Retain "Gas-Phase Panel-Style Filters" paragraph below to include panel-style gas-phase filters in air-handling units. Panel-style filters have smaller media capacity than canister-style filters and are better suited for light-duty applications.

* + - * 1. Gas-Phase Panel-Style Filters:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Flanders Corporation.

Koch Filter Corporation.

Approved equivalent.

Source Limitations: Obtain filters from single source from single manufacturer.

Description: Gas-phase panel filter for installation in a universal ASHRAE-rated filter holding frame.

Performance:

Initial Air Pressure Drop: Maximum 0.50 inch wg at a velocity of 500 fpm.

Efficiency: 60 percent ozone-removal efficiency.

Temperature: 155 deg F.

Construction:

Filters shall be plastic disposable, loose-fill sorbent[ or refillable].

Panel shall include perforated face.

Each panel shall contain at least 12 lb of sorbent.

Nominal Panel Filter Size:

Face: 24 by 24 inches.

Depth: 2 inches.

Media:

Retain any of first three subparagraphs below. If retaining more than one subparagraph, indicate media type for each application on Drawings. Consult filter manufacturers for media recommendations for specific applications.

Coconut shell activated carbon.

Activated alumina impregnated with potassium permanganate.

Blended activated carbon and alumina impregnated with potassium permanganate.

<Insert media types for specific applications>.

Pre-Installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption before installation.

Gas-Phase Panel-Style Filter Holding Frames: Use ASHRAE-rated filter holding frames.

Retain "Gas-Phase Canister-Style Filters" paragraph below to include canister-style gas-phase filters in air-handling units. Canister-style filters have more media capacity and longer service life than gas-phase panel-style filters.

* + - * 1. Gas-Phase Canister-Style Filters:

Manufacturers: Subject to compliance with requirements, provide products by the following:

[Flanders Corporation](http://www.specagent.com/Lookup?uid=123457148431).

Approved equivalent.

Source Limitations: Obtain filters from single source from single manufacturer.

Description: Factory-fabricated, dry, cylindrical canisters containing loose-fill adsorbent media.

Performance:

Initial Air Pressure Drop: 0.60 inch wg at a velocity of 500 fpm when 16 cylinders, 24 inches long are installed on frames.

Efficiency: 95 percent removal efficiency at rated airflow.

Temperature:

Retain "Plastic Construction" or "Stainless Steel Construction" subparagraph below, or both. Coordinate with canister material options.

Plastic Construction: 105 deg F.

Stainless Steel Construction: 140 deg F.

Canister Construction:

Material: **[Disposable ABS HDPE plastic] [or] [factory-refillable stainless steel]**.

Perforations around cylinder surface area for air passage through media.

Each canister shall include a mounting assembly with three integral bayonets for mounting to matching cylindrical mounting flange.

Gasket seals.

Each canister with at least 1.5 lb of sorbent per 6 inches of canister length.

Canister to mounting hardware procedure shall form a mechanical connection with a seal limiting air bypass across canister mounting assembly.

Filter Size:

Nominal Holding Frame Face: 24 by 24 inches.

Nominal Canister Diameter: 6 inches.

Nominal Canister Length: **[18 inches] [24 inches] [Length indicated on Drawings]**.

Media:

Retain any of first four subparagraphs below. If retaining more than one subparagraph, indicate media type for each application on Drawings. Consult filter manufacturers for media recommendations for specific applications.

Activated carbon.

Impregnated carbon for corrosive and acid gases.

Activated alumina impregnated with 4 percent potassium permanganate.

Blended activated carbon and activated alumina impregnated with potassium permanganate.

**<Insert media types for specific applications>**.

Pre-Installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption before installation.

Canister-Style Gas-Phase Filter Holding Frames:

Holding frames shall be 14-gauge stainless steel with cylindrical sorbent cylinder mounting perforations.

Frame shall be assembled from a single piece of metal and welded at junctures to assure a rigid and durable frame assembly.

Each frame shall hold 16 canisters.

Frame with prepunched mounting holes for cylindrical filter fastener attachment and open airflow paths.

Frame designed for front or back loading.

Frame surface shall have a flat sealing surface to ensure a secure sorbent canister mount when matched with sorbent cylinders and sealing gasket.

Cylinder to mounting hardware procedure shall form a mechanical connection forming a tight seal that minimizes air bypass.

* + - * 1. Air-Handling Unit Factory Installation:

Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.

Furnish filter quantity, size, type, and performance indicated on Drawings.

Install filter frames in a flat vertical position for horizontal airflow.

Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.

Construct stainless steel support structure to hold frames and filters.

Design support structure for weight of gas-phase filters and maximum system operating pressures encountered equal to fan shutoff pressure.

Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a **[800-lb] <Insert value>** lateral force applied at any point on the filter holding frame assembly.

* + - 1. FILTER GAUGES

retain “basis-of-design-product” paragraph below toidenty a specific product or a comparable product.

* + - * 1. Basis-of-Design Products: Subject to compliance with requirements, provide the following:

Gauge: **<Insert manufacturer's name; product name or designation>.**

Vent Valves: **<Insert manufacturer's name; product name or designation>**.

Static Pressure Sensors: **<Insert manufacturer's name; product name or designation>**.

Tubing Compression Fittings: **<Insert manufacturer and product name or designation>**.

* + - * 1. Provide a gauge to indicate pressure differential between entering and leaving side of each filter bank. Panel filter bank separate from cartridge filter bank.

Where multiple filters share a common frame, include a separate gauge for each filter bank.

Include a metal spacer constructed of same material as filter frame for one of the filters installed in filter bank to accommodate pressure differential measure across both upstream and downstream filters.

* + - * 1. Gauge shall have a nominal 4-inch- diameter face.
        2. Select range of gauge to be approximately **[twice] [three times] <Insert range>** the dirty filter pressure drop.
        3. Provide each gauge with vent valves to allow for re-zeroing the gauge without removing tubing connections.
        4. Include static pressure sensors on entering and leaving side of each filter bank.
        5. Air-Handling Unit Factory Assembly:

Mount each filter gauge on exterior surface of unit casing near associated filter sections.

Mount center of gauges **[60 inches] <Insert distance>** above bottom of air-handling unit structural base.

Connect static pressure sensors to filter gauges using **[aluminum] [copper] [or] [stainless steel]** tubing and compression type fittings.

Support tubing at intervals not greater than **[60 inches] <Insert distance>** o.c.

* + - 1. AUTOMATIC DAMPERS
         1. General: Provide air-handling units with automatic dampers where indicated on Drawings.

Unless otherwise indicated, use parallel-blade configuration for two-position control, for equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.

Factory assemble multiple damper sections to provide a single damper assembly of size required by application.

Retain subparagraph below for single-source responsibility.

Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.

* + - * 1. Rectangular Dampers with Aluminum Blades:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Greenheck Fan Corporation.

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain dampers from single source from single manufacturer.

Requirements in "Performance" and "Construction" subparagraphs below are based on Ruskin's "CD50 Series."

ASHRAE/IES 90.1 limits maximum damper leakage based on climate zone, number of stories, damper function (intake, exhaust/relief), and damper type (motorized, non-motorized). The most restrictive (across all climate zones, number of stories, damper function, and damper type) is 4 cfm/sq. ft. (20 L/s per sq. m) at 1 inch wg (250 Pa).

Performance:

Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, figure 5.3.

Velocity: Up to **[4000 fpm] [6000 fpm]**.

Temperature: Minus 40 to plus 185 deg F.

Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

Damper shall have AMCA seal for both air leakage and air performance.

Construction:

Frame:

Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.

Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of 1 inch.

Width not less than 5 inches.

Blades:

Hollow, airfoil, extruded aluminum.

Parallel- or opposed-blade configuration as required by application.

Material: ASTM B211, Alloy 6063 T5 aluminum, 0.07 inch thick.

Width not to exceed 6 inches.

Length as required by close-off pressure, not to exceed 48 inches .

Seals:

Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.

Retaining option in "Jambs" subparagraph below is less restrictive. Not all listed manufacturers offer stainless steel compression-type jamb seals. TAMCO uses extruded silicone seals.

Jambs: Stainless steel, compression type**[; or replaceable, mechanically attached extruded silicone]**.

Axles: 0.5-inch- diameter **[plated] [or] [stainless]** steel, mechanically attached to blades.

Bearings:

Molded synthetic or stainless steel sleeve mounted in frame.

Where blade axles are installed in vertical position, include thrust bearings.

Linkage:

Concealed in frame.

Constructed of aluminum and **[plated] [or] [stainless]** steel.

Hardware: Stainless steel.

Retain "Additional Corrosion Protection for Corrosive Environments" subparagraph below for applications requiring additional protection against corrosion.

Additional Corrosion Protection for Corrosive Environments:

Include anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.

Axles, damper linkage, and hardware shall be constructed of Type 316L grade stainless steel.

Retain "Airflow Measurement" subparagraph below for damper applications with integral airflow measurement.

Airflow Measurement: Where indicated, include damper assembly with integral airflow monitoring.

Manufacturers: Subject to compliance with requirements, provide products by the following:

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain damper applications from single source from single manufacturer.

Requirements in first six subparagraphs below are based on Ruskin's "AMS50 Series."

Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.

Accuracy shall be within 5 percent of actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure damper sections and flow measurement assembly as required to comply with stated accuracy over the entire modulating range.

Include a straightening device as part of flow measurement assembly to achieve the specified accuracy with configuration indicated.

Suitable for operation in untreated and unfiltered air.

Include temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.

Include automatic zeroing feature.

Retain "Airflow Control" subparagraph below for damper applications with integral airflow control.

Airflow Control: Where indicated, provide damper assembly with integral airflow measurement and control.

Manufacturers: Subject to compliance with requirements, provide products by the following:

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain damper assembly from single source from single manufacturer.

Requirements in nine subparagraphs below are based on Ruskin's "IAQ50X Series."

A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.

Controller and actuator shall communicate to control the desired airflow.

Controller shall receive a 0- to 10-V dc input signal and report a 0- to 20-mA output signal that is proportional to airflow.

Airflow measurement and control range shall be suitable for operation between 150 to 2000 fpm.

Ambient Operating Temperature Range: Minus 40 to plus 140 deg F.

Ambient Operating Humidity Range: 5 to 95 percent relative humidity, noncondensing.

Provide unit with control transformer rated for not less than 85 VA. Include transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.

Include screw terminals for interface to field wiring.

Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.

Retain "Rectangular Dampers with Insulated Aluminum Blades" paragraph below to include insulated blade dampers in applications where dampers close to outdoors.

* + - * 1. Rectangular Dampers with Insulated Aluminum Blades:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Greenheck Fan Corporation.

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain dampers from single source from single manufacturer.

General: Unless otherwise indicated on Drawings, install insulated aluminum blade dampers in applications where dampers close to outdoors.

Requirements in "Performance" and "Construction" subparagraphs below are based on TAMCO's "9000ECT Series." Other manufacturer's products listed are comparable but with slight differences. Consult listed manufacturers to determine and confirm strict compliance with requirements.

Performance:

Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure and shall not exceed 4.9 cfm/sq. ft. against 4-inch wg differential static pressure at minus 40 deg F.

Pressure Drop: 0.1 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, figure 5.3.

Velocity: Up to 4000 fpm.

Temperature: Minus 100 to plus 185 deg F.

Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

Damper shall have AMCA seal for both air leakage and air performance.

Construction:

Frame:

Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.08 inch thick.

C-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.

Width not less than 4 inches.

Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.

Damper frame shall be insulated with polystyrofoam on four sides.

Blades:

Hollow shaped, extruded aluminum.

Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.

Parallel- or opposed-blade configuration as required by application.

Material: ASTM B211, Alloy 6063 T5 aluminum, 0.08 inch thick.

Width not to exceed 6 inches.

Length as required by close-off pressure, not to exceed 48 inches.

Retaining option in "Seals" subparagraph below is less restrictive. Not all listed manufacturers offer silicon seals. Ruskin, for example, uses stainless steel compression-type frame seals.

Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions.**[ Option to use stainless steel compression-type frame seals.]**.

Axles: 0.44-inch- diameter **[plated] [or] [stainless]** steel, mechanically attached to blades.

Bearings:

Bearings shall be composed of a celcon inner bearing fixed to axle, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

Where blade axles are installed in vertical position, include thrust bearings.

Linkage:

Concealed in frame.

Constructed of aluminum and **[plated] [or] [stainless]** steel.

Hardware: Stainless steel.

Retain "Additional Corrosion Protection for Corrosive Environments" subparagraph below for applications requiring additional protection against corrosion.

Additional Corrosion Protection for Corrosive Environments:

Include anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.

Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

Retain "Industrial-Duty Rectangular Dampers with Steel Airfoil Blades" paragraph below to include galvanized steel or stainless steel airfoil blade dampers in applications where aluminum blade dampers cannot satisfy the requirements. Retain stainless steel for better resistance to corrosion.

* + - * 1. Industrial-Duty Rectangular Dampers with Steel Airfoil Blades:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Greenheck Fan Corporation.

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain dampers from single source from single manufacturer.

Requirements in "Performance" and "Construction" subparagraphs below are based on Ruskin's "CD30AF Series."

Performance:

Leakage: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

Pressure Drop: 0.06 inch wg at 2000 fpm across a 48-by-48-inch damper when tested in accordance with AMCA 500-D, figure 5.3.

Velocity: Up to 4000 fpm.

Temperature: Minus 40 to plus 250 deg F.

Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, minimum 10 inches wg.

Construction:

Frame:

Material: **[Galvanized steel] [Type 304 stainless steel] [or] [Type 316L stainless steel]**, minimum 0.11 inch thick.

C-shaped channel with mating face minimum of 1 inch.

First option in first subparagraph below is standard offering. Second option provides additional protection to blades.

Width not less than **[3 inches] [blade width plus 2 inches]**.

Blades: Hollow, airfoil shape; constructed of **[galvanized steel] [Type 304 stainless steel] [Type 316L stainless steel]**, minimum 0.06 inch thick.

Second option in first subparagraph below is standard offering.

Width not to exceed **[6 inches] [8 inches]**.

Length not to exceed **[36 inches] [48 inches] [60 inches]**.

Seals:

Blades: Replaceable, mechanically attached EPDM or extruded silicone.

Jambs: Stainless steel, double compression type.

Axles: 0.5- or 0.75-inch- diameter **[plated] [Type 304 stainless] [or] [Type 316 stainless]** steel, mechanically attached to blades**[ and continuous from end to end]**.

Bearings:

Stainless steel sleeve type mounted in frame.

Where blade axles are installed in vertical position, provide thrust bearings.

Linkage:

Face linkage exposed to airstream.

Constructed of **[plated steel] [Type 304 stainless steel] [or] [Type 316 stainless steel]**.

Hardware: **[Type 304] [or] [Type 316]** stainless steel.

* + - * 1. Damper Actuators:

General:

Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which damper is subjected.

Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

Total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

Include one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

Avoid use of excessively oversized actuators, which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

Include mounting hardware and linkages for connecting actuator to damper.

Select actuators to fail in desired position in the event of a power failure.

In "Actuator Fail Positions" subparagraph below, retain "See Drawings." option if requirements vary.

Actuator Fail Positions: **[See Drawings.] [As indicated below:]**

Retain second option in "Actuator Fail Positions" subparagraph above with any of "Exhaust Air," "Outdoor Air," "Supply Air," and "Return Air" subparagraphs below if requirements are common.

Exhaust Air: **[Close] [Last position] [Open]**.

Outdoor Air: **[Close] [Last position] [Open]**.

Supply Air: **[Close] [Last position] [Open]**.

Return Air: **[Close] [Last position] [Open]**.

**<Insert system and fail position>**.

Type: Motor operated, with or without gears, electric and electronic.

Voltage:

**[See Drawings] [Voltage selection is delegated to professional designing control system] [24 V] [120 V] <Insert requirement>**.

Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

Construction:

Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.

100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.

Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

Field Adjustment:

Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.

Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when actuator is not powered.

Two-Position Actuators: Single direction, spring return, or reversing type.

Modulating Actuators:

Capable of stopping at all points across full range, and starting in either direction from any point in range.

Control Input Signal:

Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for **[0- to 10-] [or] [2- to 10-]**V dc **[and] [4- to 20-mA]** signals.

Pulse-Width Modulation (PWM): Actuator drives to a specified position in accordance with a pulse duration (length) of signal from a dry-contact closure, triac sink, or source controller.

Retaining "Programmable Multifunction" subparagraph below limits manufacturer choices. Belimo Americas (USA) is most well-known manufacturer offering product.

Programmable Multifunction:

Control input, position feedback, and running time shall be factory or field programmable.

Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.

Service data, including at a minimum, number of hours powered, and number of hours in motion.

Position Feedback:

Retain one of first two subparagraphs below to include a signal for remote monitoring of position through positive means. Remote monitoring requires additional control inputs. Coordinate requirements with interface to control system.

**[Equip] [Where indicated, equip]** two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of **[open] [and] [close]** position.

**[Equip] [Where indicated, equip]** modulating actuators with a position feedback through **[current] [or] [voltage]** signal for remote monitoring.

Include a position indicator and graduated scale on each actuator indicating open and closed travel limits.

Fail-Safe:

Where indicated, provide actuator to fail to an end position.

Internal spring return mechanism to drive-controlled device to an end position (open or close) on loss of power.

Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

Integral Overload Protection:

Provide against overload throughout the entire operating range in both directions.

Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

Damper Attachment:

Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.

Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.

Bolt and setscrew method of attachment is acceptable only if included with at least two points of attachment.

Temperature and Humidity:

Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of **[minus 20 to plus 120 deg F] <Insert temperature range>**.

Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from **[5 to 95] <Insert numbers>** percent relative humidity, noncondensing.

Enclosure:

Suitable for ambient conditions encountered by application.

Provide actuator enclosure with a heater and controller where required by application.

NEMA 250, Type 2 for all applications except **<Insert applications>**.

NEMA 250, Type 4 or Type 4X for **<Insert applications>** applications.

Stroke Time: Select operating speed to be compatible with equipment and system operation.

Retain any of first three subparagraphs below to dictate operating performance.

Operate damper from fully closed to fully open within **[15] [60] [75] [90] [150] <Insert number>** seconds.

Operate damper from fully open to fully closed within **[15] [60] [75] [90] [150] <Insert number>** seconds.

Move damper to failed position within **[5] [15] [30] <Insert number>** seconds.

Actuators operating in smoke-control systems shall comply with governing code and NFPA requirements.

Sound:

Spring Return: 62 dBA.

Non-Spring Return: 45 dBA.

* + - 1. MANUAL BALANCING DAMPERS
         1. General: Air-handling unit manufacturer shall furnish and factory install manual balancing dampers inside air-handling units where indicated on Drawings.
         2. Rectangular Manual Balancing Dampers with Aluminum Airfoil Blades:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Greenheck Fan Corporation.

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain dampers from single source from single manufacturer.

Requirements in "Performance" and "Construction" subparagraphs below are based on Ruskin's "CD50 Series."

Performance:

Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, figure 5.3.

Velocity: Up to 6000 fpm.

Temperature: Minus 40 to plus 185 deg F.

Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

Damper shall have AMCA seal for both air leakage and air performance.

Construction:

Frame:

Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.

Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of 1 inch.

Width not less than 5 inches.

Blades:

Hollow, airfoil, extruded aluminum.

Parallel- or opposed-blade configuration as required by application.

Material: ASTM B211, Alloy 6063 T5 aluminum, 0.07 inch thick.

Width not to exceed 6 inches.

Length as required by close-off pressure, not to exceed 48 inches .

Seals:

Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.

Jambs: Stainless steel, compression type.

Axles: 0.5-inch- diameter **[plated] [or] [stainless]** steel, mechanically attached to blades.

Bearings:

Molded synthetic or stainless steel sleeve mounted in frame.

Where blade axles are installed in vertical position, include thrust bearings.

Linkage:

Concealed in frame.

Constructed of aluminum and **[plated] [or] [stainless]** steel.

Hardware: Stainless steel.

Locking Regulator:

Aluminum or stainless steel standoff with locking regulator mounted to frame in an accessible location for manual adjustment of damper blades.

Retain "Additional Corrosion Protection for Corrosive Environments" subparagraph below for applications requiring additional protection against corrosion.

Additional Corrosion Protection for Corrosive Environments:

Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.

Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

Retain "Industrial-Duty Manual Balancing Dampers with Airfoil Blades" paragraph below to include galvanized-steel or stainless steel airfoil blade dampers in applications where aluminum blade dampers cannot satisfy the requirements. Retain stainless steel for better resistance to corrosion.

* + - * 1. Industrial-Duty Manual Balancing Dampers with Airfoil Blades:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

[Greenheck Fan Corporation](http://www.specagent.com/Lookup?uid=123457148450).

[Ruskin Company](http://www.specagent.com/Lookup?uid=123457148451).

Approved equivalent.

Source Limitations: Obtain dampers from single source from single manufacturer.

Requirements in "Performance" and "Construction" subparagraphs below are based on Ruskin's "CD30AF Series."

Performance:

Leakage: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

Pressure Drop: 0.06 inch wg at 2000 fpm across a 48-by-48-inch damper when tested in accordance with AMCA 500-D, figure 5.3.

Velocity: Up to 4000 fpm.

Temperature: Minus 40 to plus 250 deg F.

Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, minimum 10 inches wg.

Construction:

Frame:

Material: **[Galvanized steel] [Type 304 stainless steel] [or] [Type 316L stainless steel]**, minimum 0.11 inch thick.

C-shaped channel with mating face minimum of 1 inch.

First option in first subparagraph below is standard offering. Second option provides additional protection to blades.

Width not less than **[3 inches] [blade width plus 2 inches]**.

Blades: Hollow, airfoil shape; constructed of **[galvanized steel] [Type 304 stainless steel] [Type 316L stainless steel]**, minimum 0.06 inch thick.

Second option in first subparagraph below is standard offering.

Width not to exceed **[6 inches] [8 inches]**.

Length not to exceed **[36 inches] [48 inches] [60 inches]**.

Seals:

Blades: Replaceable, mechanically attached EPDM or extruded silicone.

Jambs: Stainless steel, double compression type.

Axles: 0.5- or 0.75-inch- diameter **[plated] [Type 304 stainless] [or] [Type 316 stainless]** steel, mechanically attached to blades**[ and continuous from end to end]**.

Bearings:

Stainless steel sleeve type mounted in frame.

Where blade axles are installed in vertical position, provide thrust bearings.

Linkage:

Face linkage exposed to airstream.

Constructed of **[plated steel] [Type 304 stainless steel] [or] [Type 316 stainless steel]**.

Hardware: **[Type 304] [or] [Type 316]** stainless steel.

Locking Regulator:

Stainless steel standoff with locking regulator mounted to frame in an accessible location for manual adjustment of damper blades.

* + - 1. SMOKE DAMPERS

Retain "Smoke Detectors" Article to include smoke dampers in air-handling units.

* + - * 1. General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.
        2. Rectangular Smoke Dampers with Aluminum Blades:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Greenheck Fan Corporation.

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain dampers from single source from single manufacturer.

General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.

Performance:

Leakage: In accordance with UL 555S, Class 1.

Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, figure 5.3.

Velocity: Up to 4000 fpm.

Temperature: 250 deg F.

Pressure Rating: 8.0 inches wg.

Certification: NRTL listed and labeled in accordance with UL 555S, Class 1.

Construction:

Frame:

Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.

Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of 1 inch.

Width not less than 5 inches.

Blades:

Hollow, extruded airfoil shape.

Material: ASTM B211, Alloy 6063 T5 aluminum, 0.07 inch thick.

Width not to exceed 6 inches.

Length as required by close-off pressure, not to exceed 48 inches.

Seals:

Blades: Replaceable, mechanically attached extruded silicone.

Jambs: Stainless steel, compression type.

Axles: 0.5-inch- diameter **[plated] [or] [stainless]** steel, mechanically attached to blades.

Bearings:

Molded synthetic or stainless steel sleeve mounted in frame.

Where blade axles are installed in vertical position, include thrust bearings.

Linkage:

Concealed in frame.

Constructed of aluminum and **[plated] [or] [stainless]** steel.

Hardware: Stainless steel.

* + - * 1. Rectangular Smoke Dampers with Galvanized-Steel Blades:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Greenheck Fan Corporation.

Ruskin Company.

Approved equivalent.

Source Limitations: Obtain dampers from single source from single manufacturer.

General: Air-handling unit manufacturer shall furnish and factory install smoke dampers inside air-handling units where indicated on Drawings.

Performance:

Leakage: In accordance with UL 555S, Class 1.

