

**SECTION 15501**  
**HEATING, VENTILATING AND AIR CONDITIONING**  
**SYSTEMS, INSTALLATION & EQUIPMENT**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawing and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

1.2 SUMMARY

- A. This Section includes the following
1. General requirements
  2. Central-station Air-Handling Units
  3. Rooftop Air Handling Units
  4. Split-system Air Conditioning Assembly
  5. Fan-Coil Units
  6. Air-coils (HW, CHW, DX or Electric)
  7. Centrifugal Fans
  8. Laboratory Exhaust Fans
  9. Power Ventilators:
    - a. Utility-set Fans
    - b. Centrifugal Roof Ventilators
    - c. Axial Roof Ventilators
    - d. Centrifugal Wall Ventilators
    - e. In-line Centrifugal Fans
    - f. Propeller Fans
    - g. Powered Smoke Ventilators
    - h. Make-up Air Supply Fan (SF-HE-04)
  10. Cabinet Unit Heaters (Hot Water or Electric)
  11. Industrial "Ceiling fans"
  12. Hot Water Unit Heaters
  13. Electric Baseboard Heaters
  14. Gravity Roof Ventilators (Intake or Relief)

~~B. Restrictions of elastomer (plastic) materials used for Air Handling Units installed in the LINAC Tunnel:~~

~~1. Essential components of the HVAC air handling unit construction shall comply only of approved elastomer (plastic) materials listed herein.~~

C.B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 15, Section 15055, "Motors."
2. Division 15, Section 15106, "Chilled Water, Condenser, Water, Cooling Tower Water, Heating Hot Water, Condensate & Process Water piping, including Hydronic Specialties".
3. Division 15, Section 15125, "DX Refrigerant Piping System & Accessories."
4. Division 15, Section 15887, "HVAC Air Filters and Components."
5. Division 15, Section 15990, "Testing, Adjusting, and Balancing."
6. Division 16, Section 16441, "Disconnect Switches."
7. Division 16, Section 16483, "Motor Control."
8. Division 17, Section 17100, "Plant-Wide Cabling."

### 1.3 REFERENCES

- A. Air Movement and Control Associations, Inc. (AMCA).
  - 1. AMCA 210, "Laboratory Methods of Testing Fans for ratings."
  - 2. AMCA 300, "Reverberant Room Method for Sound Testing of Fans."
  - 3. AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data."
  - 4. AMCA 500 – (1991) Louvers, Dampers and Shutters.
  
- B. Air-Conditioning and Refrigeration Institute. (ARI).
  - 1. ARI 410 – (1991) "Forced Circulation Air-Cooling and Air-Heating Coils".
  - 2. ARI 430 – (1989) "Central Station Air Handling Units".
  
- C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE).
  - 1. ASHRAE 3 – (1996) "Reducing Emission of Fully Halogenated Chlorofluorocarbon (CFC) Refrigerants in Refrigeration and Air-Conditioning Equipment and Applications".
  
- D. American Society of Mechanical Engineers (ASME).
  - 1. ASME/ANSI B16.5 (1996) "Pipe Flanges & Flanged Fittings NPS ½ Through NPS 24".
  - 2. ASME B31.3 – (1996; Addenda 1996 and 1997) "Process Piping".
  - 3. ANSI/ASME B40.1 – (1991; Special Notice 1992) "Gauges – Pressure Indicating Dial Type – Elastic Element".
  
- E. American Society for Testing and Materials (ASTM).
  - 1. ASTM A 126 – (1995) "Gray Iron Castings for Valves, Flanges, and Pipe Fittings".
  
- F. National Fire Protection Association (NFPA).
  - 1. NFPA 70 – (1999) "National Electrical Code".
  - 2. NFPA 90A – (1996) "Installation of Air Conditioning and Ventilation Systems".
  
- G. Sheet Metal & Air Conditioning Contractors' National Association, Inc. (SMACNA).
  - 1. SMACNA DCS – (1995; Addendum 1997) "HVAC Duct Construction Standards – Metal and Flexible".
  - 2. SMACNA HVACTION – (1993) "HVAC Systems Testing, Adjusting and Balancing".
  
- H. Underwriters Laboratories Inc. (UL).
  - 1. UL 506 – (1994; R 1997, Bulletin 1997) "Specialty Transformers".
  - 2. UL 555S – (1996) "Leakage Rated Dampers for Use in Smoke Control Systems".
  - 3. UL 916 – (1994; "Bulletin 1994 and 1996, R 1996) Energy Management Equipment".
  - 4. UL 1449 – (1996) "Transient Voltage Surge Suppressors".
  - 5. UL 1995 – (1995) "UL Standard for Safety Heating and Cooling Equipment".