Pressure Drop: 0.07 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, figure 5.3.

Velocity: Up to 4000 fpm.

Temperature: 250 deg F.

Pressure Rating: 8.0 inches wg.

Certification: NRTL listed and labeled in accordance with UL 555S, Class 1.

Construction:

Frame:

Material: Galvanized steel, minimum 0.06 inch thick.

Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of 1 inch.

Width not less than 5 inches.

Blades:

Hollow, airfoil shape.

Material: Galvanized steel, minimum 0.06 inch thick.

Width not to exceed 6 inches.

Length as required by close-off pressure, not to exceed 48 inches.

Seals:

Blades: Replaceable, mechanically attached extruded silicone.

Jambs: Stainless steel, compression type.

Bearings:

Stainless steel sleeve type mounted in frame.

Where blade axles are installed in vertical position, include thrust bearings.

Linkage:

Concealed in frame.

Constructed of galvanized steel.

Hardware: Steel with corrosion-resistant finish.

Actuator:

Type: Electric, with electrical characteristics compatible with field power supply.

Action: **[See Drawings] [modulating] [or] [two position]**.

Control Signal: Individual damper assemblies with multiple actuators shall be factory wired to operate in unison from a single control signal.

Fail Position: Closed or open, as indicated on Drawings.

Mounting on Damper: External.

Quantity: Provide each damper assembly with least number of actuators possible for application.

Speed of Response:

Damper blade operation shall have a controlled movement of at least 5 seconds when travelling from open to close to reduce the potential for damage to duct system and connected equipment.

Damper closure shall not be instantaneous under any condition.

Operating time for completion of 90-degree damper travel, from open to close, or from close to open, shall not exceed the more stringent of the following:

NFPA references indicated.

Governing codes.

**[15 seconds] <Insert time>**.

Retain "Blade Position Switches" subparagraph below for remote monitoring of blade position.

Blade Position Switches:

Provide damper assemblies with limit switches to provide remote indication of damper blade positions.

Provide separate limit switches for remote indication of damper blade open position and damper blade closed position.

Actuators equipped with remote position indication as an integral part of actuator is acceptable in lieu of separate limit switches only if actuator with integral remote position indication is NRTL listed in accordance with UL 555S.

* + - 1. DUCT SILENCERS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Price Industries.

Ruskin Company.

Approved equivalent.

Retain "Duct Silencer Sourcing Option" paragraph below to give air-handling unit manufacturer the option of using its duct silencer products or sourcing duct silencers from a specialty duct silencer manufacturer. Not all custom air-handling unit manufacturers build duct silencer products. Consult custom air-handling unit manufacturers to review product availability and options.

* + - * 1. Duct Silencer Sourcing Option: In lieu of sourcing duct silencers from a specialty duct silencer manufacturer, air-handling unit manufacturer has option to furnish in-house silencers that achieve equal or better performance while complying with other requirements indicated.

Full-height duct silencers baffles shall span from floor to roof of air-handling unit air tunnel and consist of multiple baffles aligned to fill the entire cross-sectional area of air-handling unit air tunnel. In this alternative, the air-handling unit casing shall serve as the duct silencer casing.

* + - * 1. General: Air-handling unit manufacturer shall furnish and install duct silencers and associated support structures inside air-handling units where indicated on Drawings.

Unless otherwise indicated on Drawings, select face area of silencers to fill the entire cross-sectional area of air-handling unit air tunnel.

Silencer Type: **[Dissipative] [Reactive (packless)]** **[Type, either dissipative or reactive (packless), indicated on Drawings]**.

Factory fabricated.

Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.

Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

* + - * 1. Ratings and Performance:

Duct silencer manufacturer shall publish performance for dynamic insertion loss (DIL), self-noise power levels, and airflow static pressure loss based on results of performance testing indicated.

Duct silencer manufacturer shall test duct silencers in accordance with ASTM E477 in a qualified nationally recognized independent testing laboratory or manufacturer's National Voluntary Lab Accreditation Program accredited laboratory.

Conduct tests with air flowing through duct silencers at not less than three different flow rates and with no airflow.

Test methods shall eliminate effects due to end reflection, vibration, flanking transmission, and standing waves in the test chamber.

DIL is not less than values indicated on Drawings.

Silencer self-generated noise shall not increase system sound level.

Static pressure loss not to exceed values indicated on Drawings.

Structural Performance:

Design casing for differential air pressure of 8 inches wg between.

Reinforce duct silencer casing to limit deflection to 1/200 of span.

* + - * 1. Construction: Fabricate rectangular silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for individual unit assemblies.

Casing:

Unless otherwise indicated, construct outer casing in accordance with ASHRAE and SMACNA standards for construction of high-pressure rectangular ductwork.

Casing seams and joints shall be lock formed and mastic filled, or continuously welded.

Materials and Thickness:

Retail any of first three material subparagraphs (aluminum, galvanized steel, or stainless steel) below. Coordinate with "Duct Silencer Material Applications" subparagraph.

Aluminum, ASTM B 209 Alloy 3003-1114, smooth finish:

Outer Casing: Solid, minimum **[0.040 inch] [0.063 inch] <Insert dimension>** thick.

Baffles: Perforated, minimum **[0.032 inch] [0.040 inch] <Insert dimension>** thick for sizes through **[24 inches] <Insert dimension>** tall and **[0.040 inch] [0.063 inch] <Insert dimension>** thick for larger sizes.

Galvanized Steel, ASTM A653, **[G60] [or] [G90]** Finish:

Outer Casing: Solid, minimum **[20 gauge] [22 gauge] <Insert thickness>** thick.

Baffles: Perforated, minimum **[24 gauge] [26 gauge] <Insert thickness>**for sizes through **[24 inches] <Insert dimension>** tall and **[20 gauge] [22 gauge] <Insert thickness>** for larger sizes.

Stainless Steel, ASTM A240 or ASTM A480:

Outer Casing: Solid, minimum **[20 gauge] [22 gauge] <Insert thickness>** thick.

Baffles: Perforated, minimum **[24 gauge] [26 gauge] <Insert thickness>** for sizes through **[24 inches] <Insert dimension>** tall and **[20 gauge] [22 gauge] <Insert thickness>** for larger sizes.

Duct Silencer Material Applications:

Retain any of "Exhaust Air, General"; "Exhaust Air, Hazardous"; "Mixed Air"; "Outdoor Air"; "Return Air"; and "Supply Air" subparagraphs below.

Exhaust Air, General: **[Aluminum] [Galvanized steel] [Type 304L stainless steel] [or] [Type 316L stainless steel]**.

Exhaust Air, Hazardous: **[Aluminum] [Galvanized steel] [Type 304L stainless steel] [or] [Type 316L stainless steel]**.

Mixed Air: **[Aluminum] [Galvanized steel] [Type 304L stainless steel] [or] [Type 316L stainless steel]**.

Outdoor Air: **[Aluminum] [Galvanized steel] [Type 304L stainless steel] [or] [Type 304 stainless steel]**.

Return Air: **[Aluminum] [Galvanized steel] [Type 304L stainless steel] [or] [Type 316L stainless steel]**.

Supply Air: **[Aluminum] [Galvanized steel] [Type 304L stainless steel] [or] [Type 316L stainless steel]**.

**<Insert material application>**.

Dissipative-Type Duct Silencer Fill Materials:

Inert, vermin-proof, and moisture-proof inorganic mineral or glass fiber of a density sufficient to obtain the acoustic performance indicated. Fiber-free fill materials are an acceptable alternative to fiber fill materials if complying with other requirements.

Pack fill under not less than **[5] <Insert number>** percent compression.

Fill material and coverings shall not exceed the following values when tested in accordance with ASTM E84, NFPA 255, and UL 723:

Flame-Spread Index: 25.

Smoke-Developed Index: 50.

Fuel Contribution: 20.

Protective Coverings for Fiber Fill Materials:

Except for silencers used in exhaust applications completely cover silencer fiber fill materials with a protective covering, such as a tightly woven fiberglass fabric, to prevent particle contamination of airstream without degrading silencer acoustical performance.

For silencers located in airstreams filtered by absolute filters and where located in potentially hazardous exhaust airstreams, enclose the fiber fill material in a polymer sheeting to prevent contaminating air stream without impacting air cleanliness and hygiene. Offset polymer sheeting with honeycomb standoff to prevent polymer sheeting from coming in direct contact with perforated baffles.

Reactive-Type (Packless) Duct Silencer Baffles: Controlled impedance membranes and broadly tuned resonators without absorptive fill material.

Retain "Removable Baffles" subparagraph below to add an easily removable feature. This feature can be costly and should not be included unless specifically required by the application. Not all silencer manufacturers offer this feature. Consult manufacturers for availability.

Removable Baffles: Design and construct baffles to be easily removable for purposes of cleaning and replacement.

* + - * 1. Factory Assembly:

Install duct silencers in correct direction with respect to airflow.

Manufacturer's written installation instructions shall not be compromised.

Seal penetrations through duct silencer baffles using a sealant.

Install duct silencers with baffles oriented in the vertical position.

Duct silencer banks consisting of multiple individual duct silencers shall be as follows:

Structurally reinforced to support loading and limit deflection to 1/200 of span.

Provided with a continuous nosing to cover all joints of adjoining duct silencers. Nosing shall be constructed of same material as duct silencers and attached by friction fit, crimping, or button punch.

Fastened together using **[zinc-plated] [or] [stainless]** steel sheet metal screws that are spaced at not more than **[6 inches] <Insert dimension>** apart, starting at corners.

* + - * 1. Cleaning:

After assembly, clean duct silencers with HEPA-filtered vacuum machines and then wipe all surfaces with a cleaning agent, using clean rags.

* + - 1. ANTIMICROBIAL ULTRAVIOLET (UV) LAMP SYSTEMS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=13604) Subject to compliance with requirements, provide products by the following:

UV Resources.

Approved equivalent.

* + - * 1. Source Limitations: Obtain UV lamp systems from single source from single manufacturer.
        2. Description: UV-C lamp system consisting of power supply, wiring, lamp(s), plug(s), and holder(s) used for ultraviolet germicidal irradiation (UVGI) of cooling coil and condensate drain pan.

Factory assembled and engineered by a qualified design professional.

* + - * 1. Certification: NRTL listed and labeled in accordance with UL 153, UL 1598, and UL 1995; UL Category Code ABQK; HVAC accessories; air-duct mounted.
        2. Performance:

Operating Conditions: Suitable for operation in extreme conditions of the airstream encountered.

Relative humidity range not less than 5 to 100 percent.

Temperature range not less than **[34 to 158 deg F] <Insert temperature range>**.

Velocity range not less than **[0 to 600 fpm] <Insert velocity range>**.

Retain one of two "Irradiation Intensity" subparagraphs below. Retain second subparagraph if there are multiple applications with different requirements.

In first subparagraph below, retain one of three options for intensity best suited for the application. See the Evaluations for discussion and consult ASHRAE handbooks or other technical references for additional information.

Irradiation Intensity: Install sufficient quantity of UV-C lamps to provide an average irradiation intensity of **[500] [1000] [2000] <Insert value>** microwatts/sq. cm over coil face and exposed surfaces of drain pan.

Irradiation Intensity: Install sufficient quantity of UVGI fixtures to provide an average irradiation intensity indicated on the Drawings.

Retain first three subparagraphs below with one of two "Irradiation Intensity" subparagraphs above.

Submit calculations indicating high, low, and average irradiation intensity level across coil face area and drain pan.

Take irradiation intensity measurements of factory assembly before air-handling unit shipment to determine results and confirm compliance with requirements. Document and submit measurement results confirming compliance.

Intensity calculations shall be based on an average output over a lamp life of [9000] <Insert number> hours and account for light output degradation over the lamp life.

Lamp Life: Minimum of [9000] <Insert number> hours.

Light Output Degradation: Reduction in light output shall not exceed **[15] [20] <Insert number>** percent of initial lamp output over the rated lamp life.

* + - * 1. Construction:

Lamps:

Type: High output, hot cathode; non-ozone producing.

Output: UV-C energy, primarily at the 254-nm wavelength with a 360-degree energy distribution.

Protective Sleeve: Hermetically sealed to provide protection against lamp breakage and to ensure that lamp contents from a broken lamp are contained.

Labeling: Lamp wattage and model number visibly printed on all lamps.

Mercury Content: Less than 8 Mg of mercury in each lamp.

Lamp Sourcing: Commercially sourced from more than one manufacturer for future replacement. Proprietary lamps available from only one manufacturer are unacceptable.

Lamp Holders:

UV- and moisture-resistant materials designed to connect the lamp to the plug and ensure a watertight connection.

Adjustable positioning.

Wiring Loom: UV-C-resistant jacket materials with internal aluminum/Mylar shield.

Conduit: Loom covered with NRTL-listed flexible metal conduit, aluminum or stainless steel.

Power Supply: NRTL listed, single phase, 120 or 277 V ac as indicated, with a programmed rapid start.

Power Factor: High power factor, Class P, Sound Rated A, Type 1 Outdoor, and with inherent thermal protection and without polychlorinated biphenyl.

Wiring Harness: Plug and play.

Electrical Connection: Single electrical connection**[ with service disconnect]**.

Enclosures: NEMA 250, **[Type 1] [Type 4]** constructed of **[painted carbon steel] [stainless steel] <Insert material>**.

* + - * 1. Air-Handling Unit Factory Assembly:

Install UV-C lamp systems in accordance with manufacturer's written instructions.

Location: Install UV-C lamp system array **[immediately downstream of cooling coil bottom drain pan] [at locations indicated on Drawings] <Insert location within air-handling unit>**.

UV-C Lamp System Support Assembly: **[Aluminum] [or] [300 series grade stainless steel]** framework rigidly attached to air-handling unit casing and adequately braced to provide ridge support of UV-C lamp systems that will not move or damage when leaned on or bumped into by operators.

Service Access: Lamps shall be easily replaceable from inside the air-handling unit.

Install access door(s) with window to access UV light. Treat each window and test to confirm UV emitted through the window is below the threshold limits of NIOSH and ACGIH.

If adequate space is unavailable inside air-handling unit, install UV-C lamp systems on a slide out rail to allow lamp replacement from one exterior side of air-handling unit.

Factory wire UV-C lamp systems internally and terminate at a disconnecting switch on the exterior of the air-handling unit casing.

Switch to include a lock-out/tag-out feature.

In addition to disconnecting switch, provide each access door accessible to UV-C lamp systems with a position limit switch wired into UV-C lamp systems power circuit to de-energize power to UV-C lamp systems when door is opened.

Install a caution nameplate at each UV-C lamp systems disconnecting switch that reads: "DANGER, UV LIGHTS - Turn off before entering."

Protection from UV Damage: Materials in direct or indirect (reflected) contact with UV shall be tested and certified as UV tolerant. Any material not certified shall be completely shielded from UV using a certified UV-tolerant material such as metal. UV tolerance shall be capable of performing intended duty for a minimum of **[20] <Insert number>** years.

Shipping: Remove UV-C lamps after factory testing; package and ship UV-C lamps in protective containers for field installation.

Label exterior of enclosures with detailed description of container contents, including air-handling unit designation.

Ship UV-C lamps for each air-handling unit in separate containers.

Retain "UV-C Lamp System Irradiance Monitoring" paragraph below to include irradiation monitoring, display and reporting to a remote-control system.

* + - * 1. UV-C Lamp System Irradiance Monitoring:

Sourcing: Furnished by UV-C lamp system manufacturer with UV-C lamp systems.

General: UVGI monitoring consisting of sensor(s) and controller to measure and locally display UV output irradiance in **[absolute output (microwatts/sq. cm)] [and] [user-defined percentage of relative output]**

Measurement Range: Suitable for highest measured irradiance encountered by application, but not less than **[10,000] [20,000] <Insert value>** microwatts/sq. cm.

NIST traceable calibration.

Remote Monitoring Signal: 4- to 20-mA output signal for remote monitoring.

Retain "UV-C Lamp System Status Monitoring" paragraph below to include monitoring of lamp operating status for local display and reporting to a remote-control system.

* + - * 1. UV-C Lamp System Status Monitoring:

Sourcing: Furnished by UV-C lamp system manufacturer with UV-C lamp systems.

Monitors operating status of UV-C lamps by measuring change in electrical current.

On/off status of lamps displayed by LED lights on face of local display unit.

Remote Monitoring Signal: On/off status relays for remote monitoring.

* + - 1. HEAT WHEELS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

SEMCO, LLC; part of FlaktGroup.

[Thermotech Enterprises, Inc](http://www.specagent.com/Lookup?uid=123457148468).

Approved equivalent.

* + - * 1. Source Limitations: Obtain heat wheels from single source from single manufacturer.
        2. Performance:

Heat wheels shall be engineered by manufacturer to provide a highly reliable, low-maintenance product for use under continuous operation over an extended operating period of not less than [20] [25] <Insert number> years. Provide supporting documentation if requested to show how features of product design comply with performance indicated.

Products with ratings that exceed indicated pressure drop, fall short of sensible and latent recovery performance indicated, or transfer contaminants in excess of requirements indicated are unacceptable and should not be submitted for review and approval.

Fully-assembled and -installed heat wheel shall be suitable for use in air systems that supply air to tenant occupied space and shall comply with NFPA 90A and governing building codes.

* + - * 1. Testing and Certification:

Thermal Performance: Certification by a qualified independent testing organization documenting the following:

Sensible and latent recovery efficiencies conducted in accordance with ASHRAE 84 with results presented in accordance with ASHRAE 84 and AHRI 1060 (I-P) and AHRI 1061 (SI).

Sensible, latent, and pressure loss performance over a range of operating points as required by ASHRAE 84 and specifically for actual airflow conditions required by Project.

Cross Contamination: Cross-contamination performance reports to validate compliance with requirements indicated.

Independent test report shall document desiccant-coated transfer media exhibits **[3] [or] [4]** Angstrom behavior and does not transfer pollutants typically encountered in indoor air environment having room operations and functions indicated.

Testing shall be performed in a test facility complying with ASHRAE 84 for tracer gas testing.

Challenge gases used for testing shall include chemicals that represent contaminates typically encountered and include at least the following: acetaldehyde, methanol, methyl isobutyl ketone, propane, and xylene **<Insert contaminate>**.

Flame and Smoke: NRTL test report listing flame-spread index and smoke-developed index of media when tested in accordance with ASTM E84 to comply with requirements indicated.

Microbial Resistance: Test report documenting ability of wheel faces and transfer media to actively limit microbial growth.

Testing completed by a qualified research institution or testing laboratory using common live bacterial cultures to document antimicrobial performance with 95 percent mortality effectiveness.

Corrosion Resistance: Test report summarizing acid resistance effectiveness of media face coating completed in accordance with ASTM corrosion-test methodologies.

* + - * 1. Rotors:

Construct rotor media of aluminum base material precoated with a desiccant before forming into honeycomb media structure consisting of circular spiral layers.

Aluminum base material shall be at least **[0.0015 inch] <Insert dimension>** thick before coating.

Media layers shall be joined together using adhesive to bond between flat and corrugated media layers.

Media Coating:

Coat media surfaces with a non-migrating solid adsorbent desiccant layer before forming into the structure to ensure that all surfaces are coated.

Desiccant coating shall be inorganic and use a **[3] [or] [4]** Angstrom molecular sieve to achieve desired **[3] [or] [4]** Angstrom selectivity, excluding contaminants larger than **[3] [or] [4]** Angstroms while effectively transferring water vapor.

In addition to desiccant coating applied to aluminum substrate, cover two faces of rotor with a two-part polymer coating specifically chosen for chemical resistance and corrosion protection. Coating shall be selected to provide life expectancy indicated when exposed to airstreams encountered.

Media exposed to airstream shall exhibit effective antimicrobial action to protect against development and spread of microbial contaminants.

Rotor media with applied coatings and adhesive shall have a flame-spread index of **[0] <Insert value>** and a smoke-developed index of [5] <Insert value> when tested in accordance with ASTM E84.

Media depth shall be determined by heat wheel manufacturer to achieve performance indicated.

Media shall not transfer pollutants typically encountered in an indoor air environment having room operations and functions indicated.

Media shall be cleanable without degrading performance over time.

Dry particles up to 800 microns shall pass freely through the media.

Provide segmented rotor media to allow for field installation and replacement of one section at a time without requiring side access. Removal and replacement shall be made while facing rotor media face.

Rotor media shall be held in place by a rigid structural spoke system made of extruded aluminum.

Coat exposed surfaces of aluminum spoke system for corrosion protection.

Rotor structural spoke system shall be designed and manufactured to provide for field installation of media without possibility of media deformation or misfit.

Media shall be secured within structural spoke system by mechanical means, relying on a formed friction fit without use of adhesives or silicone.

Rotors that cannot be installed in air-handling units as a single complete factory assembly coming from heat wheel manufacturer shall be remotely assembled by trained factory service personnel that are employed by heat wheel manufacturer.

* + - * 1. Purge Sector:

Retain one of two subparagraphs below. Consult manufacturers for proof of compliance.

Factory-set, field-adjustable purge sector designed to limit cross contamination to less than **[0.04] <Insert number>** percent of that of exhaust airstream concentration into supply airstream.

Factory-set, field-adjustable purge sector designed to eliminate cross contamination of exhaust airstream into supply airstream.

* + - * 1. Seals:

Maintenance-free "non-contact" type to eliminate wear, excessive drag, and resulting added horsepower required for motor drive system, while still being capable of resisting high-pressure differences.

Equip rotor with labyrinth seals, which at no time shall make contact with any rotating surface of rotor face.

Seals shall be field adjustable and set to within factory-specified tolerances.

Provide multi-pass seals with four labyrinth stages for optimum performance or alternative design with documented test results showing comparable performance.

Seal shall be secured to housing either by an extruded-aluminum strip with adjustment slots for fastening bolts to the casing frame or by using adjustable clips. Clips shall be made of stainless steel or other noncorrosive material to resist corrosion and possible damage to transfer media.

* + - * 1. Shafts:

Shaft supporting rotor between bearings shall be one piece, solid steel, accurately turned, ground, polished, and ring gauged for accuracy.

Machine and polish shaft within bearing contact area to comply with bearing manufacturer's written recommended tolerances.

Use a dial indicator to inspect shafts for roundness and straightness.

Coat exposed surfaces of shaft with a corrosion-inhibitive coating.

Shaft shall be machined to provide a shoulder against bearings for a positive locked position to eliminate any lateral movement of rotor due to axial bearing loads.

* + - * 1. Bearings:

Support rotor shaft by two pillow block **[tapered roller ]**bearings designed for an ABMA 11 L-10 life of at least **[200,000] [1,000,000]** hours.

Bearings shall be maintainable and replaceable without removal of rotor from its casing or media from spoke support system.

Grease fittings for each bearing shall be easily accessible and within view of bearing.

Reverse Rotation: Clutch bearing and extended shaft, or equivalent alternative, to prevent reverse rotation and ensure that wheel can only rotate in direction commensurate with effective purge operation.

* + - * 1. Frame and Housing:

Design frame to limit deflection of rotor due to air pressure loss to less than **[**0.03125 inch**] <Insert deflection>**, **[as measured at the outer radius, during maximum rated airflow condition ]**when exposed to a wheel pressure differential of **[25] <Insert number>** percent above design conditions.

Construct rigid frame of welded structural **[aluminum] [galvanized steel] [painted steel] [or] [stainless steel]**.

Designed and manufactured in one, two, or more sections as required by application to provide a rigid structure, when completely assembled, capable of supporting rotor.

For horizontal airflow applications, support rotor at each end only with no additional support under center.

For vertical airflow applications, provide one additional bottom center support.

Clearly mark each section of multiple section units for easy installation.

Construct housing of **[galvanized-steel] [painted steel] [aluminum] [or] [stainless steel]** formed sheets designed to prevent corrosion.

Housing shall be reinforced as required to provide a solid mounting surface of peripheral and radial seals, to maintain a fixed distance between rotor surface and any housing part.

There shall be no special requirement to provide air-handling unit casing side access for future rotor removal and service. All rotor service shall be performed from inside air-handling unit at face of rotor.

Retain "Requirements for Painted Frame and Housing" subparagraph below if retaining "painted steel" options in frame and housing subparagraphs above.

Requirements for Painted Frame and Housing:

Comply with painting manufacturer's written preparation and application requirements.

Treat galvanized steel that is not phosphatized with a phosphate rinse to ensure that paint adheres.

Apply rust-inhibiting primer before applying finishing coats.

Apply multiple coats to achieve dry film thickness required for protection indicated.

Finish coat color to be **[manufacturer's standard] <Insert color>**.

Painted products shall have no deterioration when subjected to the following:

Salt spray test in accordance with ASTM B117 with 5 percent salt solution fog at 95 deg F for a period of **[500] [1000] [2000] <Insert number>** hours.

Acid-resistance test in accordance with ASTM D3260 with 15-minute exposure to 10 percent hydrochloric acid at room temperature.

* + - * 1. Motor and Drive Assembly:

Motor Enclosure: Totally enclosed.

Motor nameplate horsepower shall exceed maximum load of driven assembly.

Multiple belt-drive assembly shall be automatically tensioned and arranged to eliminate any side-to-side movements and slippage.

Motor and drive assembly shall be easily accessible and visible for inspection and maintenance.

Drive assembly, except motor, shall have a life expectancy of **[45,000] [90,000] <Insert number>** hours.

* + - * 1. Variable-Frequency Controller:

Variable-speed control of rotor through a variable-frequency controller.

Digital programming with a manual-speed adjustment on the front face of controller.

Rotor drive system shall allow for a turndown ratio of 80:1 (20 to 0.25 rpm).

Controller with switchable control either locally on front of controller or remotely by a control system.

Controller with a motor-rated disconnect switch or circuit breaker having a withstanding rating greater than that required by field electrical power system, but not less than **[42,000] [65,000] <Insert value>** A.

Controller mounted in a NEMA 250, **[Type 1] [Type 4] [Type 4X] [or] [Type 12]** enclosure.

Retain "Rotation Sensor" paragraph below to provide remote indication of wheel rotation if monitoring and control is not provided as a complete package by heat wheel manufacturer. Analog signal provides true indication of wheel speed and can be beneficial in troubleshooting.

* + - * 1. Rotation Sensor: Proximity-type rotation sensor and target to provide [rotational speed (rpm) analog signal and ]wheel stop digital alarm signal for interface to remote-control system.

Retain "Monitoring and Control" paragraph below for energy wheel complete monitoring and control package furnished by heat wheel manufacturer to provide a single-source responsibility. Consult heat wheel manufacturer for available features and options. No all heat wheel manufacturers offer controls.

* + - * 1. Monitoring and Control:

Single-Source Responsibility: Heat wheel manufacturer shall provide a complete monitoring and control package for heat wheel with controller, local display, operator interface, sensors, switches, transmitters, accessories, components, devices, and programming for a complete and operating heat wheel to ensure that responsibility for heat wheel and its operation resides with one source.

Enclosure:

House controller and control devices in a NEMA 250, **[Type 1] [Type 4] [Type 4X] [or] [Type 12]** enclosure.

Enclosure with LCD screen to allow viewing and changing parameters.

Enclosure with full front face hinged door and lockable handle.

Air-handling unit manufacturer shall mount enclosure of outside of air-handling unit casing in vicinity of heat wheel.

DDC with the following:

Conversion of temperature and relative humidity readings into grains, dew point, and enthalpy.

Calculation and reporting of real-time unit effectiveness.

Calculation and reporting of accumulation of energy (Btu) recovered over time.

With user input of energy costs, calculation and accumulation of dollars saved over time.

An alarm output if wheel is not rotating and not rotating in correct direction.

Programming for integration of enthalpy-based summer-winter change over, frost prevention and supply temperature control such that they also function correctly as the wheel speed is modulated.

Communications and data transfer for remote monitoring and control through ASHRAE 135 (BACnet) interface.

Option to achieve conversion and calculations indicated is for heat wheel manufacturer to employ building controls provider, to provide a field-installed DDC with LCD to be mounted directly adjacent to heat wheel manufacturer monitoring and control enclosure.

Four, field-mounted, high-precision dry-bulb temperature and either wet-bulb temperature or humidity sensors shall be provided by heat wheel manufacturer to air-handling unit manufacturer for factory mounting in accordance with heat wheel manufacturer's written instructions to measure dry-bulb temperature and either wet-bulb temperature or humidity at each of four energy wheel airstreams.

Sensors shall be wired to controller or controller expander board located within enclosure.

Wheel Rotation: Rotation detector module to detect a rotating wheel, and correct direction of rotation**[ and speed]**.

Retain "Active Monitoring and Control of Purge" subparagraph below for applications with cross contamination concerns. Consult heat wheel manufacturers for availability.

Active Monitoring and Control of Purge: Manufacturer's standard method to ensure that proper purge operation is maintained actively in response to changes in system airflows and pressures that normally occurs with a variable-volume system and where pressure changes appreciably due to filter loading and damper modulation.

* + - * 1. Air-Handling Unit Factory Assembly:

Internal Access: Provide each heat wheel with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Removal and Replacement: Each heat wheel shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.

Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.

Supports for Heat Wheel:

Construct a freestanding and self-supporting structural framework to support each heat wheel individually from and independent of adjacent heat wheels.

Construct frame work from aluminum**[, galvanized-steel,]** or stainless steel[ structural shapes].

Comply with heat wheel manufacturer's written installation instructions.

* + - 1. FIXED PLATE HEAT EXCHANGERS

See the Evaluations in Section 237219 "Fixed-Plate Air-to-Air Energy Recovery Equipment" for discussion.

* + - * 1. Fixed Plate Sensible Heat Exchangers:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Heatex, Inc.

Innergy Tech, Inc.

Approved equivalent.

Source Limitations: Obtain heat exchangers from single source from single manufacturer.

Description: A device for purpose of transferring only sensible energy from one airstream to another with no moving parts. Design may incorporate parallel, cross- or counterflow construction or a combination of these to achieve the energy transfer.

Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.

Maximum Pressure Differential: Suitable for maximum **[6 inches wg] <Insert pressure>**.

Maximum Temperature: Suitable for maximum **[194 deg F] <Insert temperature>**.

In "Casing" subparagraph below, not all manufacturers offer each option; consult manufacturers.

Casing: **[Aluminum] [Galvanized steel] <Insert material>**.

Plates: Evenly spaced, sealed, and arranged for **[counter] [cross]** airflow.

Plate Material: **[Embossed aluminum] [Stainless steel] [High-density plastic] <Insert material>**.

Coatings are available for aluminum plates in corrosive atmospheres. Retain first subparagraph below if corrosion-resistant coating is desired and is specified in Section 230546 "Coatings for HVAC." If retaining below, consult heat exchanger manufacturers to confirm that the coatings included in the referenced Section are available as a factory-applied coating.

Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for heat exchangers requiring a corrosion-resistant coating.

Retain "Aluminum Plate Coating" subparagraph below if corrosion-resistant coating is desired and is specified in this Section. Indicate coating location requirements on Drawings.

Aluminum Plate Coating: **[None] [Epoxy] <Insert coating>**. See Drawings for heat exchangers requiring a corrosion-resistant coating.

* + - * 1. Fixed Plate Total Heat Exchangers:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

CORE Energy Recovery Solutions.

Innergy Tech, Inc.

Approved equivalent.

Source Limitations: Obtain heat exchangers from single source from single manufacturer.

Description: A device for purpose of transferring total energy (sensible and latent) from one airstream to another with no moving parts. Design may incorporate parallel, counterflow construction to achieve the energy transfer.

Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.

Maximum Pressure Differential: Suitable for maximum **[6 inches wg] <Insert pressure>**.

Maximum Temperature: Suitable for maximum **[194 deg F] <Insert temperature>**.

In "Casing" subparagraph below, not all manufacturers offer each option; consult manufacturers.

Casing: **[Aluminum] [Galvanized steel] <Insert material>**.

Plates: Evenly spaced, sealed, and arranged for counter airflow.

Plate Material and Coating: Chemically treated paper, or polymer on **[aluminum] <Insert material>**, with selective hydroscopicity, moisture permeability, and gas barrier properties.

* + - * 1. Air-Handling Unit Factory Assembly:

Internal Access: Provide each fixed plate heat exchanger with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Removal and Replacement: Each fixed plate heat exchanger shall be independently removable and replaceable through a removable access panel or door installed in air-handling unit casing.

Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.

Supports for Fixed Plate Heat Exchanger:

Construct a freestanding and self-supporting structural framework to support heat exchangers.

Construct frame work from aluminum**[, galvanized-steel,]** or stainless steel**[ structural shapes]**.

Comply with fixed plate heat exchanger manufacturer's written installation instructions.

* + - 1. HEAT PIPE HEAT EXCHANGERS

See the Evaluations in Section 237216 "Heat Pipe Air-to-Air Energy Recovery Equipment" for discussion.

* + - * 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Engineered Air.

Innergy Tech, Inc.

Approved equivalent.

* + - * 1. Source Limitations: Obtain heat exchangers from single source from single manufacturer.
        2. Description: Air-to-air energy recovery heat exchanger employing tubes charged with a fluid for purpose of transferring sensible energy from one airstream to another through the vaporization of fluid.
        3. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.

In "Certification" paragraph below, not all manufacturers have AHRI listing. Not all manufacturers are NRTL listed to UL 207.

* + - * 1. Certification: Rated**[, listed and labeled]** in accordance with AHRI 1060 (I-P) and AHRI 1061 (SI).**[ NRTL listed in accordance with UL 207.]**
        2. Casing and Tube Sheets: **[Galvanized-steel] [or] [stainless steel]** flanged casing minimum **[16 gauge] <Insert thickness>** thick, with airtight **[single] [double] [foam-filled double]** partition between exhaust and supply airstreams.
        3. Fluid in Sealed Tubes: Selected by heat pipe heat exchanger manufacturer and classified as Safety Group A1 in accordance with ASHRAE 34.

Not all manufacturers offer the same combination of tube diameter, tube material, and fin material. Consult manufacturers and insert desired tube diameter, tube material, and fin material.

* + - * 1. Tubes:

Tube Diameter: Selected by heat pipe heat exchanger manufacturer; not less than nominal 1/2 inch and not more than nominal 1 inch in diameter.

Tube Material: **[Aluminum] [or] [copper] <Insert material>**; minimum thickness required for fluid pressure and temperature encountered.

Number of Tube Rows: As required by performance; not to exceed **[8] <Insert number>**.

* + - * 1. Fins: **[Aluminum] [or] [copper] <Insert material>**.

Fin Configuration: **[Extruded] [plate] [or] [spiral]**.

Fin Spacing: As required by performance; not to exceed 12 fins per inch.

Not all manufacturers offer each option in "Fin and Tube Bond" subparagraph below; consult manufacturers.

Fin and Tube Bond: **[Mechanical expanded into collared fins and tube sheets] [Silver brazed]**.

* + - * 1. Coating: **[None] [Flexible epoxy polymer E-coating] [Baked phenolic] <Insert coating>**; apply to supply and exhaust.

Retain one of two "Control" paragraphs below to require controls to be an integral part of heat pipe heat exchanger. Retain first for face-and-bypass control; second, for tilt control. Not all manufacturers offer bypass control. Not all manufacturers offer or recommend tilt control. Consult heat pipe heat exchanger manufacturers.

* + - * 1. Control: Integral plenum containing heat pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.
        2. Control: Pivot center of bottom of heat pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester-fabric-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.
        3. Air-Handling Unit Factory Assembly:

Internal Access: Provide each heat pipe heat exchanger with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Removal and Replacement: Each heat pipe heat exchanger shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.

Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.

Supports for Heat Pipe Heat Exchanger:

Construct a freestanding and self-supporting structural framework to support each heat pipe heat exchangers individually from and independent of adjacent heat pipe heat exchangers.

Construct frame work from aluminum**[, galvanized-steel,]** or stainless steel**[ structural shapes]**.

Comply with heat pipe heat exchanger manufacturer's written installation instructions.

* + - 1. AIR BLENDERS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Blender Products, Inc.

Kees, Inc.

Approved equivalent.

* + - * 1. Source Limitations: Obtain blenders from single source from single manufacturer.
        2. Description: Static air mixing devices fabricated in assemblies consisting of multidirectional vanes that are designed to reduce stratification of multiple mixed airstreams and improve uniformity of the air tunnel velocity profile located downstream of air mixer.
        3. Performance:

Certification: Documented performance verified by tests performed by an independent agency **[or] [factory tests witnessed by a professional engineer that is not a company employee]**.

Mixing: Uniform mixed airstream within **[6 deg F] <Insert temperature>** of the theoretical average temperature of two or more airstreams.

Indicated on Drawings.

* + - * 1. Construction:

Configuration: Indicated on Drawings.

In the "Material" subparagraph below, "Aluminum" option is a standard offering. Stainless steel options are available for more severe applications.

Material: **[Aluminum] [galvanized steel] [Type 304 stainless steel] [or] [Type 316 stainless steel]**.

Thickness: **[0.080 inch] [0.125 inch] <Insert dimension>**.

Attachment: Integral mounting flange for attachment to mounting substrate.

Welding: Stitch or continuous welds. Filler metals matched to welded materials.

Hardware: **[Stainless] [Zinc-plated carbon]** steel.

OEM Factory Assembly: Single-piece assembly for sizes through 96 inches. For larger sizes, air mixers shall be fabricated in two pieces, bolted together to ensure proper fit and alignment and then dissembled for shipment.

Retain "Finish" subparagraph below to require air mixer with a finish. "Anodized" option is intended for aluminum materials in applications where additional protection is required. Consult manufacturers if application requires a specialized finish.

Finish: **[Anodized] <Insert requirements>**.

* + - * 1. Air-Handling Unit Factory Assembly:

Internal Access: Provide each air mixer with internal access from **[downstream] [and] [upstream]** sides as indicated on Drawings.

Install air mixer assemblies in an internal separating wall reinforced to limit deflection to **[L/200] <Insert value>** when subjected to a horizontal force of **[200 lb] <Insert value>** at any point on the air mixer assembly.

Blank-off and seal assembly to prevent leakage and air bypass around air mixer.

Operating Clearance: Maintain upstream and downstream operating clearances in accordance with manufacturer's written installation requirements.

* + - 1. CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS
         1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Armstrong Fluid Handling.

Bell & Gossett; a Xylem brand.

Grundfos Pumps Corporation.

TACO Comfort Solutions, Inc.

Approved equivalent.

* + - * 1. Source Limitations: Obtain pumps from single source from single manufacturer.
        2. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.
        3. Pump Construction:

Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet**[, replaceable bronze wear rings,]** and threaded **[companion-flange] [or] [union-end]** connections.

Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.

Pump Shaft: **[Steel, with copper-alloy shaft sleeve] [Stainless steel]**.

Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and **[Buna-N] [EPT] [FKM] <Insert material>** bellows and gasket. Include water slinger on shaft between motor and seal.

* + - * 1. Motor: Rigidly mounted to pump casing.

Verify available enclosure types with pump manufacturers.

Enclosure: **[ODP] [or] [TEFC] [totally enclosed, nonventilated]**.

Enclosure Materials: **[Cast iron] [or] [rolled steel]**.

Permanently lubricated ball bearings are available up through 5 hp. Larger motors have grease-lubricated ball bearings.

Motor Bearings: **[Permanently lubricated] [or] [grease-lubricated]** ball bearings.

Efficiency: NEMA Premium efficient.

NEMA Design: **<Insert designation>**.

Service Factor: **[1.15] <Insert value>**.

* + - 1. AIR-HANDLING UNIT FACTORY DRAIN PIPING AND PIPING INSULATION
         1. General:

Air-handling unit manufacturer to factory install piping inside air-handling units.

If more than one material is listed, material selection is by air-handling unit manufacturer.

* + - * 1. Aluminum Piping:

Pipe: Aluminum ASTM B241, Grade 1061, Temper T6, seamless longitudinal joins with beveled or plain ends; and wall thickness as indicated under applications.

Fittings: Cast aluminum, ASTM B26, Grade 356, Temper T6, ASME B16.1 Class 150; threaded ends.

Flanges: Cast aluminum, ASTM B26, Grade 356, Temper T6, ASME B16.1, Class 150 including bolts, nuts, washers, and gaskets of the following end connections and facings:

Threaded end connections for threaded joints, welding-neck with butt-joint for welded joints, and blinds for use with flanged joints requiring close-off.

Unions: Cast aluminum, ASTM B26, Grade 356, Temper T6, hexagonal-stock body; female NPT threaded ends.

* + - * 1. Copper Tubing:

Tubing: Drawn-temper, **[ASTM B88, Type L] [ASTM B88, Type M] [or] [Type DWV in accordance with ASTM B306]**.

Fittings: Wrought-copper and copper alloy, ASME B16.22, pressure fittings.

Unions: Cast-copper-alloy, MSS SP-123, hexagonal-stock body; female NPT threaded ends

Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux in accordance with ASTM B813.

* + - * 1. Stainless Steel Piping:

Pipe: ASME B36.19, stainless steel ASTM A312, with beveled or plain ends; seamless [or welded ]longitudinal joints, Grade TP316L, and wall thickness as indicated under applications.

Fittings, Threaded: MSS SP-114, Class 150, stainless steel ASTM A351, Grade CF8M.

Fittings, Welded: ASME B16.9, stainless steel ASTM A403, Grade WP316L, seamless, wall thickness to match adjoining pipe.

Flanges: Stainless steel ASTM A182, Grade F316L, ASME B16.5, Class 150 including bolts, nuts, washers, and gaskets of the following material group, end connections, and facings:

Material Group: 2.2.

Threaded end connections for threaded joints, welding-neck with butt-joint for welded joints, and blinds for use with flanged joints requiring close-off.

Unions: MSS SP-114, Class 150, stainless steel ASTM A351, Grade CF8M; female NPT threaded ends.

Retain "Floor Drain Piping" paragraph below if air-handling unit floor drains are required. Coordinate with "Floor Drains" paragraph in "Drains" Article.

* + - * 1. Floor Drain Piping:

**[Schedule 40] <Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or] [copper tube with soldered threaded male adapters]**.

Factory install a dedicated drain pipe for each floor drain and extend pipe to access side of air-handling unit.

Terminate pipe with a threaded pipe cap **[3 inches] <Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.

Pipe size to match size of floor drain connection.

Retain "Fan Drain Piping" paragraph below if drains are required for housed centrifugal fans. Coordinate with "Housed Centrifugal Fans" Article.

* + - * 1. Fan Drain Piping:

**[Schedule 40] <Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or] [copper tube with soldered threaded male adapters]**.

Factory install a dedicated drain pipe for each housed centrifugal fan with a drain connection and extend pipe to access side of air-handling unit.

Terminate pipe with a threaded pipe cap **[3 inches] <Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.

Install a twin sphere **[EPDM] [or] [neoprene]** pipe connector in the pipe between the fan connection and the pipe penetration through the air-handling unit casing.

Pipe size to match size of fan drain connection.

Install a threaded union or thread-on flange in drain pipe at connection to fan.

* + - * 1. Drain Pan Piping:

**[Schedule 40] <Insert pipe schedule or wall thickness>** aluminum or stainless steel pipe with threaded ends **[or] [copper tube with soldered threaded male adapters]**.

Factory install drain piping for drain pan(s). Install a dedicated drain pipe for each drain pan serving different air-handling unit internal components. Where multiple drain pans serve like components interconnect drain piping to a single drain pipe for field connection.

Where interconnecting cooling coil condensate drain pans from upstream and downstream sides of cooling coil, provide pipe with a water seal trap configured to prevent air bypass.

Terminate pipe with a threaded pipe cap **[3 inches] <Insert dimension>** beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.

Drain pipe size to match size of drain pan connection.

Retain "Piping Insulation" paragraph below to require air-handling unit factory installed insulation.

* + - * 1. Piping Insulation:

Retain any of three subparagraphs below.

Factory insulate bottom cooling coil drain pan pipe with **[1-inch-] <Insert dimension>** thick, flexible elastomeric insulation where pipe is located under and outside of the air-handling unit casing but within the air-handling unit base.

Factory insulate steam and steam condensate piping located inside of air-handling with **[2-inch-] <Insert dimension>** thick, preformed mineral-fiber pipe insulation.

Cover pipe insulation with a factory-applied aluminum or stainless steel jacket.

* + - 1. AIR-HANDLING UNIT FACTORY HYDRONIC PIPING AND PIPING INSULATION
         1. Chilled-Water Piping:

Design Pressure and Temperature: **[See Drawings] <Insert pressure and temperature>**.

Pipe: ASME B36.10M, carbon steel ASTM A53, with beveled or plain ends; **[electric resistance weld] [or] [seamless]** longitudinal joints, Grade B; standard weight.

Fittings, Threaded: Malleable iron, ASME B16.3; **[Class 150] [or] [Class 300]**.

Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.

Flanges, Weld: Weld-neck, forged carbon-steel, ASME B16.5; **[Class 150] [or] [Class 300]**.

Unions, Threaded: Malleable iron, ASME B16.39; **[Class 150] [or] [Class 300]**.

Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304] [or] [Type 316]** stainless steel with openings not larger than 0.032 inch; **[Class 125] [or] [Class 250]**.

Valves:

Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, extended stem, and stationary outer sleeve to protect insulation vapor seal.

Butterfly: Lugged body; MSS SP-67; cast-iron, ductile-iron, or cast-steel body; stainless steel disk, EPDM seat, and **[lever] [or] [gear]** operator; rated for system pressure, but not less than **[250-psig] <Insert value>** bi-directional dead-end shutoff with downstream flange removed.

Check: Globe-style, MSS SP-125; cast-iron ASTM A126 body, stainless steel spring, and bronze seat; **[Class 125] [or] [Class 250]**.

**<Insert valve type>**.

Vents: Cast-iron body, stainless steel float, NPS 1/2 or larger inlet connection.

Flow Meters: In-line electromagnetic type with integral display and accuracy within 3 percent of reading.

Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A] [or] [Grade B]** accuracy; metal case with nominal **[4-1/2-inch] [6-inch] <Insert dimension>** shatter-resistant glass face and NPS 1/2 threaded brass connection.

Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded NPS 1/2 connection.

Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch] <Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.

Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.

NPS 2 and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.

Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.

Gradually slope piping for venting and drainage.

Include threaded drain connections and ball valves with threaded hose-end, cap, and chain at all low points in piping.

Comply with requirements indicated on Drawings.

Make connections to coils with a **[flange] [or] [union]**.

Connect to each coil inlet with shutoff valve, test plug, **[strainer] [pressure gauge] [and] [thermometer]**.

Connect to each coil outlet with balancing valve, test plug, **[pressure gauge] [thermometer] [flow meter] [and] [shutoff valve]**.

Connect each coil drain connection with a drain valve, which is full size of drain connection.

Connect each coil vent connection with **[automatic] [or] [manual]** vent, which is full size of vent connection.

Retain first two subparagraphs below for air-handling units with factory-installed pumps.

Connect to each pump inlet with flange or union, shutoff valve, test plug, strainer**[ and pressure gauge]**.

Connect to each pump outlet with flange or union, check valve, balancing valve, test plug, **[pressure gauge] [flow meter] [and] [shutoff valve]**.

Include with each strainer a blowdown connection consisting of a nipple and threaded ball valve with threaded hose-end, cap, and chain.

* + - * 1. Chilled-Water Piping Insulation and Identification:

Insulation: Preformed, **[cellular glass] [phenolic foam] [or] [flexible elastomeric] <Insert material>**; minimum **[2 inches] <Insert dimension>** thick.

Adhesive: Compatible with insulation material and recommended in writing by insulation manufacturer.

Jacket: **[None] [ASJ] [PVC, color selected by Architect, 20 mils thick] [Aluminum, smooth, 0.020 inch thick] <Insert jacket>**.

Air-Handling Unit Factory Assembly: Continuously insulate and vapor seal piping system throughout its entire length. Insulate all surface capable of forming condensation.

Install high-density insulation insert products, consisting of two 180-degree halves, at pipe hangers and supports. Material density sufficient to accommodate loading without deformation.

Insulation thickness determined by air-handling unit manufacturer to comply with governing codes, ASHRAE/IES 90.1, and minimum thickness indicated and to prevent condensation.

Insulate piping system only after successful completion of pressure tests.

Install adhesive-backed acrylic identification labels indicating **[pipe size ]**service and direction of flow at multiple locations sufficient for operators to easily follow the flow path. Each branch pipe should have at least one label.

* + - * 1. Heating Water Piping:

Design Pressure and Temperature: **[See Drawings] <Insert pressure and temperature>**.

Pipe: ASME B36.10, carbon steel ASTM A53, with beveled or plain ends; **[electric resistance weld] [or] [seamless]** longitudinal joints, Grade B; standard weight.

Fittings, Threaded: Malleable iron, ASME B16.3; **[Class 150] [or] [Class 300]**.

Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.

Flanges, Weld: Weld-neck, forged carbon-steel, ASME B16.5; **[Class 150] [or] [Class 300]**.