### 1.4 SUBMITTALS

- A. General: Submit each item in this Article for approval according to the conditions of the Contract and General and Supplementary Conditions.
  
- B. Product Data for each HVAC equipment listed in Section 1.2 A. and shall include the following:
  - 1. Certified fan-performance curves with system operating conditions indicated.
  - 2. Certified fan-sound power ratings.
  - 3. Certified coil-performance ratings with system operating conditions indicated.
  - 4. Motor ratings and electrical characteristics plus motor and fan accessories.
  - 5. Material gages and finishes.
  - 6. Filters with performance characteristics.

7. Dampers, including housings, linkages, and operators.
  8. Smoke Detectors.
- C. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, and methods of field assembly, components, and location and size of each field connection.
  - D. Wiring diagrams detailing wiring for power and control systems, control interface differentiating between manufacturer-installed and field-installed wiring.
  - E. Coordination Drawings, including floor plans and sections drawn to scale. Submit with Shop Drawings. Show mechanical-room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
  - F. Field test reports indicating and interpreting test results relative to compliance with specified requirements.
  - G. Operating and Maintenance data: For air-handling units are to be included in the Operation and Maintenance (O&M) manuals as specified in General and Supplementary Conditions and Division 15 requirements.

#### 1.5 QUALITY INSURANCE

- A. NFPA Compliance: Air-handling equipments and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
- B. AMCA Compliance for centrifugal fans: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. ARI Certification: Air-handling units and their components shall be factory tested according to the applicable portions of ARI 430, "Central-Station Air-Handling Units," and shall be listed and bear the label of the Air-Conditioning and Refrigeration Institute (ARI).
- D. UL and NEMA Compliance: Provide motors required as part of air-handling units that are listed and labeled by UL and comply with applicable NEMA standards.
- E. Comply with NFPA 70 for electrical components devices and accessories installation.
- F. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.
  1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code (NEC), Article 100.
  2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulations 1910.7.
- G. Coordination: Coordinate layout and installation of central-station air-handling units with piping and ductwork and with other installations.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver air-handling unit as a factory-assembled module with protective crating and covering.

- B. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 EXTRA MATERIALS/SPARE PARTS

- A. Provide two sets of filters and belts for each unit.

1.8 SEQUENCING AND SCHEDULING

- A. Coordinate size and location of concrete housekeeping bases. Drill concrete expansion anchors into base. Anchor points in accordance with manufacturers' instructions.
- B. Coordinate size and location of structural-steel support members.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide HVAC equipment and components in accordance with each facility's specific equipment schedules as indicated on drawings.
- B. HVAC equipment shall be factory assembled and tested.
- C. Each piece of equipment's housing or cabinet assembly shall be free from the development of external sweating.

D. Equipment Isolation:

1. For equipment located on the roof of the cleanroom or in EVA sensitive areas (EVA= Emissions, Vibrations and Acoustics), provisions need to be made to prevent the transmission of mechanical vibrations from the equipment to the support structure. When necessary, an effective structural isolation break (SIB) shall be provided.
2. Structural Isolation Breaks shall be provide at specified locations to reduce coupling between vibration-sensitive areas and areas containing vibration-producing equipment, such as fans and pumps.
3. Install isolators for fans, pumps and other such equipment associated with the equipment package. Unless otherwise allowed by the Vibration Consultant, no equipment of more than three horsepower is to be attached to the structure without suitable vibration isolation. Where piping connects to such equipment, provide flexible connectors
4. Passive mechanical equipment such as heat exchangers, storage tanks, and expansion tanks do not require vibration isolation from the building structure.
5. All rotating equipment shall operate at speeds less than 80% of their true critical speed.
6. Pumps, fans, and other rotating equipment shall be tested after installation and under operating conditions. Vertical and horizontal vibration shall not be greater than the levels indicated. The vibration shall be measured on the equipment bearing caps when the equipment is mounted on its vibration isolation mounts. If the equipment has an inertia base, the allowable vibration level is reduced by the ratio of the equipment weight alone to the equipment weight plus inertia base weight. A balance report will be provided for each item of equipment.