Unions, Threaded: Malleable iron, ASME B16.39; **[Class 150] [or] [Class 300]**.

Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304] [or] [Type 316]** stainless steel with openings not larger than 0.032 inch; **[Class 125] [or] [Class 250]**.

Valves:

Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, and extended stem.

Butterfly: Lugged body; MSS SP-67; cast-iron, ductile-iron, or cast-steel body; stainless steel disk, EPDM seat, and **[lever] [or] [gear]** operator; rated for system pressure, but not less than **[250-psig] <Insert pressure>** bi-directional dead-end shutoff with downstream flange removed.

Check: Globe-style, MSS SP-125; cast-iron ASTM A126 body, stainless steel spring, and bronze seat; **[Class 125] [or] [Class 250].**

**<Insert valve type>**.

Vents: Cast-iron body, stainless steel float, NPS 1/2 or larger inlet connection.

Flow Meters: In-line electromagnetic type with integral display and accuracy within 3 percent of reading.

Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A] [or] [Grade B]** accuracy; metal case with nominal **[4-1/2-inch] [6-inch] <Insert dimension>** shatter-resistant glass face and NPS 1/2 threaded brass connection.

Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded NPS 1/2 connection.

Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch] <Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.

Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.

NPS 2 and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.

Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.

Gradually slope piping for venting and drainage.

Include threaded drain connections and ball valves with threaded hose-end, cap, and chain at all low points in piping.

Comply with requirements indicated on Drawings.

Make connections to coils with a **[flange] [or] [union]**.

Connect to each coil inlet with shutoff valve, test plug, **[strainer] [pressure gauge] [and] [thermometer]**.

Connect to each coil outlet with balancing valve, test plug, **[pressure gauge] [thermometer] [flow meter] [and] [shutoff valve]**.

Connect each coil drain connection with a drain valve, which is full size of drain connection.

Connect each coil vent connection with **[automatic] [or] [manual]** vent, which is full size of vent connection.

Retain first two subparagraphs below for air-handling units with factory-installed pumps.

Connect to each pump inlet with flange or union, shutoff valve, test plug, strainer**[ and pressure gauge]**.

Connect to each pump outlet with flange or union, check valve, balancing valve, test plug, **[pressure gauge] [flow meter] [and] [shutoff valve]**.

Include each strainer with a blowdown connection consisting of a nipple and threaded ball valve with threaded hose-end, cap, and chain.

* + - * 1. Heating Water Piping Insulation and Identification:

Insulation: Preformed, **[cellular glass] [mineral fiber] [or] [phenolic foam] <Insert material>; minimum [2 inches] <Insert dimension>** thick.

Adhesive: Compatible with insulation material and recommended in writing by insulation manufacturer.

Jacket: **[ASJ] [PVC, color selected by Architect, 20 mils thick] [Aluminum, smooth, 0.020 inch thick] <Insert jacket>**.

Air-Handling Unit Factory Assembly: Continuously insulate and seal piping insulation system throughout its entire length.

Install high-density insulation insert products, consisting of two 180-degree halves, at pipe hangers and supports. Material density sufficient to accommodate loading without deformation.

Insulation thickness determined by air-handling unit manufacturer to comply with governing codes, ASHRAE/IES 90.1, and minimum thickness indicated and to prevent condensation.

Insulate piping system only after successful completion of pressure tests.

Install adhesive-backed acrylic identification labels indicating **[pipe size ]**service and direction of flow at multiple locations sufficient for operators to easily follow the flow path. Each branch pipe should have at least one label.

* + - * 1. Piping Hangers and Supports:

Finish: Galvanized metallic coatings including pregalvanized, hot-dip galvanized, or electro-galvanized.

Hangers: MSS-SP-58, Type 1.

Supports: MSS-SP-58, Type 4, Type 24, or Type 37.

Threaded Rods: Continuous-thread rod, nuts, and washer made of **[galvanized steel] [or] [stainless steel] <Insert material>**.

Strut: MFMA-4, continuous slotted **[carbon-steel] [stainless steel, Type 304] [stainless steel, Type 316] [extruded-aluminum] <Insert material>** channel with inturned lips.

Air-Handling Unit Factory Assembly:

Ridgely support piping from internal structure in accordance with governing codes and MSS SP-58.

* + - 1. AIR-HANDLING UNIT FACTORY STEAM AND CONDENSATE PIPING AND PIPING INSULATION
         1. Steam Piping:

Design Pressure and Temperature: **[See Drawings] <Insert pressure and temperature>**.

Pipe: ASME B36.10, carbon steel ASTM A53, with beveled or plain ends; **[electric resistance weld] [or] [seamless]** longitudinal joints, Grade B; standard weight.

Fittings, Threaded: Cast iron, ASME B16.4; **[Class 125] [or] [Class 250]**.

Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.

Flanges, Weld: Weld-neck, forged carbon-steel, ASME B16.5; **[Class 150] [or] [Class 300]**.

Unions, Threaded: MSS SP-83, Class 3000, ASTM A105.

Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304] [or] [Type 316]** stainless steel with openings not larger than 0.032 inch; **[Class 125] [or] [Class 250]**.

Valves:

Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, and extended stem.

Check:

Bronze with Bronze Disc: MSS SP-80, Type 3; Class 150.

Iron with Metal Seats: MSS SP-71, Type I; **[Class 125] [or] [Class 250]**.

Gate:

Bronze: **[MSS SP-80, Type 1] [or] [MSS SP-80, Type 2]**; Class 150.

Iron: MSS SP-70, Type I, **[NRS] [OS & Y]**; **[Class 125] [or] [Class 250]**.

Globe:

Bronze: MSS SP-80, Type 2; Class 150.

Iron: MSS SP-85, Type I; **[Class 125] [or] [Class 250]**.

Flow Meters: Vortex-shedding type with integral display and accuracy within 5 percent of reading.

Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A] [or] [Grade B]** accuracy; metal case with nominal **[4-1/2-inch] [6-inch] <Insert dimension>** shatter-resistant glass face and NPS 1/2 threaded connection.

Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded NPS 1/2 connection.

Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch] <Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.

Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.

NPS 2 and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.

Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.

Gradually slope piping for venting and drainage at not less than 2 percent.

Include threaded drain connections and ball valves with threaded hose-end, cap, and chain at all low points in piping.

Comply with requirements indicated on Drawings.

Make connections to coils[ and humidifiers] with a **[flange] [or] [union]**.

Connect to each coil inlet with shutoff valve, test plug, vacuum breaker, **[strainer] [flow meter] [pressure gauge] [and] [thermometer]**.

Connect to each humidifier inlet with shutoff valve, test plug, vacuum breaker **[strainer] [flow meter] [pressure gauge] [and] [thermometer]**.

Include each strainer with a blowdown connection consisting of a nipple and threaded gate valve with threaded hose-end, cap, and chain.

* + - * 1. Steam Condensate Piping:

Design Pressure and Temperature: **[See Drawings] <Insert pressure and temperature>**.

Pipe: ASME B36.10, carbon steel ASTM A53, with beveled or plain ends; **[electric resistance weld] [or] [seamless]** longitudinal joints, Grade B; Schedule 80.

Fittings, Threaded: Cast iron, ASME B16.4; **[Class 125] [or] [Class 250]**.

Fittings, Butt Welded: ASME B16.9, wrought-steel ASTM A234, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.

Flanges, Weld: Weld-neck, forged carbon-steel, ASME B16.5; **[Class 150] [or] [Class 300]**.

Unions, Threaded: MSS SP-83, Class 3000, ASTM A105.

Strainers: Y-pattern; body and cap constructed of cast-iron, ASTM A126, Class B, removable basket constructed of **[Type 304] [or] [Type 316]** stainless steel with openings not larger than 0.032 inch; **[Class 125] [or] [Class 250]**.

Steam Traps:

Material: **[Cast iron] [Stainless steel] [Stainless steel, Grade 304] [Stainless steel, Grade 316]**.

Type: **[Inverted bucket] [or] [float and thermostatic]**.

Capacity: Sized for a minimum of **[3] <Insert number>** times the maximum rated condensate flow at **[1/2-psig] <Insert value>** differential pressure.

Valves:

Ball: Two-piece with threaded ends, MSS SP-110, 600 WOG; cast-bronze or forged copper-alloy body, stainless steel vented ball, corrosion-resistant plastic-coated handle, and extended stem.

Check:

Bronze with Bronze Disc: MSS SP-80, Type 3; Class 150.

Iron with Metal Seats: MSS SP-71, Type I; **[Class 125] [or] [Class 250]**.

Gate:

Bronze: **[MSS SP-80, Type 1] [or] [MSS SP-80, Type 2]**; Class 150.

Iron: MSS SP-70, Type I, **[NRS] [OS & Y]**; **[Class 125] [or] [Class 250]**.

Globe:

Bronze: MSS SP-80, Type 2; Class 150.

Iron: MSS SP-85, Type I; **[Class 125] [or] [Class 250]**.

Vents: Cast-iron body, stainless steel float, NPS 1/2 or larger inlet connection.

Flow Meters: In-line electromagnetic type with integral display and accuracy within 3 percent of reading.

Pressure Gauges: Bourdon-tube, ASME B40.100 with **[Grade A] [or] [Grade B]** accuracy; metal case with nominal **[4-1/2-inch] [6-inch] <Insert dimension>** shatter-resistant glass face and NPS 1/2 threaded brass connection

Test Plugs: Brass or stainless steel body with core inserts and gasketed and threaded cap, extension for insulation; threaded NPS 1/2 connection.

Thermometers: Bi-metal actuated, ASME B40.200 with 1 percent accuracy; adjustable-angle stainless steel case with nominal **[5-inch] <Insert dimension>** shatter-resistant glass face. Include thermometers with stainless steel extended-neck thermowells.

Air-Handling Unit Factory Assembly: Factory install a complete piping system inside air-handling units as indicated on Drawings.

NPS 2 and smaller with threaded fittings, strainers, and valves. Larger sizes with welded joints, fittings, and flanges for valves and strainers.

Arrange piping with sufficient clearance between piping and other components to accommodate removal and replacement of installed components.

Gradually slope piping for venting and drainage at not less than 2 percent.

Include threaded drain connections and valves with threaded hose-end, cap, and chain at all low points in piping.

Comply with requirements indicated on Drawings.

Make connections to coils **[and humidifiers ]**with a **[flange] [or] [union]** .

Connect to each coil outlet with strainer, steam trap, test plug, vent **[pressure gauge] [thermometer] [flow meter] [and] [shutoff valve]**.

Connect to each humidifier outlet with strainer, steam trap, test plug, **[pressure gauge] [thermometer] [flow meter] [and] [shutoff valve]**.

Connect each coil drain connection with a drain valve, which is full size of drain connection.

Include each strainer with a blowdown connection consisting of a nipple and threaded ball valve with threaded hose-end, cap, and chain.

* + - * 1. Steam and Condensate Piping Insulation:

Insulation: Preformed, **[cellular glass] [or] [mineral fiber] <Insert material>**; minimum **[3 inches] [4 inches] [5 inches] <Insert dimension>** thick.

Adhesive: Compatible with insulation material and recommended in writing by insulation manufacturer.

Jacket: **[ASJ] [Aluminum, smooth, 0.020 inch thick] <Insert jacket>**.

Air-Handling Unit Factory Assembly: Continuously insulate and seal piping insulation system throughout its entire length.

Install high-density insulation insert products, consisting of two 180-degree halves, at pipe hangers and supports. Material density sufficient to accommodate loading without deformation.

Insulation thickness determined by air-handling unit manufacturer to comply with governing codes, ASHRAE/IES 90.1, and minimum thickness indicated and to prevent condensation.

Insulate piping system only after successful completion of pressure tests.

Install adhesive-backed acrylic identification labels indicating **[pipe size ]**service and direction of flow at multiple locations sufficient for operators to easily follow the flow path. Each branch pipe should have at least one label.

* + - * 1. Piping Supports:

Finish: Galvanized metallic coatings including pregalvanized, hot-dip galvanized, or electro-galvanized.

Hangers: MSS-SP-58, Type 1.

Supports: MSS-SP-58, Type 4, Type 24, or Type 37.

Threaded Rods: Continuous-thread rod, nuts, and washer made of **[galvanized steel] [or] [stainless steel] <Insert material>**.

Strut: MFMA-4, continuous slotted **[carbon-steel] [stainless steel, Type 304] [stainless steel, Type 316] [extruded-aluminum] <Insert material>** channel with inturned lips.

Air-Handling Unit Factory Assembly:

Ridgely support piping from internal structure in accordance with governing codes and MSS SP-58.

* + - 1. DRAINS
         1. Floor Drains:

Drain Body: Fabricate floor drain body of NPS 4 or larger aluminum or stainless pipe and weld a plate of same material to the bottom. Option to fabricate an aluminum or stainless steel rectangular box drain at least 4 by 4 inches of material at least 0.1 inch thick.

Drain Connection: Weld a nominal **[NPS 2] <Insert pipe size>** half coupling in side of drain body located within 1 inch from bottom.

Drain Cover: Perforated plate, at least 0.1 inch thick, or grating, fabricated from aluminum or stainless steel. Drain cover shall be supported and secured in place by drain body, but not fastened to drain body with fasteners.

Fluid Seal: **[Seal] [Weld]** floor drain body to air-handling unit floor for a watertight installation.

Mounting: Recess floor drain body into structural base. Top of floor drain to be slightly recessed below air-handling unit finished floor for unobstructed gravity flow from floor into drain.

Retain one of three "Application" subparagraphs below. Floors drains can be provided for various purposes such as cleaning and disinfecting, or to contain small amounts of accumulated water or fluid due to leaks or other abnormal operation. Consult Owner about need for cleaning and servicing.

Application: Install floor drains in air-handling unit floors at locations indicated on Drawings.

Application: Install floor drains in air-handling unit floors of all sections.

Application: Install floor drains in air-handling unit floors of **[coil] [coil and humidifier]** **[coil, heat wheel, heat exchanger, humidifier] [potentially wet] <Insert floor drain locations>** sections and associated access sections.

* + - 1. FACTORY ASSEMBLED ELECTRICAL
         1. Factory install **[UV-C and switches,] [service light fixtures and switches,] [and] [receptacles]** for each air-handling unit.

Locate in a convenient and field-accessible location.

Installation shall comply with NFPA 70.

Wire, Conduit, and Enclosures:

Minimum Conduit Size: **[3/4 inch] <Insert dimension>**.

Materials: **[Metal, with a corrosion-resistant finish] [Aluminum or stainless steel] [Stainless steel]**.

Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware**[ constructed of stainless steel]**.

Conduit: Locate conduit inside the air-handling unit casing. Conduit installed on exterior of air-handling unit casing is unacceptable.

Wire:

Copper, rated for 600 V, solid wire for size **[No. 10 AWG] <Insert wire size>** and smaller and stranded wire for larger sizes.

Minimum Wire Size: **[No. 12 AWG] <Insert wire size>**.

Each circuit shall have a ground wire.

Install wire in conduit.

Boxes, Conduit Outlet Bodies, and Enclosures:

Located in Airstream: NEMA 250, **[Type 4] [Type 4X] [or] [Type 12] <Insert Type>**.

Retain "Located in Service Corridor" or "Located on Exterior of Air-Handling Unit Casing" subparagraph below, or both, as applicable.

Located in Service Corridor: NEMA 250, **[Type 1] [Type 4] [or] [Type 12] <Insert Type>**.

Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R] [Type 4] [or] [Type 4X] <Insert Type>**.

Seals: Seal pathways to prevent air leakage between air-handling unit exterior and interior, and between internal component sections.

UV-C Lamp System Applications: Wire all UV-C lamp systems located in the same air tunnel to a single circuit.

Service Lighting Applications:

Provide quantity of 20-A branch circuits required to power service light fixtures.

For air-handling units consisting of multiple stacked tiers, provide separate circuits for top and bottom tiers of air-handling units.

Factory install a **[main disconnect switch] [field power junction box]** for interfacing air-handling power for service lighting with single-point field power wiring connection.

Receptacle Applications:

For air-handling units consisting of multiple stacked tiers, provide separate circuits for top and bottom tiers of air-handling units.

Factory wire receptacles to a **[main disconnect switch] [field power junction box]** for interfacing air-handling power for receptacles with a single-point field power wiring connection.

Retain "Main Disconnect Switches" paragraph below to require factory-installed disconnect switches for single point interface with field power to service lights and receptacles. Coordinate with service light and receptacle subparagraphs above.

* + - * 1. Main Disconnect Switches: Factory-install main disconnect switch mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.

Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.

Three pole, **[fused] [or] [nonfused]**.

600 V rated.

Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000] [65,000] <Insert value>** A.

Enclosure:

Retain "Located in Service Corridor" or "Located on Exterior of Air-Handling Unit Casing" subparagraph below, or both, as applicable.

Located in Service Corridor: NEMA 250, **[Type 1] [Type 4] [or] [Type 12] <Insert Type>**.

Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R] [Type 4] [or] [Type 4X] <Insert Type>**.

Operating handle shall be of box-mounted type that directly drives switch mechanism.

Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.

Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.

Include a solid neutral as required by authorities having jurisdiction.

Disconnect switch shall have a ground lug for ground wire termination.

Operating handle shall be lockable in open position.

Horsepower rated.

Feed through or double lugged.

Retain "Field Power Junction Box" paragraph below to require factory-installed junction box for connection to field power.

* + - * 1. Field Power Junction Box: Factory-install junction box with internal wire terminal block mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.

Retain "Exterior Service Light Fixtures" paragraph below for air-handling units requiring service lights installed on exterior casing of air-handling units.

* + - * 1. Exterior Service Light Fixtures:

LED Luminaires for Outdoors:

Retain "Basis-of-Design Product" subparagraph below to identify a specific product or a comparable product.

Basis-of-Design Product: Subject to compliance with requirements, <Insert manufacturer's name; product name or designation>.

Finish: Selected by Architect from available finishes offered by manufacturer.

Mounting: Wall.

Intended for direct exposure in outdoor locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.

Light Color: **[4000] [5000]** K.

Light Output: **[3000] [6000] [8000]** lumens.

Additional Protection: **[Vandal guard] [or] [wire guard]**.

On/Off Operation: **[Local toggle switch] [Photo cell with local override toggle switch]**.

Vaportight Fixtures:

Retain "Basis-of-Design Product" subparagraph below to identify a specific product or a comparable product.

Basis-of-Design Product: Subject to compliance with requirements, <Insert manufacturer's name; product name or designation>.

Finish: Selected by Architect from available finishes offered by manufacturer.

Mounting: Wall.

Intended for direct exposure in outdoor locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.

Cast-aluminum housing and guard with heat-resistant, tempered, clear glass globe.

Retain one "Incandescent Lamps" or "LED A21 Series Lamps" subparagraph below.

Incandescent Lamps: **[150] [200] [300]** W.

LED A21 Series Lamps:

Light Color: **[3000] [5000]** K.

Light Output: **[1700] <Insert value>** lumens.

Retain one of two "Application" subparagraphs below.

Application: Provide service light fixtures where indicated on Drawings.

Application: Provide one service light fixture on each side of air-handling unit with access doors. Position fixture at midpoint of most remote access doors.

Retain "Interior Service Light Fixtures" paragraph below for air-handling units requiring service lights.

* + - * 1. Interior Service Light Fixtures:

Retain any of Fluorescent Luminaires," "LED Luminaires," and "Vaportight Fixtures" subparagraphs below. In retaining more than one type of service light fixture, indicate each type of service light fixture on Drawings.

Fluorescent Luminaires:

Retain "Basis-of-Design Product" subparagraph below to identify a specific product or a comparable product.

Basis-of-Design Product: Subject to compliance with requirements, **<Insert manufacturer's name; product name or designation>**.

Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.

High-impact, UV-stabilized, fiberglass-reinforced polyester housing; high-impact acrylic lens.

Two, cool white, T **[5] [5HO] [8] [8HO]** lamps; and an electronic ballast.

LED Luminaires:

Retain "Basis-of-Design Product" subparagraph below to identify a specific product or a comparable product.

Basis-of-Design Product: Subject to compliance with requirements, **<Insert manufacturer's name; product name or designation>**.

Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.

High-impact, UV-stabilized fiberglass housing and acrylic lens.

Light Color: **[3500] [4000] [5000]** K.

Light Output: **[2000] [3000] [4000]** lumens.

Driver: 1 percent dimming.

Vaportight Fixtures:

Retain "Basis-of-Design Product" subparagraph below to identify a specific product or a comparable product.

Basis-of-Design Product: Subject to compliance with requirements, <Insert manufacturer's name; product name or designation>.

Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.

Cast-aluminum housing and guard with heat-resistant, tempered, clear glass globe.

Retain "Incandescent Lamps" or "LED A21 Series Lamps" subparagraph below.

Incandescent Lamps: **[150] [200] [300]** W.

LED A21 Series Lamps:

Light Color: **[3000] [5000]** K.

Light Output: **[1700] <Insert value>** lumens.

Retain one of three "Application" subparagraphs below.

Application: Provide service light fixtures where indicated on Drawings.

Application: Provide one service light fixture in each accessible section of air-handling units.

Application: Provide one service light fixture in fan**[, coil] [filter] <Insert section>** sections of air-handling units.

* + - * 1. Toggle Switches for Service Light Fixtures:

Retain any of first four subparagraphs below as applicable. Coordinate with service light fixture switching requirements indicated in retained "Application" subparagraph.

Single-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.

Two-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.

Three-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.

Four-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.

Retain "Lighted Single-Pole Switches, 120/277 V, 20 A " subparagraph below to add visual indication of switch operation. Coordinate with retained "Application" subparagraph.

Lighted Single-Pole Switches, 120/277 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.

Description: Handle illuminated when switch is on.

Toggle Switch Box and Cover: Mount toggle switch in a **[metal] [cast-aluminum]** outlet box with **[cast-aluminum] [or] [stainless steel]** cover. Weatherproof where exposed to outdoors.

Retain one of three "Application" subparagraphs below.

Application: Factory install service light switches at locations indicated on Drawings.

Application: Factory install a single service light switch to switch all service light fixtures from a single location.

Application:

Factory install a service light switch for each service light fixture or group of service light fixtures accessible from a single access door adjacent to the access door.

Factory install switching configuration (single, three way, or four way) required to operate a single service light fixture or group of service light fixtures from any access door that opens to respective service light fixtures.

Retain "Switches with Lighted Handles Applications" subparagraph below for switch applications with lighted handles serving sections with access doors not having windows.

Switches with Lighted Handles Applications: Lighted handle feature may be omitted where on/off status of internal lights can be viewed through an access door window.

Retain "Receptacles" paragraph below for air-handling units requiring receptacles.

* + - * 1. Receptacles:

Retain "Isolated-Ground Duplex Receptacles, 125 V, 20 A" or "Duplex GFCI Receptacles, 125 V, 20 A" subparagraph below, or both. If retaining both receptacle types, indicate each type on Drawings.

Isolated-Ground Duplex Receptacles, 125 V, 20 A:

Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.

Configuration: NEMA WD 6, Configuration 5-20R.

Standards: Comply with UL 498 and FS W-C-596.

Duplex GFCI Receptacles, 125 V, 20 A:

Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.

Configuration: NEMA WD 6, Configuration 5-20R.

Type: Non-feed through.

Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

Receptacle Box and Cover: Mount receptacle in a **[metal] [cast-aluminum]** outlet box with **[cast-aluminum] [or] [stainless steel]** cover. Weatherproof where exposed to outdoors.

Applications: Factory install a receptacle in a convenient and field-accessible location on air-handling unit exterior of casing **[at locations indicated on Drawings] [near access doors accessing fans] [near access doors accessing electric heaters and fans] [near access doors accessing energy wheels and fans] [near access doors accessing electric heaters, energy wheels and fans] <Insert locations>**.

Retain one of two "Power Supply to Fan Motors" paragraphs below with applicable subparagraphs below.

* + - * 1. Power Supply to Fan Motors: As indicated on Drawings.
        2. Power Supply to Fan Motors: Factory install a **[disconnect switch] [junction box] [motor controller] [variable-frequency controller]** for each fan motor.

Locate in a convenient and field-accessible location on unit exterior.

Installation shall comply with NFPA 70.

Wire, Conduit, and Enclosures:

Minimum Conduit Size: **[3/4 inch] <Insert dimension>**.

Materials: Metal, corrosion resistant**[ and constructed of stainless steel]**.

Motor Termination: Flexible conduit, NRTL listed, not to exceed 36 inches long.

Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware**[ constructed of stainless steel]**.

Wire:

Copper, rated for 600 V, solid wire for size **[No. 10 AWG] <Insert wire size>** and smaller and stranded wire for larger sizes.

Minimum Wire Size: **[No. 12 AWG] <Insert wire size>**.

Each circuit shall have a ground wire.

Install wire in conduit.

Boxes, Conduit Outlet Boxes, and Enclosures:

Located in Airstream: NEMA 250, **[Type 4] [Type 4X] [or] [Type 12] <Insert Type>**.

Retain "Located in Service Corridor" or "Located on Exterior of Air-Handling Unit Casing" subparagraph below, or both, as applicable.

Located in Service Corridor: NEMA 250, **[Type 1] [Type 4] [or] [Type 12] <Insert Type>**.

Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R] [Type 4] [or] [Type 4X] <Insert Type>**.

Retain "Disconnect Switches" paragraph below to require factory-installed disconnect switches.

* + - * 1. Disconnect Switches:

Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.

Three pole, **[fused] [or] [nonfused]**.

600 V rated.

Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000] [65,000] <Insert value>** A.

Enclosure:

Retain "Located in Service Corridor" or "Located on Exterior of Air-Handling Unit Casing" subparagraph below, or both, below as applicable.

Located in Service Corridor: NEMA 250, **[Type 1] [Type 4] [or] [Type 12] <Insert Type>**.

Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R] [Type 4] [or] [Type 4X] <Insert Type>**.

Operating handle shall be of box-mounted type that directly drives switch mechanism.

Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.

Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.

Include a solid neutral as required by authorities having jurisdiction.

Disconnect switch shall have a ground lug for ground wire termination.

Operating handle shall be lockable in open position.

Horsepower rated.

Feed through or double lugged.

Retain "Motor Field Power Junction Box" paragraph below to require factory-installed motor junction box for connection to field power.

* + - * 1. Motor Field Power Junction Box:

Provide junction box with internal wire terminal block mounted on unit exterior for interface with field power wiring.

Provide for each motor not installed with a factory disconnect or controller with integral disconnect.

Factory install internal wiring and conduit to motor.

Retain "Motor Controllers" paragraph below to require factory-installed motor controllers.

* + - * 1. Motor Controllers:

NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.

Configured for control of single- or multispeed motors as indicated.

Enclosure: Hinged full-front access door with lock and key.

Retain "Located in Service Corridor" or "Located on Exterior of Air-Handling Unit Casing" subparagraph below, or both, below as applicable.

Located in Service Corridor: NEMA 250, **[Type 1] [Type 4] [or] [Type 12] <Insert Type>**.

Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R] [Type 4] [or] [Type 4X] <Insert Type>**.

Externally Operated**[, Door-Interlocked] Disconnect: [Fused disconnect switch] [Nonfused disconnect switch] [Circuit breaker]** with lockable handle.

Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000] [65,000] [100,000] <Insert value>** A.

Hand-Off-Auto Switch: Mounted on face of enclosure.

Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.

Control Relays: Time-delay relays.

Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.

Retain "Elapsed-Time Meters" subparagraph below to add local display of operating hours.

Elapsed-Time Meters: Numerical readout in hours on face of enclosure.

Retain "Number-of-Starts Counter" subparagraph below to add local display of fan motor starts.

Number-of-Starts Counter: Numerical readout on face of enclosure.

Retain "Variable-Frequency Controllers" paragraph below to require factory-installed, variable-frequency controllers.

* + - * 1. Variable-Frequency Controllers:

Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.

Enclosure: Unit mounted, with hinged full-front access door with lock and key.

Retain any "Located in Service Corridor" or "Located on Exterior of Air-Handling Unit Casing" subparagraph below, or both, below as applicable.

Located in Service Corridor: NEMA 250, **[Type 1] [Type 4] [or] [Type 12] <Insert Type>**.

Located on Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 3R] [Type 4] [or] [Type 4X] <Insert Type>**.

Externally Operated**[, Door-Interlocked]** Disconnect: **[Fused disconnect switch] [Nonfused disconnect switch] [Circuit breaker]** with lockable handle.

Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than **[42,000] [65,000] [100,000] <Insert value>** A.

Technology: Pulse-width-modulation (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.

Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.

Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.

Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.

Operating Requirements:

Input AC Voltage Tolerance: **[10] <Insert number>** percent.

Input frequency tolerance of 60 Hz, plus or minus 2 Hz.

Capable of driving full motor load, without derating.

Minimum Efficiency: 96 percent at 60 Hz, full load.

Minimum Displacement Primary-Side Power Factor: 95 percent.

Overload Capability: 1.05 times the full-load current for 7 seconds.

Starting Torque: As required by fan and motor drive assembly.

Speed Regulation: 1 percent.

Speed Range: 10:1 speed range.

To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.

Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.

Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or need for replacement:

Surge suppression.

Loss of input signal protection.

Critical frequency rejection.

Overtemperature.

Short circuit at controller output.

Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.

Open circuit at controller output.

Input undervoltage.

Input overvoltage.

Loss of input phase.

Reverse phase.

AC line switching transients.

Instantaneous overload, line to line or line to ground.

Sustained overload exceeding 100 percent of controller rated current.

Starting a rotating motor.

**<Insert features>**.

Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.

Automatic Reset and Restart:

Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.

Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

Visual Indication: On face of controller; indicating the following conditions:

Retain any of first 13 subparagraphs below as required by application. Some requirements may not be available from all listed manufacturers. Consult listed manufacturers to confirm availability.

Power on.

Run.

Overcurrent and overvoltage.

Motor speed (percentage).

Various faults with alarm status.

Input kilovolt amperes.

Power factor.

Input kilowatts and kilowatt-hours.

Three-phase input and output voltage.

Three-phase input and output current.

Output frequency.

Elapsed operating time (hours).

Diagnostic and service parameters.

**<Insert conditions>**.

Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.

Hardwired Control Signal Interface: A minimum of **[two] <Insert number>** analog inputs (0 to 10 V or 0/4 to 20 mA) and **[four] <Insert number>** programmable digital inputs.

Remote Communication Interface: **[ASHRAE 135 BACnet MS/TP] [ASHRAE 135 BACnet IP] <Insert requirements>**.

Line Conditioning:

Input line conditioning.

Output filtering.

EMI/RFI filtering.

Retain "Bypass Controller" subparagraph below to require variable-frequency controller with added operational reliability.

Bypass Controller:

Bypass Controller/Variable-Frequency Controller Selector Switch: Include manual selector switch on face of enclosure for local operator control of preferred controller.

Bypass Mode: **[Manual operation only] [Field-selectable automatic or manual]**.

Retain first subparagraph below if retaining "Field-selectable automatic or manual" option in "Bypass Mode" subparagraph above.

In automatic mode, include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.

Type: Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.

Arrangement: Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller for safe servicing of variable-frequency controller.

Enclosure: Install bypass controller in same enclosure as variable-frequency controller.

Remote Monitoring: Include control relay for remote indication of bypass controller operation.

* + - 1. FACTORY-ASSEMBLED CONTROLS

Retain "General" paragraph below to include factory installation of controls located inside air-handling unit casing. See the Evaluations.

* + - * 1. General:

Air-handling unit manufacturer shall furnish and factory install control instruments, control power circuit, control transformers, power supplies, wiring, tubing, raceways, and control panels.

Provide for a single-point field connection to **[120] [277]**-V electrical power for all factory-installed controls. Terminate power connection with a toggle switch mounted in control panel.

Control panel shall serve as field tie-in point for all electric damper actuators, and control instruments located within air-handling unit. Controls for control dampers, control valves and instruments installed in ductwork and piping are not included as part of air-handling unit factory-installed controls.

Control instruments shall be installed in accordance with manufacturer's written instructions.

Control panel shall house flow, moisture, pressure and temperature transmitters, transformers, dc voltage power supplies, and wiring terminal strip.

Carbon dioxide transmitters shall be mounted on air-handling unit casing exterior with sensor port exposed to the airstream.

Factory install the following control instruments:

Retain any of first seven subparagraphs below. If requirements differ between air-handling units, indicate requirements on Drawings.

Flow station and flow transmitter for each fan.

Pressure sensors (inlet and discharge) and one combination pressure differential transmitter, switch, and controller for each filter bank installed in the air-handling unit.

Pressure sensor and combination pressure differential transmitter, switch, and controller at the inlet of each fan.

Pressure sensor and combination pressure differential transmitter, switch, and controller at the discharge of each fan.

Carbon dioxide sensor/transmitters at locations indicated on Drawings.

Moisture and temperature sensors and transmitters at locations indicated on Drawings.

Temperature switches at locations indicated on Drawings.

Control instruments indicated on Drawings.

**<Insert requirements>**.

* + - * 1. Wire and Cable:

Single Conductor Control Wiring above 24 V:

Wire size shall be at least No. 16 AWG.

Conductor shall be 7/24 soft annealed copper stranding with a 2- to 2-1/2-inch lay.

Conductor insulation shall be 600 V, Type THWN or Type THHN, 90 deg C in accordance with UL 83.

Conductor colors shall be black (hot), white (neutral), and green (ground).

Single Twisted Shielded Instrumentation Cable above 24 V:

Wire size shall be minimum No. 18 AWG.

Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2-1/2-inch lay.

Conductor insulation shall have a Type THHN/THWN or Type TFN rating.

Shielding shall be 100 percent 0.35/0.5-mil aluminum/mylar tape, helically applied with 25 percent overlap, and aluminum side in with a No. 18 AWG-7/26 tinned copper drain wire.

Outer jacket insulation shall have a 600-V, 90 deg C rating and shall be Type TC cable.

For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red, and white.

Single Twisted Shielded Instrumentation Cable 24 V and Lower:

Wire size shall be minimum No. 18 AWG.

Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2-1/2-inch lay.

Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.

Shielding shall be 100 percent 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with a No. 20-22 AWG tinned copper drain wire.

Outer jacket insulation shall have a 300-V, 105 deg C rating and shall be Type PLTC cable.

For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red, and white.

Wire and Cable Installation:

Comply with manufacturer's written instructions and NFPA 70.

Grounding shall be in accordance with IEEE C2. Ground wire shall be copper. Demonstrate ground resistance.

Wiring and cables shall be installed in conduit. Exposed wire and cable are unacceptable.

Wire and cables may be grouped in a common raceway, except do not group wires and cables from different voltages.

Install control wiring in a separate conduit from power wiring.

Wiring shall be continuous from terminal to terminal without splices.

Do not install low-voltage wire and cable closer than [12 inches] <Insert distance> from line voltage electrical power wire and cables. Provide an installation free of EMI.

Use insulated spade lugs for wiring connection to screw terminals.

Use shielded cable to transmitters.

Terminate wiring and cables within a control panel, within instrument housing, or in a junction box. Clamp the cable over the jacket, in the junction box. Individual conductors in the stripped section of cable shall be slack between clamping point and terminal block.

Terminate wire and cable in control panel with terminal blocks.

Identify each wire and cable on each end and at each terminal with a number coded identification tag. Each wire and cable conductor shall have a unique tag.

Perform continuity and meager testing on wiring and cable.

* + - * 1. Raceways:

Conduit:

Install wiring and cable in conduit.

Minimum Conduit Size: **[1/2 inch] [3/4 inch] <Insert dimension>**.

Materials: Metal, corrosion resistant**[ and constructed of stainless steel]**.

Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware**[ constructed of stainless steel]**.

Terminations to Actuators and Instruments: Flexible conduit, NRTL listed, not to exceed 24 inches long.

Boxes, Conduit Outlet Boxes, and Enclosures:

Located in Airstream: NEMA 250, **[Type 4] [Type 4X] [or] [Type 12] <Insert Type>**.

Retain "Located in Service Corridor" or "Located on Exterior of Air-Handling Unit Casing" subparagraph below, or both, as applicable.

Located in Service Corridor: NEMA 250, **[Type 1] [Type 4] [or] [Type 12] <Insert Type>**.

Located on Exterior of Air-handling Unit Casing: NEMA 250, **[Type 4] [or] [Type 4X] <Insert Type>**.

Seals: Seal pathways to prevent air leakage between air-handling unit exterior and interior, and between internal component sections.

Conduit Installation:

Conduit shall be continuous and secured in a manner that is electrically continuous throughout.

Secure threaded conduit entering a cabinet, box or enclosure with a locknut on outside and on inside, such that conduit system is electrically continuous throughout.

Install a metal bushing with insulated throat on inside.

Locknuts designed to bite into metal, or on inside of enclosure and shall have a grounding wedge lug under locknut.

Conduit box connectors for conduit entering enclosures shall be insulated throat type.

Connect conduit with watertight sealing locknuts that are suitable for wet applications.

Offset conduits where they enter surface-mounted equipment and panels.

Neatly loop and lace wiring installed in panels and other enclosures.

Seal conduit runs to prevent the circulation of air by installing seal fittings.

Install conduit inside of air-handling unit casing. Wiring and conduit running on exterior of air-handling unit casing is unacceptable.

* + - * 1. Tubing and Fittings:

Products in this paragraph are intended for use with the following:

Retain first subparagraph below if Project includes pneumatic products.

Main air and signal air to pneumatically controlled instruments, actuators, and other control devices and accessories.

Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.

Copper Tubing:

Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties in accordance with ASTM B75.

Performance, dimensions, weight and tolerance in accordance with ASTM B280.

Diameter, as required by application, not less than nominal 0.25 inch.

Wall thickness, as required by application, but not less than 0.030 inch.

Copper Tubing Fittings: Brass, compression type.

Polyethylene Tubing:

Fire-resistant black virgin polyethylene in accordance with ASTM D1248, Type 1, Class C and Grade 5.

Tubing shall comply with stress crack test in accordance with ASTM D1693.

Diameter, as required by application, of not less than nominal 0.25 inch.

Polyethylene Tubing Fittings: Brass, compression type.

Retain "Stainless Steel Tubing" subparagraph below where tubing is exposed to a corrosive airstream.

Stainless Steel Tubing:

Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale.

Chemical and physical properties in accordance with ASTM A269.

Diameter, as required by application, of not less than nominal 0.25 inch.

Wall thickness, as required by application, but not less than 0.035 inch.

Furnish stainless steel tubing in **[20-foot]** straight random lengths.

Stainless Steel Tubing Connectors and Fittings:

Connectors and fittings shall be stainless steel, with stainless steel collets, flareless type.

Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.

Tubing Installation:

Use **[copper] [or] [stainless steel]** tubing except use fire-resistant polyethylene for tubing located in control panels.

Run tubing parallel to, and at right angles to, casing.

Route multiple runs of tubing in neat parallel lines.

Support tubing as follows:

Support metal tubing with hangers, clips, and tube trays.

Do not use tapes for mounting tubing.

Place a support within 1 foot of each change in direction and each branch take off.

Spacing between supports shall not exceed **[60 inches] <Insert distance>**.

Tubing shall not interfere with access to dampers and equipment or obstruct passageways of any kind.

Provide vibration loops in tubing when connecting to equipment that might vibrate.

Where joining or mating dissimilar metals where galvanic action could occur, provide dielectric isolation.

Make tubing bends with a bending tool. Hard bends, or wrinkled or flattened bends are unacceptable.

Install tubing fitting make-up in accordance with manufacturer's written instructions.

Do not make tubing connections to a fitting before completing make-up connection.

Properly align tubing with fitting. Springing tube into position can result in excessive stress on both tubing and fitting with possible resulting leaks.

Do not install fittings close to a bend. Length of straight tubing, not deformed by bending is required for a proper connection.

Check tubing for correct diameter and wall thickness. Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.

Wrap threads of fittings with a single wrap of PTFE tape.

Install tubing with extreme care to keep foreign matter out. Keep open ends of tubing plugged to keep out dust, dirt, and moisture.

Mark each tube on each end with a number-coded identification. Each tube shall have a unique number.

Test tubing shall as follows:

Test for leaks and obstructions. Disconnect each tubing run before test is run, and blow out trash, condensate, and other foreign material with compressed air.

After foreign matter is expelled and the line is free from obstructions, plug the far end of tubing run.

Connect a pressure source to the near end with a needle valve between air supply and tubing run. Only commercially pure dry compressed air or nitrogen as distributed in gas cylinders is acceptable for this test.

* + - * 1. Control Panels:

Design control panels for grouping and protecting various electric, and/or electronic components.

NRTL listed in accordance with UL 50 or UL 50E.

Enclosure:

Retain "Located in Service Corridor" or "Located on Exterior of Air-Handling Unit Casing" subparagraph below, or both, as applicable.

Located in Service Corridor: NEMA 250, **[Type 1] [Type 4] [or] [Type 12] <Insert Type>**.

On Exterior of Air-Handling Unit Casing: NEMA 250, **[Type 4] [or] [Type 4X] <Insert Type>**.

Construct enclosure of steel, not less than the following:

Enclosure Size Less Than 24 inches: **[0.053 inch] [or] [0.067 inch]** thick.

Enclosure size 24 inches and Larger: **[0.067 inch] [or] [0.093 inch]** thick.

Support front panel using a non-removable piano hinge that runs entire height of cabinet.

Each panel shall not exceed height of air-handling unit casing and 72 inches high.

Secure front panel with a key locking mechanism. Common key the locks, and provide one pair of keys per panel.

Front panel with a window of size so all instrument displays are visible with door closed.

Mount panels on exterior wall of air-handling unit casing on primary access side of unit.

Paint control panel exterior with enamel at least 5 mils thick. Color of panel exterior and interior shall be white.

Include panel field power supply with a toggle-type switch located at entrance inside panel to disconnect power.

Retain first subparagraph below for enclosure-mounted receptacle.

Include panel with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.

Size control panel to provide at least 25 percent spare area on subpanel.

Arrange control panel so similar type equipment is grouped together, and a barrier is installed between electrical and electronic equipment.

Interior ambient temperature shall not rise above manufacturer's recommended maximum operating temperature for products installed within the panels. Provide filtered louvers and circulating fans, when necessary, to meet criteria.

Panel shall serve as a central tie-in point for control devices such as remote sensors, transmitters, power supplies, and transformers.

Factory install internal wiring in compliance with specified standards.

Terminate wiring using an electric terminal strip with heavy-duty terminal blocks.

Include spare terminals, equal to not less than **[10] [20] <Insert number>** percent of used terminals.

Include spade lugs for stranded wire.

Install a maximum of two wires on each side of a terminal.

Label each end of cable, wire, and tubing within panel following an approved identification system.

Polyethylene tubing may be used within panel enclosure in place of copper.

Supply each control panel with a complete set of as-built schematics, tubing, and wiring diagrams that are bound in a three-ring protective binder and located within panel.

Mount instruments and other products within control panel on an internal panel(s) and provide with nameplates. Provide engraved, laminated phenolic nameplates (black letters on a white background). Nameplates shall have at least 1/4-inch- high lettering.

Route tubing, cable and wiring located inside control panel within a raceway that has a continuous removable cover.

* + - * 1. Pitot Tube Airflow Stations:

"Fan Inlet Airflow Sensor (Piezometer Ring)" paragraph below is an alternative to externally mounted fan inlet airflow sensors. These airflow sensors can be provided by some fan manufacturers as a component of the fan. Requirements in remaining subparagraphs below are based on Twin City Fan's "Piezometer Ring." For other pitot tube airflow stations options, see Section 230923.14 "Flow Instruments."

Fan Inlet Airflow Sensor (Piezometer Ring):

Manufacturers: Subject to compliance with requirements, provide products by the following:

Greenheck Fan Corporation.

Approved equivalent.

Source Limitations: Obtain sensors from single source from single manufacturer.

Requirements in remaining subparagraphs below are based on Twin City Fan's "Piezometer Ring."

Provide fans with airflow measurement integral to fan inlet cones for continuously measurement of air volume flow rate.

Fan inlet airflow sensor shall contain multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.

Sensor points shall neither protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.

Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.

Sensor shall be non-intrusive and not impact fan performance.

Product shall be a standard offering of fan manufacturer and include published literature with supporting test data to validate sensor performance.

* + - * 1. Thermal Airflow Measurement Stations:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Ebtron, Inc.

Approved equivalent.

Source Limitations: Obtain stations from single source from single manufacturer.

Requirements in remaining subparagraphs below are based on Ebtron's "Gold Series." For other airflow stations, see Section 230923.14 "Flow Instruments."

Description: Airflow station shall consist of one or more sensor probes and a remotely mounted microprocessor-based transmitter.

Performance:

Capable of independently processing up to **[16] <Insert number>** independently wired sensor assemblies.

Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.

Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output unless temperature sensor has an accuracy of 0.1 deg F.

Listed and labeled by an NRTL as successfully tested as an assembly in accordance with UL 873 or UL 60730.

Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-plenum-rated cable placed in conduit.

Each flow station shall be factory calibrated at a minimum of **[six] [16] <Insert number>** airflow rates and **[two] [three] <Insert number>** temperatures to standards that are traceable to NIST.

Individual Sensor Airflow Accuracy: Within **[2] [3] <Insert number>** percent of reading over the entire operating airflow range.

Thermal Airflow Station Assembly Airflow Accuracy: Within **[2] [3] [5] <Insert number>** percent of reading over the entire operating airflow range.

Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets performance requirements throughout the measurement range.

Temperature Accuracy: Within 0.2 deg F over entire operating range of minus 20 to plus 140 deg F.

Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F.

Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F.

Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, noncondensing.

Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.

Pressure Drop: 0.05 inch wg at 2000 fpm across a 24-by-24-inch area.

Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than **[1] [2] <Insert number>** percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan to deliver Project design airflow indicated.

Sensor Assemblies:

Option in first subparagraph below may not be available from all listed manufacturers. Consult manufacturers for availability.

Each sensor probe shall contain two individually wired, hermetically sealed **[bead-in-glass ]**thermistors.

Mount thermistors in sensor using a marine-grade, waterproof material.

Thermistor leads shall be protected and not exposed to environment.

Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.

Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.

Sensor Probe Material: Gold anodized, extruded Alloy 6063 aluminum tube or Type 304 stainless steel.

Probe Assembly Mounting Brackets Material: Type 304 stainless steel.

Transmitter:

Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.

Capable of field configuration and diagnostics using an onboard push-button interface and digital display.

Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:

Integral protection from transients and power surges.

Circuitry to ensure reset after power disruption, transients, and brownouts.

Integral transformer to convert field power source to operating voltage required by instrument.

Remote Signal Interface:

Retain one of four subparagraphs below.

Linear Analog Signals for Airflow**[ and Temperature]**: Fuse protected and isolated, **[field selectable,] [0 to 10 V dc] [or] [4 to 20 mA]**.

RS-485: BACnet-ARCNET, BACnet-MS/TP, and Modbus-RTU.

10 Base-T Ethernet: BACnet Ethernet, BACnet-IP, Modbus-TCP, and TCP/IP.

LonWorks free topology.

* + - * 1. Flow Transmitters for Pitot Tube Sensors:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Air Monitor Corporation.

Approved equivalent.

Source Limitations: Obtain sensors from single source from single manufacturer.

Requirements in remaining subparagraphs are based on Air Monitor's "Veltron II. For other transmitters, see Section 230923.14 "Flow Instruments."

Receives total and static pressure signals from a flow element, amplify, extract the square root, and scale the signal to produce a 4- to 20-mA dc output signal linear to airflow.

Housed in NEMA 250, Type 1 enclosure.

Assembly constructed so that shock, vibration, and pressures surges of up to 1 psig will neither harm transmitter nor affect its accuracy.

Provide transmitter with an automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. Automatic zeroing circuit shall re-zero transmitter to within 0.1 percent of true zero.

Performance:

Range: At least 20 percent below minimum airflow and 20 percent greater than design airflow.

Calibrated Span: Field adjustable, minus 40 percent of the range.

Accuracy: Within 0.10 percent of natural span.

Repeatability: Within 0.15 percent of calibrated span.

Linearity: Within 0.2 percent of calibrated span.

Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.

Equip transmitter with an integral digital LED or LCD for continuous indication of airflow.

Install in control panel.

* + - * 1. Humidity Sensors and Transmitters with Digital Display:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Vaisala.

Approved equivalent.

Source Limitations: Obtain sensors and transmitters from single source from single manufacturer.

Requirements in remaining subparagraphs are based on Vaisala's "Model HMT100 Series." For other transmitters, see Section 230923.19 "Moisture Instruments."

Performance:

Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent relative humidity when operating between 60 to 77 deg F.

Relative Humidity Range: Zero to 100 percent.

Factory calibrated and NIST traceable with certificate included.

Construction:

Provide housing with remote sensor probe for ducted applications.

Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least 2 inches long for duct-mounted applications.