Equipment Speed	Vibration Displacement (MILS) peak-to-peak
<b>Under 600 rpm</b>	<b>4</b>
600 to 1000 rpm	3
1000 to 2000 rpm	2
Over 2000 rpm	1

7. All vibration-isolation mounts shall be supplied by one of the following approved manufacturer's. Exception to this clause may be permitted in the case of internally isolated equipment with the explicit approval of the Contractor.
- a. Kinetics Noise and Control, Inc., Dublin, Ohio.
  - b. Mason Industries, Inc., Hollis, New York.
  - c. Amber/Boot Company, Houston, Texas.

## ~~2.2 APPROVED ELASTOMER (PLASTIC) MATERIALS FOR AIR HANDLING UNITS IN LINAC TUNNEL.~~

~~A. In the LINAC Tunnel, essential components are critical for the continuous operation of four (4) HVAC Air Handling Units, AH-LN-01, -02, -03 & -04. These essential components shall be defined herein as follows: Fan-belts, Motor components, Bearing-grease, Bearing-seal & Grease-lines. All essential components listed shall be radiation-resistant. To achieve this they must be constructed only of the following approved materials:~~

- ~~1. UHMWPE Ultra High Molecular Weight Poly-Ethylene~~
- ~~2. EPDM Ethylene Propylene Diene Monomer~~
- ~~3. EPR Ethylene Propylene Rubber~~
- ~~4. PUR Polyurethane Rubber~~
- ~~5. SBR Styrene Butadiene Rubber~~
- ~~6. Nitrile Acrylonitrile & Butadiene~~
- ~~7. Buna-N Acrylonitrile~~
- ~~8. Neoprene Polychloroprene~~

## 2.32.2 CENTRAL STATION AIR-HANDLING UNITS

- A. General Description: Units shall be factory assembled, consisting of fans, motor and drive assembly, coils, damper, pneumatic damper-operators, plenums, filters, drip pans, and mixing dampers.
- B. Cabinet / Housing.
  1. Materials: Formed and reinforced double-wall, galvanized steel panel construction, fabricated to allow removal for access to internal parts and components, with joints between sections sealed. Panels shall be rigid construction with inside retainer and shall be capable of withstanding 6 inches positive static pressure or -4 inches negative static pressure.
  2. Insulation: Coated, glass-fiber insulation, between outer housing and internal retainer shall comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," for insulation. No exposed (or uncoated) insulation will be allowed in the air stream.
    - a. Thickness: 2 inches (51 mm), and of 1.5 pounds per cubic foot (24 kg/cum) density.
  3. Access Panels and Doors: Same materials and finishes as cabinet and complete with hinges, latches, handles, and gaskets.

- a. Fan section shall have inspection and access panels and doors sized and located to allow periodic maintenance and inspections.
  4. Drain Pans: Formed sections of stainless steel sheet. Fabricate pans in sizes and shapes to collect condensate from cooling coils (including coil piping connections and return bends) and humidifiers when units are operating at maximum-catalogued face velocity across cooling coil.
    - a. Drain Connections: Either ends of pan for positive draining.
    - b. Units with stacked coils shall have an intermediate drain pan or drain trough to collect condensate from top coil.
- C. Fan Section:
1. Fan-Section Construction: Belt-driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure, equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels. Mount fan scroll, wheel, shaft, bearings, and motor on structural-steel frame, with frame mounted on base with vibration isolation.
  2. Fan Housings: Fabricate from formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff, spun-metal inlet bell, and access doors or panels to allow entry to internal parts and components.
    - a. Performance Class: AMCA 99-2408, Class I.
  3. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor power. Fan wheel shall be double-width, double-inlet type with forward-curved blades or backward-curved airfoil blades as indicated.
    - a. Backward Inclined: Steel or aluminum construction with curved inlet flange, back plate, backward-curved blades, and cast-iron or cast-steel hub.
    - b. Shafts: Hot-rolled steel, turned, ground, and polished, and having keyway to secure to fan wheel hub.
    - c. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow-block-type ball or roller bearings with adapter mount and two-piece, cast iron housing.
      - 1) Ball bearing Rating Life: ABMA 50, L-50 of 200,000 hours.
      - 2) Roller bearing Rating Life: ABMA 50, L-50 of 200,000 hours.
    - d. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation. Service Factor Based on Fan Motor: 1.5.
    - e. Pulleys: Cast iron or steel with split, tapered bushing, dynamically balanced at factory.
    - f. Motor Pulleys: Adjustable pitch, selected so pitch adjustment is at middle of adjustment range at fan design conditions.
    - g. Belts: Oil resistant, non-sparking, and non-static; matched for multiple belt drives.
    - h. Belt Guards: Fabricate to OSHA/SMACNA requirements, 0.1046 inch (2.7 mm) thick, 3/4-inch (20-mm) diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Provide belt guards for motors mounted on outside of cabinet.
    - i. Motor Mount: Adjustable for belt tensioning.
    - j. Vibration Control: Install fan-assemblies on "open-spring" type vibration isolators, minimum 1-inch (25-mm) static deflection, with side snubbers or seismic restraints.
  4. Fan-Section Source Quality Control: The following factory tests are required:
    - a. Sound Power Level Ratings: Comply with ARI 260, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data."
    - b. Test fans according to ARI 260, "Reverberant Room Method for Sound Testing of Fans."
    - c. Fans shall bear AMCA-certified sound ratings seal.