Provide sensor with cable for field installation in conduit.

For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.

Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless steel filter.

Housing shall be ABS/PC plastic or powder-coated aluminum.

Housing Classification: NEMA 250, Type 4 or Type 4X.

Provide housing with wall-mounting plate.

Output Signal: Two-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24 V dc.

Provide unit with a digital display of relative humidity in percent.

* + - * 1. Air Pressure Sensors:

Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

**<Insert manufacturer's name>**.

Approved equivalent.

Source Limitations: Obtain sensors from single source from single manufacturer.

Requirements in remaining subparagraphs below are based on Dwyer's "Model A 301 Series." For other sensors, see Section 230923.23 "Pressure Instruments."

Insertion length shall be at **[4 inches] [6 inches] [8 inches] [12 inches]**.

Sensor with four radial holes of 0.04-inch diameter.

**[Brass] [or] [stainless steel]** construction.

Sensor with threaded end support, sealing washers, and nuts.

Connection: NPS 1/4 compression fitting.

* + - * 1. Air-Pressure Differential Indicating Transmitter, Switch, and Controller:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Dwyer Instruments, Inc.

Approved equivalent.

Source Limitations: Obtain from single source from single manufacturer.

Requirements in remaining subparagraphs below are based on Dwyer's "Series DH3 Digihelic." For other transmitters and switches, see Section 230923.23 "Pressure Instruments."

Description:

Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.

Field configurable for pressure, velocity, and volumetric flow applications through user interface.

Select instrument range based on application. Range shall be approximately 2 times set point.

Performance:

Accuracy Including Hysteresis and Repeatability:

Within 1 percent for ranges less than 5 inches wg.

Within 0.5 percent at 77 deg F for other ranges.

Stability: Within 1 percent per year.

Response Time: 250 ms.

Overpressure: 5 psig for instrument ranges less than 50 inch wg and 9 psig for 100-inch wg range.

Temperature Limits: 32 to 140 deg F.

Thermal Effects: 0.020 percent per deg F.

Warm-up Period: One hour.

Controller Programming through Menu Keys to Access Five Menus:

Security level.

Pressure, velocity, or flow application.

Engineering units.

K-factor for use with flow application.

Set-point control only; set-point and alarm operation; and alarm operation as high, low, or high/low with manual or automatic reset and delay.

View high and low readings.

Digital dampening for smoothing erratic applications.

Scaling of analog output to fit range and field calibration.

Display:

Digital, four-digit display with backlight, with 0.4-inch- high, alphanumeric characters.

Four indicators; two for set point and two for alarm status.

Operator Interface:

Set-point adjustment through keypad on face of instrument.

Zero and span adjustments accessible through menu.

Programming through keypad.

Analog Output Signal:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into a 900-ohm load.

Digital Output Signal:

Two SPDT relays.

Each rated for 1 A at 30 V ac or dc.

Construction:

Die cast-aluminum casing and bezel.

Threaded, NPS 1/8 connections on side and back.

Vertical plane mounting.

NEMA 250, Type 1.

Nominal 4-inch- diameter face.

Mounting Bracket: Appropriate for installation.

* + - * 1. Carbon Dioxide Sensors/Transmitters:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Vaisala.

Approved equivalent.

Source Limitations: Obtain sensors/transmitters from single source from single manufacturer.

Requirements in remaining paragraphs below are based on Vaisala's "GMD 20 Series." For other transmitters, see Section 230923.16 "Gas Instruments."

Description:

NDIR technology or equivalent technology providing long-term stability and reliability.

Two-wire, 4- to 20-mA output signal; linearized to carbon dioxide concentration in ppm.

Construction:

House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 4.

Equip with digital display for continuous indication of carbon dioxide concentration.

Performance:

Measurement Range: 0 to 2000 ppm.

Accuracy: Within 2 percent of reading, plus or minus 30 ppm.

Repeatability: Within 1 percent of full scale.

Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F.

Long-Term Stability: Within 5 percent of full scale after more than five years.

Response Time: Within 60 seconds.

Warm-up Time: Within five minutes.

Provide calibration kit. Turn over to Director’s Representative at start of warranty period.

* + - * 1. Air Temperature Sensors:

Platinum Resistance Temperature Detector (RTD): Common Requirements:

100 or 1000 ohms at 0 deg C and a temperature coefficient of 0.00385 ohms/ohm/deg C.

Two-wire Teflon insulated 22-gauge stranded copper leads.

Performance Characteristics:

Range: Minus 50 to plus 275 deg F.

Interchangeable Accuracy: At 32 deg F within 0.5 deg F.

Repeatability: Within 0.5 deg F.

Self-Heating: Negligible.

Transmitter Requirements:

Transmitter required for each 100-ohm RTD.

Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

Platinum RTD, Averaging Sensor:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Minco.

Approved equivalent.

Source Limitations: Obtain sensors from single source from single manufacturer.

Requirements in nine subparagraphs below are based on Minco's "S400 Series PD or PF." For other sensors, see Section 230923.27 "Temperature Instruments."

**[100] [or] [1000]** ohms.

Temperature Range: Minus 50 to plus 275 deg F.

Multiple sensors to provide average temperature across entire length of sensor.

Rigid probe of aluminum, brass, copper or stainless steel sheath.

Flexible probe of aluminum, brass, copper or stainless steel sheath and formable to a 4-inch radius.

Length: As required by application to cover entire cross section of air tunnel.

Enclosure: Junction box with removable cover; NEMA 250, Type 4.

Gasket for attachment to duct or equipment to seal penetration airtight.

Conduit Connection: 1/2-inch trade size.

* + - * 1. Air Temperature Switches:

Thermostat and Switch for Low Temperature Control:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Honeywell Building Solutions; Honeywell International, Inc.

Siemens Industry, Inc., Building Technologies Division.

Approved equivalent.

Source Limitations: Obtain switches from single source from single manufacturer.

General:

Two-position control.

Field-adjustable set point.

Manual reset.

NRTL listed.

Performance:

Operating Temperature Range: 15 to 55 deg F.

Temperature Differential: 5 deg F, non-adjustable and additive.

Enclosure Ambient Temperature: Minus 20 to plus 140 deg F.

Sensing Element Maximum Temperature: 250 deg F.

Voltage: 120 V ac.

Current: 16 full-load A.

Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.

Construction:

Vapor-Filled Sensing Element: Nominal 20 feet long.

Dual Temperature Scale: Fahrenheit and Celsius visible on face.

Set-Point Adjustment: Screw.

Enclosure: Painted metal, NEMA 250, Type 1.

Electrical Connections: Screw terminals.

Conduit Connection: 1/2-inch trade size.

* + - * 1. Air Temperature RTD Transmitters:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Minco.

Approved equivalent.

Source Limitations: Obtain transmitters from single source from single manufacturer.

Requirements in remaining paragraphs are based on Minco's "TT Series." For other transmitters, see Section 230923.27 "Temperature Instruments."

House electronics in NEMA 250, Type 1 enclosure. Mount transmitter in control panel.

Conduit Connection: 1/2-inch trade size.

Functional Characteristics:

Input:

100-ohm platinum RTD temperature coefficient of 0.00385 ohms/ohms/deg C; two-wire sensors.

1000-ohm platinum RTD temperature coefficient of 0.00385 ohms/ohms/deg C; two-wire sensors.

Span (Adjustable):

Exhaust Air: 50 to 100 deg F.

Mixed Air: Minus 40 to plus 140 deg F.

Outdoor: Minus 40 to plus 140 deg F.

Supply Air, Cooling, and Heating: 40 to 120 deg F.

Return Air: 50 to 100 deg F.

Output: 4- to 20-mA dc linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24 V dc.

Zero and span field adjustments plus or minus 5 percent of span. Minimum span 50 deg F.

Match sensor with temperature transmitter and factory calibrate together.

Performance Characteristics:

Calibration Accuracy: Within 0.1 percent of span.

Stability: Within 0.2 percent of span for at least six months.

Combined Accuracy: Within 0.5 percent.

Provide each transmitter with a digital display.

* + - * 1. Liquid Flow Meters:

General: Extended range of **[10] [20] <Insert number>** percent above Project design flow and **[10] [20] <Insert number>** percent below Project minimum flow to signal abnormal flow conditions.

In-Line Body Electromagnetic Flow Meter:

Manufacturers: Subject to compliance with requirements, provide products by the following:

ONICON Incorporated.

Approved equivalent.

Source Limitations: Obtain flow meters from single source from single manufacturer.

Requirements in remaining subparagraphs below are based on Onicon's "F-3200 Series." For other flow meter types, see Section 230923.14 "Flow Instruments."

Description:

No moving parts.

Suitable for flow measurement of fluids with electrical conductivity more than 5 micro-Seimens per cm.

Inherent bi-directional flow measurement.

Flow measurement with three pipe diameters upstream and two pipe diameters downstream.

Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.

Transmitter **[integral to] [remote from]** meter.

Performance:

Accuracy for Velocities between 3.3 and 33 fps: Within 0.2 percent of reading.

Accuracy for Velocities between 1.0 and 3.3 fps: Within 0.75 percent of reading.

Accuracy for Velocities Less than 1.0 fps: Within 0.0075 fps.

Ambient Temperature: Minus 4 to plus 140 deg F.

Process Temperature: Minus 4 to plus 212 deg F.

Pressure: **[225 psig ] [580 psig ]**.

Analog Output Current Signal:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into 1000-ohm load.

Isolated.

Digital Output Signal: Two, programmable, digital/pulse outputs configurable for frequency, pulse, or directional flow.

Operator Interface:

Keypad.

Digital Display: Multiple-line digital display of alphanumerical characters.

LED for normal and alarm operation.

Construction:

Body: **[Epoxy-coated carbon steel] [Type 316 stainless steel]**.

PTFE liner offers greater size and temperature range. Consult manufacturer for liner limitations.

Body Liner Material: **[PTFE] [Ebonite] [Polypropylene]**.

Flow Tube: Type 304 stainless steel.

Connection: **[150 Class flange] [300 Class flange] [Threaded] [Wafer]**.

Electrodes: Type 316 stainless steel. Quantity determined by manufacturer based on application.

Electronics Enclosure:

Painted aluminum.

Removable cover.

NEMA 250, Type 4 or Type 6.

Vortex Shedding Flow Meter with Integral Pressure and Temperature Measurement:

Manufacturers: Subject to compliance with requirements, provide products by the following:

ONICON Incorporated.

Approved equivalent.

Source Limitations: Obtain flow meters from single source from single manufacturer.

Requirements in remaining subparagraphs below are based on Onicon's "F-2500 Series." For other flow meter types, see Section 230923.14 "Flow Instruments."

Description:

Mass flow measurement corrected for density using vortex shedding body with integral piezoelectric pressure sensors and 1000-ohm platinum RTD.

Meter NPS 1/2 through NPS 12.

Each meter shall be factory calibrated at five points from 0 to 250 fps and tagged accordingly against manufacturer's flow standards. Manufacturer shall provide a certificate of calibration for meter.

Each meter shall be programmed using Project-specific application data.

Meter shall include integral diagnostics to verify installation conditions and proper operation.

Performance:

Volumetric Flow Accuracy for Liquid: Within 0.75 percent of reading for Reynolds numbers 20000 and larger.

Volumetric Flow Accuracy for Steam and Gas: Within 1 percent of reading for Reynolds numbers 20000 and larger.

Mass Flow Accuracy for Steam and Gas: Within 1.5 percent of reading for Reynolds numbers 20000 and larger.

Repeatability: Within 0.1 percent.

Long-Term Stability: Within 0.1 percent per year.

Ambient Temperature: Minus 40 to plus 185 deg F.

Process Temperature: Minus 40 to plus 464 deg F.

Pressure: Equal to flange rating.

Output Signals:

Analog Current Signal of Flow Rate:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into 1000-ohm load.

Analog Current Signals for Pressure and Temperature: Separate 4- to 20-mA signals for gauge pressure and temperature.

Digital Signal:

Pulse output for flow totalization. Two wire, scaled pulse, 0.5 Hz, 100 mA at 30 V dc.

HART, FSK protocol.

Operator Interface:

Keypad.

Digital Display: Two-line digital display of alphanumerical characters. Meter shall display flow rate, flow totalization, pressure, temperature, and support field programming of all parameters.

Construction:

Material: Type 316L stainless steel.

Connection: **[Class 150] [Class 300] [Class 600]** flange.

Enclosure:

Epoxy-painted cast aluminum.

Removable screw-on cover.

NEMA 250, Type 4 or Type 6.

Electrical Connection: Screw terminals.

Conduit Connection: Two, 1/2-inch trade size.

Upstream Flow Straightener:

Meter manufacturer shall provide flow straightener where required by installation to comply with manufacturer's written installation instructions.

Straightener shall be wafer type, constructed of Type 304 stainless steel, designed to be installed between field-installed flanges.

Straightener size shall match meter size.

* + - * 1. Liquid Pressure Differential Switches:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Ashcroft Inc.

Approved equivalent.

Source Limitations: Obtain switches from single source from single manufacturer.

Requirements in remaining subparagraphs below are based on Ashcroft's "LPA, S Series." For other switches, see Section 230923.23 "Pressure Instruments."

Description:

Type 316 stainless steel double opposing bellows operate to actuate an SPDT snap switch.

Wetted Materials: Type 316 stainless steel.

First option in "Seal" subparagraph below has process temperature limitation of 150 deg F.

Seal: **[Buna-N] [or] [FKM]**.

Electrical Connections: Screw terminal.

Enclosure Conduit Connection: Knock-out or threaded connection.

User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.

High and Low Process Connections: Threaded, NPS 1/4.

Enclosure: NEMA 250, Type 4 or Type 4X.

Operating Data:

Electrical Rating: 10 A at 120- to 240 V ac.

Pressure Limits: 0 to 500 psig.

Ambient Temperature Limits: Minus 20 to plus 150 deg F.

"Buna-N" seal has process temperature limitation of 150 deg F. Revise upper temperature limit in "Process Temperature Limits" subparagraph below if using Buna-N material.

Process Temperature Limits: 20 to 300 deg F.

Operating Range: 2 times set point unless otherwise required by application.

Deadband: **[Adjustable] [Fixed] [Adjustable or fixed as required by application]**.

Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

* + - * 1. Liquid Pressure Transmitters:

Liquid Gauge Pressure Transmitter with Adjustable Span:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Rosemount; Emerson Process Management.

Approved equivalent.

Source Limitations: Obtain transmitters from single source from single manufacturer.

Requirements in remaining subparagraphs below are based on Rosemount's "Model 3051CG." For other transmitters, see Section 230923.23 "Pressure Instruments."

Performance:

Range: Minus 300 to 300 psig.

Span: Field adjustable.

Minimum Span: 3 psig.

Reference Accuracy: Within 0.07 percent of span or better.

Stability: Within 0.125 percent of upper range limit for five years.

Overpressure Limits: 3626 psig .

Process Temperature Limits: Minus 40 to plus 250 deg F.

Ambient Temperature Limits: Minus 40 to plus 185 deg F.

Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.

Shock and vibration shall not harm the transmitter.

Analog Output Current Signal:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into 1000-ohm load.

Digital signal based on HART protocol carried with current signal.

Dampening: Field selectable from zero to 30 seconds.

Operator Interface: Zero and span adjustments located behind cover.

Display: Digital, five-digit, two-line display with 0.4-inch- high, alphanumeric characters.

Construction:

Non-wetted parts of transmitter constructed of aluminum or stainless steel.

Enclosure with removable cover on each side.

Wetted parts of transmitter constructed of Type 316 stainless steel.

Threaded, NPS 1/2 process connection on bottom of instrument.

Drain/vent valve on process connection.

Two 1/2-inch trade size conduit connections on side of instrument enclosure.

Screw terminal block for wire connections.

NEMA 250, Type 4X.

Mounting Bracket: Appropriate for installation.

Three-Valve Manifold:

Include with each transmitter an integrally mounted manifold.

Construct manifold body of Type 316 stainless steel.

Manifold with threaded, NPS 1/2 female process connections.

Liquid, Pressure-Differential Transmitter with Adjustable Span:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Rosemount; Emerson Process Management.

Approved equivalent.

Source Limitations: Obtain transmitters from single source from single manufacturer.

Requirements in remaining subparagraphs below are based on Rosemount's "Model 3051CD." For other transmitters, see Section 230923.23 "Pressure Instruments."

Performance:

Range: Minus 300 to 300 psig.

Span: Field adjustable.

Minimum Span: 3 psig.

Reference Accuracy: Within 0.07 percent of span or better.

Stability: Within 0.125 percent of upper range limit for five years.

Overpressure Limits: 3626 psig.

Process Temperature Limits: Minus 40 to plus 250 deg F.

Ambient Temperature Limits: Minus 40 to plus 185 deg F.

Temperature Effect: Within 0.025 percent of upper range limit plus 0.125 percent of span.

Shock and vibration shall not harm the transmitter.

Analog Output Current Signal:

Two-wire, 4- to 20-mA dc current source.

Signal capable of operating into 1000-ohm load.

Digital signal based on HART protocol carried with current signal.

Dampening: Field selectable from zero to 30 seconds.

Operator Interface: Zero and span adjustments located behind cover.

Display: Digital, five-digit, two-line display with 0.4-inch- high, alphanumeric characters.

Construction:

Non-wetted parts of transmitter constructed of aluminum or stainless steel.

Enclosure with removable cover on each side.

Wetted parts of transmitter constructed of Type 316 stainless steel.

Threaded, NPS 1/2 process connection on bottom of instrument.

Drain/vent valve on process connection.

Two 1/2-inch trade size conduit connections on side of instrument enclosure.

Screw terminal block for wire connections.

NEMA 250, Type 4X.

Mounting Bracket: Appropriate for installation.

Five-Valve Manifold:

Include with each transmitter an integrally mounted manifold.

Construct manifold body of Type 316 stainless steel.

Manifold with threaded, NPS 1/2 female process connections.

* + - * 1. Liquid Temperature Sensors:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Minco.

Approved equivalent.

Source Limitations: Obtain sensors from single source from single manufacturer.

Requirements in remaining subparagraphs are based on Minco's "RTD Series." For other sensors, see Section 230923.27 "Temperature Instruments."

Resistance temperature (RTD) sensors shall comply with IEC 60751, Class B requirements.

Platinum with a value of 100 ohms at 0 deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.

Encase RTD in a Type 316 stainless steel sheath with a 0.25-inch OD.

Provide three-wire, PTFE-insulated, nickel-coated, 22-gauge, stranded copper leads.

Retain first subparagraph below for spring-loaded holder. Spring-loaded holder provides direct connect with thermowell for improved temperature measurement.

Provide spring-loaded RTDs for thermowell installations.

Performance Characteristics:

Range: Minus 328 to plus 932 deg F.

Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.

Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F.

Hysteresis: Within 0.04 percent of range.

Response Time: 62.8 percent of change in four seconds with water flowing across sensor at 3 fps.

Thermowells:

Requirements in first eight subparagraphs are based on Minco's "TW Series."

Stem: [Straight] [or] [stepped] [or] [tapered] shank formed from solid bar stock.

Material: [Type 304] [or] [Type 316] stainless steel.

Process Connection: Threaded, NPS 3/4.

Sensor Connection: Threaded, NPS 1/2.

Bore: Sized to accommodate sensor with tight tolerance between sensor and well.

Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.

Length: As required by application and pipe size.

Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

Connection Heads:

Requirements in first four subparagraphs are based on Minco's "CH 359 Connection Head."

Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.

Terminals: Six or eight as required by sensor.

Conduit Connection: 1/2-inch trade size.

Sensor Connection: NPS 1/2.

Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.

* + - * 1. Liquid Temperature Transmitters:

Manufacturers: Subject to compliance with requirements, provide products by the following:

Minco.

Approved equivalent.

Source Limitations: Obtain transmitters from single source from single manufacturer.

Requirements in remaining subparagraphs are based on Minco's "TT Series." For other transmitters, see Section 230923.27 "Temperature Instruments."

Enclosure: House electronics in NEMA 250, **[Type 4] [or] [Type 4X]** enclosure.

Enclosure Connection: 1/2-inch trade size.

Functional Characteristics:

Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, three-wire sensors.

Default Span (Adjustable):

Chilled Water: 0 to 100 deg F.

Heating Hot Water: 32 to 212 deg F.

**<Insert system and span>**.

Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.

Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.

Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

Performance Characteristics:

Calibration Accuracy: Within 0.1 percent of the span.

Stability: Within 0.2 percent of the span for at least six months.

Combined Accuracy: Within 0.5 percent.

* + - * 1. Control Transformers:

Size each transformer for the total connected load, plus an additional 25 percent of the connected load.

Each transformer shall be at least 100 VA.

Provide transformer with both primary and secondary fuses.

* + - * 1. 25-V dc Power Supply:

Plug-in style suitable for mating with a standard eight-pin octal socket.

Enclose circuitry within a housing.

Include line and load regulation to ensure a stable output. To protect both power supply and load, include power supply with an automatic current limiting circuit.

Performance:

Output voltage nominally 25 V dc within 5 percent.

Output current up to 100 mA.

Input voltage nominally 120 V ac, 60 Hz.

Load regulation within 0.5 percent from 0- to 100-mA load.

Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.

Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

* + - * 1. Instrument Identification:

Engraved tag bearing instrument identification.

Each tag identifying an instrument shall have a unique identification that does not match identification of a similar device.

Tag field instruments identified by equipment being controlled or monitored, followed by point identification used on I/O schematics.

Example: DDC-AHU-01.01; PDIT1.

Letter size shall be minimum 1/4 inch high.

Letter type shall be sans serif gothic bold style.

Lettering and background color scheme shall be white letters on black background.

Tag shall be engraved phenolic constructed of three layers of pressure rigid laminate. Top and bottom layers are color-coded, contrasting white center is exposed by engraving through outer layer. Engrave both sides. Material shall be stain proof, heat resistant, non-conductive, or non-corrosive.

Tag shall be fastened to equipment/instrument with drive pins or attached with a stainless steel chain.

Instruments furnished with identification tags provided by original manufacturer do not require an additional tag.

* + - * 1. Checkout Procedures:

Check instruments for proper location and accessibility.

Check instruments for proper installation for direction of flow, elevation, orientation, and other applicable considerations.

Damper Check-out: Verify that proper blade alignment, either parallel or opposed, has been provided.

* + - * 1. Calibration and Adjustment:

Calibrate every instrument.

For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

Equipment and procedures used for calibration shall meet requirements of instrument manufacturer's written instructions. Test equipment used in calibration of instruments shall have an accuracy at least double that of instrument being calibrated.

Calibrate each instrument in accordance with the accuracy outlined in instruction manual supplied for instrument by manufacturer.

Control System Inputs and Outputs:

Check analog inputs using a precision voltage or current source at zero, 50, and 100 percent of span.

Check analog outputs using a milliampere meter at zero, 50, and 100 percent output.

Check digital inputs using a jumper wire.

Check digital outputs using an ohmmeter to test for contact making or breaking.

Check resistance temperature inputs at zero, 50, and 100 percent of span using a precision-resistant source.

Flow: Set differential pressure flow transmitters for zero and 100 percent values with three-point calibration accomplished at 100, 50, and 90 percent of span.

Gas: Calibrate gas transmitters at zero, 50, and 100 percent of span.

Humidity: Calibrate relative humidity transmitters at zero, 50, and 100 percent of span.

Pressure: Calibrate pressure transmitters at zero, 50, and 100 percent of span.

Temperature: Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

Dampers: Stroke and adjust control dampers following the recommended procedure from manufacturer, such that damper is 100 percent open and closed.

Replace out of tolerance instruments failing the test.

Provide diagnostic and test instruments for calibration and adjustment.

* + - 1. SMOKE DETECTORS

Retain "this article if smoked detectors are to be included as part of factory-built air-handling units. If retaining more than one smoke detector type below, indicate smoke detector types on drawings.

Retain "System, Duct Smoke Detectors" paragraph below for applications that require connection to a conventional fire alarm system. Coordinate interface requirements with fire-alarm system designer.

* + - * 1. System, Duct Smoke Detectors: For connection to conventional fire-alarm system.

UL 268A covers detectors that are part of a fire-alarm system and detectors intended solely for control of releasing devices such as dampers.

Operating at 24-V dc, nominal.

In first subparagraph below, retain "four" option for additions to existing four-wire systems or if detector auxiliary contacts are used for critical control functions such as air-handler shutdowns. Otherwise, retain type based on class of initiating-device circuit.

Detectors shall be **[four] [two]**-wire type.

Retain "Base Mounting" subparagraph below if mounting directly to outlet box is not required. Base-mounted detectors should be used for units with auxiliary alarm outputs.

Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.

Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.

Integral Visual-Indicating Light: LED type, indicating detector has operated**[ and power-on status]**.

Number of settable levels in fire-alarm control unit varies among manufacturers and between detector types. Indicate specific number of levels on Drawings or in the "Remarks" column of a detector schedule.

Provide multiple levels of detection sensitivity for each sensor**[, with alarm-verification feature]**.

Coordinate "Duct Smoke Detectors" subparagraph below with Drawings for power supply and fire-alarm control unit connections. Review two- and four-wire options in "System, Duct Smoke Detectors" paragraph above.

Duct Smoke Detectors: Photoelectric type complying with UL 268A.

Remote indication**[ and test]** station.**[ Operating key switch initiates an alarm test.]**

Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC systems.

Sampling Tubes: Design and dimensions as recommended by manufacturer for specific size, air velocity, and installation conditions where applied.

Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

Retain "Nonsystem, Single-Station Duct Smoke Detectors" paragraph below for applications that do not require connection to a building fire-alarm system.

* + - * 1. Nonsystem, Single-Station Duct Smoke Detectors:

Nonsystem smoke detectors shall be listed as compatible with fire-alarm equipment installed or shall have a contact closure interface listed for the connected load.

Nonsystem smoke detectors shall meet the monitoring for integrity requirements in NFPA 72.

Comply with UL 268A; operating at 120 V ac.

Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to mounting brackets air-handling unit. Provide terminals in the fixed base for connection to building wiring.

Enclosure: NEMA 250, Type 4X; listed for use with the supplied detector.

Sampling Tubes: Design and dimensions as recommended by manufacturer for specific size, air velocity, and installation conditions where applied.

Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

Retain "Air-Handling Unit Factory Assembly" and "Air-Handling Unit Factory Testing" paragraphs below if retaining "System, Duct Smoke Detectors" or "Nonsystem, Single-Station Duct Smoke Detectors" paragraph above.

* + - * 1. Air-Handling Unit Factory Assembly:

Furnish and install smoke detectors inside air-handling units to comply with governing building codes.

Install smoke detectors in accordance with smoke detector manufacturer's written installation instructions.

Sampling tubes shall extend the full width of airstream.

Sampling tubes greater than 36 inches long shall be supported on both ends.

Install smoke detectors within air-handling units in a location that is easily accessible for inspection, repair, and replacement of smoke detector, and in a location that does not hinder access to other internal components.

* + - * 1. Air-Handling Unit Factory Testing: Functionally test smoke detectors to ensure proper operation in accordance with smoke detector manufacturer's written instructions.

Retain "Air-Handling Unit Factory Installation of Addressable Smoke Detectors Furnished by Building Fire-Alarm System Supplier" paragraph below only if air-handling unit manufacturer is to factory install components of addressable smoke detectors that are furnished by building fire-alarm system supplier.

* + - * 1. Air-Handling Unit Factory Installation of Addressable Smoke Detectors Furnished by Building Fire-Alarm System Supplier:

Where addressable duct smoke detectors are indicated to be installed within air-handling unit casing, air-handling unit manufacturer shall install duct smoke detector components supplied by building fire-alarm system supplier.

Mount duct smoke detector sampling housing on exterior of air-handling unit casing. Locate on accessible side and coordinate with installers before installation.

Seal air-handling unit casing penetrations.

Install duct smoke detector components in accordance with written instructions furnished by supplier.

Sampling tubes shall extend the full width of airstream.

Sampling tubes greater than 36 inches long shall be supported on both ends.

Photograph installation and transmit photos to fire-alarm system Installer before air-handling unit shipment to ensure proper installation. Fire-alarm system Installer shall review photos and provide written acceptance of installation to air-handling unit manufacturer before air-handling unit shipment.

Document date of photos and approval for record purposes.

Make corrective measures required by fire-alarm system Installer as required for acceptance.

Coordinate work schedule of air-handling unit manufacturer and fire-alarm system supplier to meet requirements of Project schedule.

* + - 1. CATWALKS, HANDRAILS, AND LADDERS

Retain this article for multilevel and elevated air-handling units to require access by catwalks, handrails, and ladders furnished by air-handling unit manufacturer.

* + - * 1. General:

Provide elevated air-handling units and top levels of multilevel stacked units with catwalks, handrails, and ladders to provide service access.

Factory-fabricate catwalks, handrails, and ladders to ensure proper alignment and attachment.

Catwalks, handrails, and ladders may be disassembled and shipped separate from the air-handling unit for field installation.

Design and fabricate catwalk to be completely self-supported from air-handling unit frame without need for any type of field-installed supports.

Comply with OSHA requirements where requirements are more stringent than requirements indicated.

Install catwalk, handrails, and ladders level and plumb.

* + - * 1. Catwalks:

Extend catwalks to service elevated portions of air-handling units that are accessible through access doors and panels.

Catwalk width shall be of sufficient size to properly access and service equipment and maintain code-required clearances to electrical devices. Width shall be at least **[60 inches] <Insert dimension>** clear between the exterior casing and handrail.

Cantilever catwalk base frame from the air-handling unit base frame. Removable catwalks shall bolted to the air-handling unit base frame at multiple points to ensure a rigid and firm attachment.

Catwalk base frame material and finish shall match air-handling unit frame.

Catwalk floor material shall match air-handling unit floor material.

Catwalk walking surface elevation shall match floor surface inside air-handling unit.

* + - * 1. Handrails:

Provide catwalk with handrail, kneerail, toeboard, and vertical supports along entire length of catwalk. Comply with 29 CFR 1910.23.

Handrail shall be a minimum of **[42 inches] <Insert dimension>** high and comply with OSHA requirements. Vertical supports shall be spaced not more than **[96 inches] <Insert value>** o.c.

Construct handrail, kneerail, and vertical supports from not less than nominal **[1-1/2-inch-] <Insert dimension>** diameter tube.

Handrail shall be capable of withstanding a live load force of not less than **[100 lb/ft.]** and a **[200-lb] <Insert value>** concentrated force in any direction.

Provide lift-out sections of handrail to facilitate removal of air-handling unit internal components from the top-level to grade.

Provide self-closing gate at ends of catwalk accessible by ladders to provide fall protection.

Construct handrails, kneerails, toeboards, and vertical supports of **[aluminum] [fiberglass] [galvanized-steel] [or] [stainless steel]** materials.

Retain "Finish" subparagraph below if retaining "galvanized-steel" option in last subparagraph above to require a more durable corrosion-resistant finish.

Finish: Hot-dip galvanize assemblies constructed of steel after fabrication.

* + - * 1. Ladders with Safety Cages:

Provide a permanently attached ladder at **[one] [each]** end of catwalk.

Ladder shall rise from building structural floor to the top of handrail.

Provide for construction tolerance and adjustable means to fasten the ladder at its base to the building structural floor.

Fabricate ladders with dimensions, spacing, details, and anchorages as required.

Comply with requirements of ALI A14.3 and 29 CFR 1910.27.

Support each ladder at top and bottom. Use welded or bolted brackets, designed for adequate support and anchorage, and to hold ladder [7 inches] <Insert dimension> clear from catwalk walking surface.

Extend rails at least **[42 inches] <Insert dimension>** above top rung, and return rails with secure handholds fastened to handrail.

Construct ladders of **[aluminum] [fiberglass] [galvanized-steel] [or] [stainless steel]** materials.

Retain "Finish" subparagraph below if retaining "galvanized-steel" option in last subparagraph above to require a more durable corrosion-resistant finish.

Finish: Hot-dip galvanize ladders, brackets, and fasteners constructed of steel after fabrication.

Provide non-slip surface on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung that has a non-slip top surface.

* + - 1. HARDWARE
         1. Screws:

For Galvanized-Steel Materials: Self-tapping, hex-head, **[zinc-plate steel] [or] [300 series stainless steel]** screws with a neoprene gasket encapsulated by a **[zinc-plate steel] [or] [300 series stainless steel]** washer.

For Aluminum and Stainless Steel Materials: Self-tapping, hex-head, 300 series stainless steel screws with a neoprene gasket encapsulated by a 300 series stainless steel washer.

Provide protective covers on exposed screws to prevent personnel injury.

* + - * 1. Bolts, Nuts, and Washers:

For Joining Galvanized and Painted Carbon-Steel Materials: Hex-head, high-strength, **[galvanized steel] [or] [300 series stainless steel]**.

For Joining Aluminum and Stainless Steel Materials: Hex-head, high-strength, 300 series stainless steel.

Use washers and lock washers at each bolted connection.

Select bolt size and spacing sufficient for load and application.

* + - 1. WELDING
         1. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.

Use welding materials with corrosion properties equal to material being welded.

* + - * 1. Use welders that are certified to weld at least **[twice ]**the thickness of the material to be welded. Certification shall be within **[three] [six] <Insert number>** months of work being performed.
        2. Welds shall be continuous, full-penetration welds unless otherwise indicated. Intermittent welds, stitch welds and tack welds are permitted only in specific applications indicated.
        3. Use welders and welding procedures complying with the following:

Piping Systems: Section IX of the ASME Boiler and Pressure Vessel Code and Section V of ASME B31.1.

Structural Aluminum: AWS D1.2.

Structural Carbon Steel: AWS D1.1.

Structural Stainless Steel: AWS D1.6.

Sheetmetal: AWS D9.1.

* + - 1. PAINTING
         1. General:

Painted OEM components do not require additional coating other than touch-up to damaged areas. Match the touchup coating to surrounding undamaged surfaces.

Finish miscellaneous surfaces to match continuous surfaces.

Protect mill galvanized surfaces that are exposed to view, such as raw steel cuts and damage by welding, with multiple coats of matching galvanized paint.

Protect mill galvanized surfaces that are concealed, such as raw steel cuts and damage by welding, with multiple coats of zinc-rich paint or matching galvanized paint.

Touch up or entirely repaint surface finishes, damaged during shipment and installation, to the original condition, using original materials and methods.

* + - * 1. Preparation:

Submit proposed manufacturer's written preparation and application instructions for information.

If paint manufacturer's recommended preparation requirements differ from those indicated, use the more stringent requirements.

Structural carbon steel to be painted shall be deburred, ground smooth, cleaned, and blasted in accordance with **[SSPC-SP 6/NACE No. 3] [or] [SSPC-SP 10/NACE No. 5]**.

Before applying a primer and a finish coat, remove oil and grease from surfaces to be coated using clean rags soaked in thinner in accordance with SSPC-SP 1.

Treat surfaces to be painted to ensure that paint adheres.

* + - * 1. Primer:

Rust-inhibiting type, with a minimum dry film thickness of **[1] [2] <Insert value>** mil(s) per coat.

Apply at least **[two] <Insert number>** coats of primer to unfinished carbon-steel surfaces and at least one coat of primer to other surfaces.

Use primer that is compatible with substrate and finish coat.

* + - * 1. Finish Coat:

Finish coat painting system shall be **[alkyd-enamel] [epoxy] [polyurethane] <Insert coating>**.

Use dry film thickness recommended by paint manufacturer for each coat. Total dry film thickness of all finish coats not less than **[3] [5] <Insert value>** mils.

Painted Surfaces Minimum Properties:

Retain any of "Salt Spray ASTM B117," "Adhesion ASTM D3359," "Acid Resistance ASTM D3260," "Alkali Resistance ASTM D1647," "Humidity Resistance ASTM D2247," and "Pencil Hardness ASTM D3363" subparagraphs below to establish performance requirements for paint system. Tests and results indicated below are representative of paint performance requirements. Consult paint manufacturers for performance related to a specific paint type and revise to suit Project.

Salt Spray ASTM B117: 5 percent salt solution fog at 95 deg F for **[1000] [2000] [4000] <Insert value>** hours with no deterioration.

Adhesion, ASTM D3359: When the coating is cut into 0.0625-inch squares and 3M No. 600 tape is suddenly removed, there is no loss of adhesion.

Acid Resistance ASTM D3260: 15-minute exposure to 10 percent hydrochloric acid at room temperature with no effect.

Alkali Resistance ASTM D1647: 15-minute exposure to 10 percent sodium hydroxide at room temperature with no effect.

Humidity Resistance ASTM D2247: 850-hour exposure to 100 deg F and at least 95 percent relative humidity with no effect.

Pencil Hardness ASTM D3363: A hardness of 1H.

Finish coat color shall be selected by Architect and not be limited to manufacturer's standard offering.

Submit a written request for color selection and indicate in the request the date color selection must be returned without impacting schedule.

* + - * 1. Application: Paint the following surfaces with primer and finish coat indicated:

Unfinished carbon-steel surfaces.

Retain any of three subparagraphs below to require a painted exterior casing. It is unnecessary to paint aluminum, galvanized-steel, and stainless steel surfaces for corrosion protection. See the Evaluations for discussion.

Exposed mill galvanized-steel surfaces of air-handling unit casing exterior.

Exposed aluminum surfaces of air-handling unit casing exterior.

Exposed stainless steel surfaces of air-handling unit casing exterior.

* + - 1. CLEANLINESS REQUIREMENTS
         1. General:

Provide equipment that has been manufactured, shipped, stored, and installed maintaining highest degree of cleanliness possible.

Retain "Owner Cleanliness Inspection" subparagraph below to require Owner inspection. Consult Owner to determine if requirement is necessary.

Director’s Representative Cleanliness Inspection: Air-handling unit(s) cleanliness is subject to Director’s Representative cleanliness inspection **[and must pass a white glove test ]**before packaging for shipment.

**<Insert requirements>**.

* + - * 1. During Manufacturing:

Clean materials to be free of mill grease, oxidation, dirt, dust, and other impurities before manufacturing and assembly.

Protect casing materials from contamination during manufacturing and assembly.

Use sealing materials that do not outgas.

Provide OEM components and equipment from their respective manufacturers free of grease, oxidation, and dirt. Store OEM components and equipment indoors. Cover and protect OEM components and equipment to maintain cleanliness. Follow OEM instructions for equipment storage.

* + - * 1. After Manufacturing:

Before shipment, after unit is completely assembled, clean unit inside and out.

Vacuum entire inside to remove dirt, dust, and debris using HEPA-filtered vacuum equipment.

Purge hard to reach surfaces with dry, oil-free, compressed or bottled nitrogen.

Wipe down all surfaces, inside and out, with a residue-free cleaning agent.

Protect unit to maintain cleanliness.

* + - * 1. Shipping:

Protect interior and exterior of air-handling unit from exposure to weather dirt, dust, and debris during shipment and rigging.

Cover openings with puncture-resistant durable coverings to ensure that cleanliness is maintained inside unit while providing an air- and watertight seal.

* + - * 1. On-Site Storage:

If air-handling unit is to be stored before installation, Installer shall work closely with air-handling unit manufacturer for air-handling unit manufacturer to provide adequate protection at the factory to ensure that cleanliness for both unit interior and unit exterior is maintained. This protection shall remain in place until unit startup is performed.

For extended periods of storage, provide a means to rotate fan and motor assemblies on a periodic basis (as recommended in writing by manufacturer) without compromising unit cleanliness.

* + - 1. ACCESSORIES
         1. Tool Kit:

Manufacturer shall assemble a tool kit specially designed for use in servicing air-handling units furnished.

Include only special tools required to service air-handling unit components not readily available for purchase by Director’s Representative service personnel in performing routine maintenance.

Place tools in a lockable case with hinged cover.

Mark case cover with large and permanent text to indicate special purpose of tool kit, such as "Air-Handling Unit Tool Kit." Text size shall be at least **[1 inch] <Insert dimension>** high.

Provide a list of each tool furnished and permanently attach the list to underside of case cover. Text size shall be at least **[1 inch] <Insert dimension>**high.

* + - 1. SOURCE QUALITY CONTROL
         1. AHRI Compliance:

Retain "AHRI 260 (I-P)" subparagraph below only when indicating air-handling unit sound levels in accordance with AHRI 260 (I-P).

AHRI 260 (I-P): Air-handling unit sound ratings shall be in accordance with AHRI 260 (I-P), "Sound Rating of Ducted Air Moving and Conditioning Equipment."

Retain "AHRI 261 (SI)" subparagraph below only when indicating air-handling unit sound levels in accordance with AHRI 261 (SI). AHRI 261 (SI) is the SI equivalent to AHRI 260 (I-P).

AHRI 261 (SI): Air-handling unit sound ratings shall be in accordance with AHRI 261 (SI), "Sound Rating of Ducted Air Moving and Conditioning Equipment."

AHRI 410: Air-handling unit coils shall be rated in accordance with AHRI 410 and shall be listed by AHRI **[ and labeled in accordance with AHRI]**.

Retain "AHRI 1060 (I-P) Certification" subparagraph below if retaining "Heat Wheels," "Fixed Plate Heat Exchangers," or "Heat Pipe Heat Exchangers" Article and if AHRI certification is desired. Not all manufacturers offer this certification. Consult manufacturers.

AHRI 1060 (I-P) Certification: Air-handling units that include **[energy wheels] [fixed plate heat exchangers] [and] [heat pipe heat exchangers]** shall be rated in accordance with AHRI 1060 (I-P) and shall be listed by AHRI **[ and labeled in accordance with AHRI]**.

Retain "AHRI 1061 (SI) Certification" subparagraph below if retaining "Heat Wheels," "Fixed Plate Heat Exchangers," or "Heat Pipe Heat Exchangers" Article and if AHRI certification is desired. AHRI 1061 (SI) is the SI equivalent to AHRI 1060 (I-P). Not all manufacturers offer this certification. Consult manufacturers.

AHRI 1061 (SI) Certification: Air-handling units that include **[energy wheels] [fixed plate heat exchangers] [and] [heat pipe heat exchangers]** shall be rated in accordance with AHRI 1061 (SI) and shall be listed by AHRI **[ and labeled in accordance with AHRI]**.

* + - * 1. AMCA Compliance:

AMCA 201: Air-handling unit manufacturer shall evaluate fan's performance within the air-handling unit in accordance with AMCA 201, "Fans and Systems" and account for conditions within the air-handling unit that could be detrimental to fan's performance by adjusting the fan performance indicated on Drawings.

AMCA 205 Certification: Air-handling unit fan's fan efficiency grade (FEG) shall be rated in accordance with AMCA 205, "Energy Efficiency Classifications for Fans"**[ and shall bear the AMCA-certified fan efficiency grade seal]**.

AMCA 210 Certification: Air-handling unit fan's air performance shall be rated in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating"**[ and shall bear the AMCA-certified air ratings seal]**.

AMCA 300: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 300, "Reverberant Room Method for Sound Testing of Fans."

AMCA 301 Certification: Air-handling unit fans sound performance shall be rated in accordance with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data"**[ and shall bear the AMCA-certified sound ratings seal]**.

AMCA 500-D: Air-handling unit damper's performance shall be rated in accordance with AMCA 500-D, "Laboratory Methods of Testing Dampers for Rating"**[ and shall bear the AMCA-certified air ratings seal]**.

* + - * 1. NFPA Compliance:

NFPA 70: Electrical components, devices, and accessories shall be listed and labeled by a qualified testing agency, and marked for intended location and application.

NFPA 90A: Design, fabrication, and installation of air-handling units and components shall comply with NFPA 90A.

* + - * 1. UL Compliance:

Retain "UL 1598 Certification" subparagraph below if retaining "Antimicrobial Ultraviolet (UV) Lamp Systems" Article and if certification is desired. Not all UVGI manufacturers offer this certification. Consult UVGI manufacturers.

UL 1598 Certification: Air-handling unit UVGI shall be NRTL listed and labeled in accordance with UL 1598, "Luminaires."

UL 1995 Certification: Where indicated, air-handling unit components shall be NRTL listed and labeled in accordance with UL 1995, "Standard for Safety Heating and Cooling Equipment."

* + - 1. SOURCE QUALITY CONTROL - INDEPENDENT LABORATORY TESTING
         1. General:

Project-specific testing by an independent laboratory is not required if air-handling unit manufacturer has written independent laboratory test results of past tests performed on same casing construction proposed for use on this Project.

If Project-specific testing is required, testing shall be performed in ample time to include test reports with submittals and before manufacturing of air-handling units. Include sufficient lead time for unit delivery, installation, and testing required by construction schedule.

Retain "Casing Structural Deflection Test" paragraph below to verify that casing construction complies with requirements before air-handling unit manufacturing begins. Casing testing before unit assembly provides assurance that casing complies with performance requirements while reducing risks associated with noncompliant air-handling units that are factory tested after assembly.

* + - * 1. Casing Structural Deflection Test:

Include service of an independent testing laboratory to verify casing structural deflection requirements indicated.

In lieu of independent laboratory testing, manufacturer may perform factory deflection testing of proposed construction to prove compliance if witnessed by **[Architect] [and] [Director’s Representative]**. Manufacturer shall bear cost of labor and travel expenses to witness testing.

Test casing construction to performance criteria indicated.

Test casing construction proposed for use on Project. Include, at a minimum, particulars such as metal materials and thickness, internal support and reinforcing, and insulation material and thickness.

Test largest full-size casing panel proposed for use on Project.

Test proposed construction of walls, floor, and roof. Include a separate test for each unique casing construction proposed.

Submit test reports for each test to show compliance with performance indicated.

Retain "Casing Airborne Sound Transmission Test" paragraph below for sound-sensitive applications to verify that casing construction complies with requirements before air-handling unit manufacturing begins. Casing testing before unit assembly provides assurance that casing complies with performance requirements while reducing risks associated with noncompliant air-handling units that are factory tested after assembly.

* + - * 1. Casing Airborne Sound Transmission Test:

Include services of an independent testing laboratory to test proposed casing construction for sound transmission. Include a separate test for each unique casing construction proposed.

Conduct tests in accordance with ASTM E90.

Determine sound transmission class by using ASTM E413.

Test proposed construction of walls and roof.

Test proposed construction of floor assembly only if air-handling unit is not installed on a concrete housekeeping pad or building structural floor.

Submit test reports for each test to show compliance with performance indicated.

Retain "Casing Sound Absorption Test" paragraph below for sound-sensitive applications to verify that casing construction complies with requirements before air-handling unit manufacturing begins. Casing testing before unit assembly provides assurance that casing complies with performance requirements while reducing risks associated with noncompliant air-handling units that are factory tested after assembly.

* + - * 1. Casing Sound Absorption Test:

Include services of an independent testing laboratory to verify casing sound absorption coefficients for perforated casing panels. Provide a separate test for each unique casing construction proposed.

Conduct tests in accordance with ASTM C423 and ASTM E795.

Test proposed construction of walls and roof.

Submit test reports to show compliance with performance indicated.

* + - 1. SOURCE QUALITY CONTROL - AIR-HANDLING UNIT FACTORY TESTS

Retain "Witness of Testing" paragraph below to allow Owner access to witness testing.

* + - * 1. Witness of Testing: Allow **[Architect] [Commissioning Agent] [Construction Manager] [and] [Director’s Representative] <Insert entity>** access to place where air-handling units are being tested for witness testing.

Submit written notification at least **[30] [20] <Insert number>** days in advance of testing.

Schedule testing at mutually agreeable dates and times.

Retain "Witness Testing Travel Expenses" paragraph below to include the cost of travel in the Construction Contract. Consult Owner to determine if requirement should be included.

* + - * 1. Witness Testing Travel Expenses:

Include in bid the cost of travel expenses to witness factory testing. Total cost for travel expenses shall be clearly indicated separately in bid.

Expenses shall include roundtrip **[coach] [or] [first]** class airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation and parking, and all associated taxes and fees.

Exclude other incidental expenses not indicated.

Revise subparagraph below if multiple people are traveling from different locations.

Include travel expenses for **[one] [two] <Insert value>** representative(s) with origin of **<Insert city and state>**.

Retain "Casing Leakage Test" paragraph below to require factory testing to verify compliance with leakage performance requirements.

* + - * 1. Casing Leakage Test:

Perform a leak test for **[each assembled air-handling unit] [each assembled air-handling unit of unique size and arrangement] <Insert requirement>**.

Follow testing procedures in accordance with ASHRAE 111.

Perform leak test before shipping first air-handling unit[ of unique size and arrangement].

Test results shall indicate that units comply with leakage requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.

Prepare test reports in accordance with ASHRAE 111.

Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

Retain "Casing Structural Deflection Test" paragraph below to require factory testing to verify compliance with structural deflection performance requirements. Factory testing of assembled air-handling unit may not be required if retaining "Casing Structural Deflection Test" paragraph included in "Source Quality Control - Independent Laboratory Testing" Article above.

* + - * 1. Casing Structural Deflection Test:

Perform a structural deflection test for **[each assembled air-handling unit] [each assembled air-handling unit of unique size and arrangement] [only one air-handling unit with the worst-case condition] <Insert requirement>**.

Pressurize and load air-handling units to the performance criteria indicated for structural deflection. Test air-handling unit **[floors] [walls and roofs]**.

Test results shall indicate that units comply with deflection requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.

Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

* + - * 1. Functional Run Test:

Run test each unit before shipment.

Test and balance fans to comply with vibration requirements indicated.

Energize each electrical device to ensure it is operational.

Take meter readings for volts, amperes, and kVAr on each phase leg of each motor.

Take meter readings for volts, amperes, and kVAr on each single-phase power connection to field power.

Exercise each damper to ensure proper operation.

Exercise each access door to ensure proper fit.

Exercise each valve to ensure proper operation.

Submit a written report for each unit tested. Written report shall include, at a minimum, full name of each person witnessing test, detailed list of each unit component tested, condition observed, and corrective action required. Each line item shall have full name of the person doing the checkout and date and time the checkout was performed.

Retain "Fan Vibration Test" paragraph below to require air-handling unit factory testing of vibration for applications where further validation of vibration by test is required.

* + - * 1. Fan Vibration Test:

Perform a fan vibration test for **[each assembled air-handling unit] [each assembled air-handling unit of unique size and performance] <Insert requirement>**.

Energize each fan within the air-handling unit after air-handling unit final assembly and perform a vibration analysis with fan operating at design speed**[ and at all speeds throughout the range from design to minimum speed]**.

Three vibration measurements shall be taken for each bearing in horizontal, vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency**[ with filter-in]**.

Fan bearing measurement points shall be marked or scribed on bearings for permanent record.

Test results shall indicate that units comply with vibration requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.

Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

Retain "Acoustical Performance Test" paragraph below to require air-handling unit factory testing of sound for applications where further validation of sound by test is required.

* + - * 1. Acoustical Performance Test:

Perform an acoustical performance test for **[each assembled air-handling unit] [each assembled air-handling unit of unique size and performance] <Insert requirement>**.

Air-handling unit acoustic performance shall be verified by factory test in accordance with AHRI 260 (I-P) or AHRI 261 (SI).

Air-handling unit supply-air discharge, return-air inlet, and casing radiated sound components shall be measured with air-handling unit operating at design conditions.

Retain "Testing Location" subparagraph below to qualify requirements for test location. Requirement may restrict competition. Consult air-handling unit manufacturers to verify compliance.

Testing Location: Perform testing in a location complying with AHRI 220, "Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment."

Test location shall be broadband qualified in accordance with AHRI 220 Section 5.1 and discrete frequency qualified in accordance with Section 5.2.

Retain option in first subparagraph below to qualify requirements for test location. Requirement may restrict competition. Consult manufacturers to verify compliance.

Operating conditions used in acoustic testing shall be verified by test in accordance with AMCA 210**[ in an AMCA-accredited facility]**.

Test results shall indicate that units comply with acoustical requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.

Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

Retain "Airflow Capacity Performance Test" paragraph below to require factory testing to verify compliance with airflow performance requirements.

* + - * 1. Airflow Capacity Performance Test:

Perform an airflow capacity performance test for **[each assembled air-handling unit] [each assembled air-handling unit of unique size and performance] <Insert requirement>**.

Retain option in first subparagraph below to qualify requirements for test location. Requirement may restrict competition. Consult air-handling unit manufacturers to verify compliance.

Operating conditions shall be verified by test in accordance with AMCA 210**[ in an AMCA-accredited facility]**.

Test results shall indicate that units comply with design airflow requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.

Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

Retain "Hydronic Piping Systems Testing" paragraph below for air-handling units with factory-assembled hydronic piping.

* + - * 1. Hydronic Piping Systems Testing: Pressure test factory-assembled piping systems with compressed air or water at a pressure to comply with governing codes and ASME B31.9, but not less than design pressure indicated.

Test results shall indicate that piping systems are without leaks. Make changes to noncompliant piping systems and retest until units comply with requirements.

Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

Retain "Steam and Condensate Piping Systems Testing" paragraph below for air-handling units with factory-assembled steam and condensate piping.

* + - * 1. Steam and Condensate Piping Systems Testing: Pressure test factory-assembled piping systems with compressed air or water at a pressure to comply with governing codes and ASME B31.1 or ASME B31.9 as applicable for service, but not less than design pressure indicated.

Test results shall indicate that piping systems are without leaks. Make changes to noncompliant piping systems and retest until units comply with requirements.

Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

* + - 1. SOURCE QUALITY CONTROL - OEM COMPONENT FACTORY TESTS

Retain "Air Blender Testing" paragraph below to verify air blender performance. Project testing is not required if air blender manufacturer can provide sufficient documentation of result of past testing. Consult Owner to discuss needed for testing.

* + - * 1. Air Blender Testing:

Director’s Representative-witnessed performance test to demonstrate compliance with performance requirements indicated.

* + - * 1. Coil Testing:

Retain any of "Hydronic Coils," "Refrigerant Coils," and "Steam Coils" subparagraphs below as applicable. Consult coil manufacturers for available test pressures.

Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig] <Insert pressure>** internal pressure.

Refrigerant Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than **[300-psig] <Insert pressure>** internal pressure.

Steam Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than to **[300-psig] <Insert pressure>** internal pressure.

Coils to display a tag with inspector's identification as proof of testing.

* + - * 1. Fan Vibration Testing:

Perform a fan vibration test for **[each fan] <Insert requirement>**.

Energize each fan after final assembly and perform a vibration analysis with fan operating at design speed**[ and at all speeds throughout the range from design to minimum speed]**.

Three vibration measurements shall be taken for each bearing in the, vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency**[ with filter-in]**.

Fan bearing measurement points shall be marked or scribed on bearings for permanent record.

Test results shall indicate units comply with vibration requirements indicated. Make changes to noncompliant fans and retest until fans comply with requirements.

Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single fan, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

1. EXECUTION
   * + 1. EXAMINATION
          1. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
          2. Examine air-handling units before installation. Reject units with physical damage, and air-handling unit components that are wet, moisture damaged, or mold damaged.
          3. Examine roughing-in for the following before installation of air-handling units:

Structural substrate mounting and anchorage to verify actual sizes, types, and locations.

Piping systems to verify actual sizes, types, and locations of connections.

Ductwork and plenums to verify actual sizes, types, and locations of connections.

Electrical services and controls to verify actual sizes, types, and locations of connections.

* + - * 1. Proceed with installation only after unsatisfactory conditions have been corrected.
      1. INSTALLATION
         1. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on concrete equipment bases.

Retain any of "Units Mounted on Concrete Bases," "Units Mounted to Structural-Steel Supports," "Units Mounted Directly to Finished Floors," and "Suspended Units" subparagraphs below as applicable.

Retain "Units Mounted on Concrete Bases" subparagraph below to require equipment to be installed on cast-in-place concrete equipment bases.

Units Mounted on Concrete Bases:

Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material.

Fill voids between air-handling unit bases and concrete bases using high-strength non-shrink grout.

Continuously seal between concrete bases and perimeter of air-handling unit bases with nonhardening sealant.

Units Mounted to Structural-Steel Supports: Level unit air-handling bases using aluminum or stainless steel shims compatible with air-handling unit base material. Continuously seal between structural supports and air-handling unit bases with nonhardening sealant.

Units Mounted Directly to Finished Floors: Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material. Continuously seal between floor and perimeter of air-handling unit bases with nonhardening sealant.

Suspended Units: Suspend and laterally brace air-handling units from building structure by attaching to only air-handling unit bases at manufacturer-designated locations.

Retain subparagraph below for air-handling units installed on roof curbs.

Install air-handling units on curbs following air-handling unit manufacturer's written procedures.

Install gaskets before setting air-handling units on curbs.

Secure air-handling units to curbs using stainless steel fasteners.

Install curb and fasten to structure.

Coordinate curb requirements, attachment, and location before installation.

Retain "Roof Openings" paragraph below for roof openings associated with roof-mounted air-handling units.

* + - * 1. Roof Openings:

Provide exact size and location of roof openings to trade installing structural framing and roof structure.

Supervise framing of openings to ensure coordinated installation with air-handling units.

Retain "Seismic Control" paragraph below for projects in seismic areas. Indicate seismic-control device types on Drawings.

* + - * 1. Seismic Control: Comply with requirements for seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
        2. Equipment Clearances and Access:

Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.

Provide clearance and access required by governing codes and NFPA 70.

At a minimum, comply with requirements indicated on Drawings and air-handling unit manufacturer's written instructions.

* + - 1. PROTECTION DURING CONSTRUCTION
         1. Exterior Covers: Cover air-handling units during construction with sealed covers to protect air-handling unit casing and externally mounted components from physical damage, dirt, dust and debris, paint splatter, and any other construction materials.

Minor physical damage, as determined by Director’s Representative, shall be repaired by air-handling unit factory service personnel to factory-finished condition.

Replace air-handling units with damage that in any way compromises the performance indicated.

* + - * 1. Internal Access: Keep access doors locked to maximum extent possible and restrict access to only authorized personnel.

Open access doors only during periods authorized work inside air-handling units is required.

Coordinate and monitor work inside air-handling units on a shift basis. Lock access doors once work is complete or at the end of each shift.

Immediately report unauthorized access and any observed damage to Director’s Representative.

* + - 1. DUCT CONNECTIONS

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

* + - * 1. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 233113 "Metal Ducts."

Retain first paragraph below to require flexible connections at units. Air-handling units include internal vibration isolation, so flexible connections at duct connections may not be necessary.

* + - * 1. Connect ducts and plenums to air-handling unit connections with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
        2. Provide duct transitions required to make field connections to air-handling units.
        3. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units.
      1. PIPING CONNECTIONS

Coordinate piping installations and specialty arrangements with Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

* + - * 1. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
        2. Where installing piping adjacent to air-handling unit, provide unobstructed access to inside of air-handling units for service and maintenance.

Retain first paragraph below for vibration-sensitive applications. Air-handling units with internal vibration isolation do not normally require flexible connectors for most applications.

* + - * 1. Connect piping to air-handling units with flexible connectors.
        2. Drain Pan Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."

Make connections to air-handling unit connections with **[flanges or ]**unions.

Extend **[dedicated ]**drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.

Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.

Install threaded cleanouts at changes in direction.

Secure drain piping to structure.

Retain "Air-Handling Unit Floor Drains" or "Air-Handling Unit Floor Drain Piping" paragraph below if retaining "Drains" Article. First paragraph does not require permanent drain piping and should be the default choice. Consult Owner.

* + - * 1. Air-Handling Unit Floor Drains: Do not require installation of permanent drain piping.

Retain "Air-Handling Unit Floor Drain Piping" paragraph below for rare applications that require permanent drain piping from air-handling unit floor drains.

* + - * 1. Air-Handling Unit Floor Drain Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."

Make connections to air-handling unit connections with **[flanges or ]**unions.

Extend **[dedicated ]**drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.

Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.

Install threaded cleanouts at changes in direction.

Secure drain piping to structure.

Retain "Chilled-(and Hot-)Water Coil Piping" paragraph below for air-handling units with hydronic coils. Revise requirements for units with factory piping different from units with field piping. If factory piping includes valves, pressure gauges, thermometers, and flow meters, revise text in subparagraphs to avoid duplication. If Project has some air-handling units with factory-installed piping and some without, revise to address both conditions.

* + - * 1. Chilled-**[and Hot-]**Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

Comply with requirements indicated on Drawings.

Make connections to coils with a **[flange] [or] [union]**.

Connect to each coil inlet with shutoff valve, test plug, **[pressure gauge] [and] [thermometer]**.

Connect to each coil outlet with balancing valve, test plug, **[pressure gauge] [thermometer] [flow meter] [and] [shutoff valve]**.

Connect each coil drain connection with a drain valve, which is full size of drain connection.**[ Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.]**

Connect each coil vent connection with **[automatic] [or] [manual]** vent, which is full size of vent connection.

Retain "Steam and Condensate Coil Piping" paragraph below for air-handling units with steam coils. Revise requirements for units with factory piping different from units with field piping. If factory piping includes valves and float and thermostatic trap assemblies, revise text below to avoid duplication. If Project has some air-handling units with factory-installed piping and some without, revise to address both conditions.

* + - * 1. Steam and Condensate Coil Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap assembly, and union or flange at each coil return connection.

Retain "Refrigerant Coil Piping" paragraph below as applicable.

* + - * 1. Refrigerant Coil Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve at each supply and return connection.

Retain "Steam Humidifier Piping" paragraph below as applicable. Revise requirements for units with factory piping different from units with field piping. If factory piping includes valves and float and thermostatic trap assemblies, revise text below to avoid duplication. If Project has some air-handling units with factory-installed piping and some without, revise to address both conditions.

* + - * 1. Steam Humidifier Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install gate valve and inlet strainer at supply connection of steam humidifiers and steam trap assemblies to condensate return connection.
      1. ELECTRICAL CONNECTIONS
         1. Install field power to each air-handling unit electrical power connection. Coordinate with air-handling unit manufacturer and installers.
         2. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
         3. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
         4. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
         5. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

Retain one of two subparagraphs below. First subparagraph cross-references Section 260553 "Identification for Electrical Systems" and should be retained for consistent electrical identification. Second subparagraph is an abbreviated version of the product specified in Section 260553 "Identification for Electrical Systems."

Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **[1/2 inch] <Insert dimension>** high.

* + - 1. CONTROL CONNECTIONS
         1. Install control and electrical power wiring to field-mounted control devices.
         2. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
         3. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

Retain one of two subparagraphs below. First subparagraph cross-references Section 260553 "Identification for Electrical Systems" and should be retained for consistent electrical identification. Second subparagraph is an abbreviated version of the product specified in Section 260553 "Identification for Electrical Systems."

Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **[1/2 inch] <Insert dimension>** high.

* + - 1. STARTUP SERVICE
         1. Engage an air-handling unit factory**[-authorized]** service representative to perform startup service.

Retain any of first 11 subparagraphs as applicable.

Complete installation and startup checks in accordance with manufacturer's written instructions.

Verify that shipping, blocking, and bracing are removed.

Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, controls, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.

Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.

Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.

Verify that face-and-bypass dampers provide full face flow.

Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.

Comb coil fins for parallel orientation.

Verify that proper thermal-overload protection is installed for electric heaters.

Install new, clean filters.

Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

**<Insert requirement>**.

* + - * 1. Starting procedures for air-handling units include the following:

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.]**

Measure and record motor electrical values for voltage and amperage.

Manually operate dampers from fully closed to fully open position and record fan performance.

**<Insert requirement>**.

Retain "Heat Wheel Startup Service" paragraph below to require heat wheel manufacturer personnel to perform startup service.

* + - * 1. Heat Wheel Startup Service:

After field installation is complete, a final checkout and startup shall be completed to ensure proper purge adjustment, seal adjustment, control settings, and other key operational functions.

Service shall be completed by trained factory service personnel employed by heat wheel manufacturer.

Submit a report summarizing findings, adjustments made, and final settings.

* + - 1. 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.
         3. Before turning equipment over to Director’s Representative for use, adjust air-handling unit components that require further adjustment for proper operation. Consult air-handling unit manufacturer for instruction.
         4. Occupancy Adjustments: When requested within **[12] <Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two] <Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.
         5. Seasonal Adjustments: Make seasonal visits during warranty period to inspect and review operation of equipment. Make necessary adjustments for components observed to require adjustments for proper operation. Prepare and submit a report to Director’s Representative documenting each visit, observations, and any adjustments made.
      2. CLEANING
         1. Cleaning Schedule: After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before Director’s Representative use, clean air-handling units to remove foreign material and construction dirt and dust.

Retain "Unit Interior" or "Unit Exterior" paragraph below, or both.

* + - * 1. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.

Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.

Clean casing floors, roofs, wall surfaces, access doors, and panels.

Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.

Clean light fixtures and control devices.

* + - * 1. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.
        2. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.
        3. Acceptance: Following unit cleaning submit a written request for review and **[Director’s Representative]** acceptance. Acceptance for cleaning of air-handling units **[with absolute filters ]**must pass a white glove test.
      1. FIELD QUALITY CONTROL

Retain "Manufacturer's Field Service" or "Perform the following tests and inspections" paragraph below. Retain "Manufacturer's Field Service" paragraph below to require a factory service representative to perform tests and inspections.

* + - * 1. Manufacturer's Field Service: Engage a Company Field Advisor per OGS Spec Section 014216 to test and inspect components, assemblies, and equipment installations, including connections.

Retain "Perform the following tests and inspections" paragraph below to require Contractor to perform tests and inspections and retain option to require Contractor to arrange for the assistance of a factor-authorized service agent.

* + - * 1. Perform the following tests and inspections**[ with the assistance of a Company Field Advisor per OGS Spec Section 014216]**.

After field piping connections are complete, test **[hydronic] [and] [steam]** coils and connections for leaks.

Charge refrigerant coils with refrigerant and test for leaks.

Field-Assembly Supervision: Instruct Installer and supervise field installation of **[first] <Insert quantity>** air-handling unit(s) shipped in multiple pieces for field assembly.

Roof-Mounted Field-Installation Supervision: Instruct Installer and supervise field installation of **[first] <Insert quantity>** roof-mounted air-handling unit(s).

Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

Retain "Field Casing Leakage Test" paragraph below for applications requiring additional quality assurance. Consider including requirement for air-handling units with knockdown construction that are field assembled and not factory tested.

* + - * 1. Field Casing Leakage Test:

Perform leak testing of air-handling units that include field assembly of multiple sections. Air-handling units that are shipped and installed as a single piece do not require field testing.

Leak test **[one] <Insert value>** air-handling unit(s) of each unique size and arrangement randomly selected by **[Architect] [Commissioning Agent] [Director’s Representative]**.

Follow procedures complying with ASHRAE 111.

Assembled air-handling units shall satisfy leakage criteria indicated. Modify air-handling units that fail to satisfy criteria and retest. For every air-handling unit that fails test, another air-handling unit shall be tested until all air-handling units tested pass leakage criteria on first attempt.

Submit a test report for each test indicating test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.

Test report shall be in accordance with ASHRAE 111.

Witness Testing:

Provide written notification at least **[30] [20] <Insert number>** business days in advance of testing.

Testing shall be conducted in presence of testing and balancing agent.

Other parties such as Architect, Commissioning Agent, and Director’s Representative shall be invited to witness testing with attendance being optional.

Retain "Field Fan Vibration Test" paragraph below for applications requiring additional quality assurance. Consider including requirement for air-handling units with knockdown construction that are field assembled and not factory tested.

* + - * 1. Field Fan Vibration Test:

Perform fan vibration testing for every one out of **[10] <Insert number>** air-handling unit fans randomly selected by **[Architect] [Commissioning Agent] [Director’s Representative]**.

Test after air-handling unit installation is complete.

Three vibration readings shall be taken for each bearing in horizontal, vertical, and axial directions. Record each reading including vibration amplitude verses frequency.

Modify fans that fail to satisfy performance criteria and retest. For every fan that fails test, another fan shall be tested until all fans tested pass criteria on first attempt.

Submit a report for each fan tested indicating air-handling unit designation, fan designation, test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.

Witness Testing:

Provide written notification at least **[30] [20] <Insert number>** business days in advance of testing.

Testing shall be conducted in presence of testing and balancing agent.

Other parties such as Commissioning Agent, Architect, and Director’s Representative shall be invited to witness testing with attendance being optional.

* + - * 1. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
        2. Prepare test and inspection reports.
      1. OPERATION DURING CONSTRUCTION

Air-handling units should not be used for temporary cooling, heating, and ventilation unless expressly approved by Owner. If used during construction, see SMACNA 008,"IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

* + - * 1. Operation of air-handling units for temporary cooling, heating, and ventilation is not allowed without Director’s Representative authorization.

Submit written request for Director’s Representative approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:

Description of construction activities while units are operating.

Operation:

Beginning and ending calendar dates.

List each day during week.

List start and stop time and hours for each day.

Startup procedures and shut-down procedures.

Provisions for routine monitoring of unit operation.

Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage and current and electrical fault.

Provisions and safeguards for filtration to keep inside of units from getting dirty.

Record keeping.

If approved by Director’s Representative, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least **[two] <Insert number>** years after the warranty indicated expires.

Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Director’s Representative.

* + - * 1. Filtration During Temporary Use:

Protect air-handling system ducts (exhaust air, outdoor air, and return air) with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV **[8] [11] [13]** **<Insert MERV>** in accordance with ASHRAE 52.2.

Protect air-handling units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and by-pass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV **[8] [11] [13] <Insert MERV>** in accordance with ASHRAE 52.2.

Do not operate air-handling units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.

Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting and balancing.

* + - * 1. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.
      1. DEMONSTRATION
         1. Engage air-handling unit manufacturer **[employed training instructor] [or] [Company Field Advisor per OGS Spec Section 014216]** to train Director’s Representative's maintenance personnel to adjust, operate, and maintain air-handling units.
         2. Training shall include, but not be limited to, procedures and schedules related to performance, safety, startup and shut down, troubleshooting, servicing, preventive maintenance, and how to obtain replacement parts.

Retain any of first 17 subparagraphs below as applicable.

Access Doors: Adjustment, gasket removal and replacement, handle removal and replacement, and spare parts.

Access Panels: Removal and replacement, adjustment, gasket removal and replacement, and spare parts.

Air Blenders: Cleaning, operation, removal, and replacement.

Coils: Cleaning, combing fins, draining, venting, removal, and replacement.

Controls: Calibration, cleaning, operation, service, removal and replacement, and spare parts.

Damper Assemblies: Cleaning, operation, service, removal and replacement, and spare parts.

Drain Pans: Cleaning, removal, and replacement.

Duct Silencers: Cleaning, removal, and replacement.

Electric Heaters: Cleaning, operation, service, removal and replacement, and spare parts.

Heat Wheels: Cleaning, operation, service, removal and replacement, and spare parts.

Fan and Motor Assemblies: Cleaning, operation, removal and replacement, service, and spare parts.

Filters: Operation, removal and replacement, frame gasket removal and replacement, clip removal and replacement, and spare parts.

Fixed Plate heat Exchangers: Cleaning, removal, and replacement.

Heat Pipe Heat Exchangers: Cleaning, combing fins, removal, and replacement.

Humidifiers: Cleaning, operation, service, removal and replacement, and spare parts.

UV-C Lamp Systems: Cleaning, operation, service, removal and replacement, and spare parts.

Lights, Receptacles and Switches: Cleaning, operation, service, removal and replacement, and spare parts.

**<Insert requirement>**.

* + - * 1. Instructor:

Instructor shall be factory trained and certified by air-handling unit manufacturer with current training on equipment installed.

Instructor's credentials shall be submitted for review by **[Commissioning Agent] [Director’s Representative]** before scheduling training.

Instructor(s) **[primary] [sole]** job responsibility shall be Director’s Representative training.

Instructor(s) shall have not less than **[three] <Insert number>** years of training experience with air-handling unit manufacturer and past training experience on at least **[three] <Insert number>** projects of comparable size and complexity.

* + - * 1. Schedule and Duration:

Schedule training with Director’s Representative at least **[20] <Insert number>** business days before first training session.

Training shall occur before Director’s Representative occupancy.

Training shall be held at mutually agreed date and time during normal business hours.

Each training day shall not exceed **[eight] <Insert number>** hours of training. Daily training schedule shall allow time for a **[one] <Insert number>**-hour lunch period and **[15] <Insert number>**-minute break after every **[two] <Insert number>** hours of training.

Perform not less than **[eight] [16] [24] <Insert number>** hours of training.

* + - * 1. Location: Director’s Representative to provide a suitable on-site location to host classroom training.

Consult Owner to determine the number of training attendees to be included in "Training Attendees" paragraph below.

* + - * 1. Training Attendees: Assume **[three] <Insert number>** people.
        2. Training Attendance Records: For record purposes, document training attendees at start of each new training session. Record date, time, brief description of training covered during the session, attendee's name, signature, phone number, and e-mail address. Submit scanned copy of sign-in sheet to Director’s Representative for each training session.
        3. Training Format: Individual training modules to include classroom training followed by hands-on field demonstration and training.
        4. Training Materials: Provide training materials in electronic format to each attendee.

Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.

* + - * 1. Training Video Recording: Video record each classroom training session and submit an electronic copy to Director’s Representative before requesting Director’s Representative acceptance of training.
        2. Written Acceptance: Obtain **[Commissioning Agent] [or] [Director’s Representative]** written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 237343.19