- d. Factory Test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to ARI 430, "Laboratory Methods of Testing Fans for ratings."

D. Motors:

1. General: Refer to Division 15, Section 15055 "Motors" for general requirements.
2. Motor Construction: NEMA MG-1, general purpose, continuous duty, high efficiency, Design B, mounted on adjustable base.
3. Enclosure: Open drip-proof motors where satisfactorily housed or remotely located during operation (unless otherwise indicated).
4. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
5. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range.
6. Temperature Rating: 50 deg C maximum temperature rise at 40 deg C ambient for continuous duty at full load (Class A Insulation).
7. Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.
8. Bearings: The following features are required:
  - a. Ball or roller bearings with inner and outer shaft seals.
  - b. Grease lubricated.
  - c. Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.
9. Overload Protection: Built-in, automatic reset, thermal overload protection.
10. Nameplate: Indicate full identification of manufacturer, ratings, characteristics, construction, and special features.
11. Starters, Variable Frequency Drives, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 16 Sections.

E. Coils:

1. Coil Sections: Common or individual, insulated, galvanized steel casings for heating and cooling coils. Design and construct to facilitate removal and replacement of coil for maintenance and to assure full airflow through coils.
2. Water coils: Water coils shall be, self-draining, fabricated according to ARI 410. : Drainable with threaded plugs, serpentine with return bends in smaller sizes and with return headers in larger sizes. Maximum coil face velocity shall not exceed 500 FPM for chilled water coils and 700 FPM for hot water coils.
  - a. Fins: Aluminum, mechanically bonded to tubes. Fin spacing range shall be 4 to 12 Fins / Inch as required to meet design capacity requirements.
  - b. Tubes: Seamless copper.
  - c. Coil Frame: Galvanized-steel channel frame, 0.064 inch (1.6 mm).
  - d. Headers: Seamless copper tube with brazed joints, prime coated, complete with connections for drain valve, air vent, and threaded, same-end, piping connections.
  - e. Coil construction: Drainable with threaded plugs, serpentine with return bends in smaller sizes and with return headers in larger sizes.
  - f. Ratings: Design shall be factory performance tested and rated of working pressure of 200 psig (1380 kPa), and 325 deg. F (163 deg. C), according to ASHRAE 33 and ARI 410.
3. Electric-Resistance Coils: Finned-tube construction with 80 percent nickel, 20 percent chromium elements, mounted in copper-plated steel tube and surrounded by magnesium-oxide powder; spirally wound with copper-plated steel fins brazed to tubes; mounted in aluminized- or galvanized steel frame.
  - a. Control Panel: NEMA 250, Type 1 enclosure, with thermal cutouts, primary and secondary controls, back-up contactors, circuit fusing, airflow switch, and fused control transformer. Include integral primary automatic and secondary manual reset thermal-protection devices and airflow switches.

- F. Dampers, Damper Operators, Mixing Box and Combination Filter/Mixing Box:
1. Dampers and damper operators: Damper air-leakage rate shall be defined according to AMCA 500, "Test Methods for Louvers, Dampers and Shutters," and shall not exceed 2 percent of air quantity at 2,000-fpm (10-m/s) face velocity through damper and 4-inch WG (1,000-Pa) pressure differential.
    - a. Damper operator(s) shall be pneumatic. Operator(s) shall be of suitable size and capacity shipped as part of the mixing box assembly ready for controls connection under Division 17, "Instrumentation and Controls".
  2. Mixing Box: Housing shall be reinforced galvanized steel. Return air and outdoor airflow shall be controlled by parallel-blade or opposed blade type galvanized steel damper. Damper blades shall be mechanically fastened to a common operating rod. Operating rods shall be connected with a common linkage. Interconnect linkages to operate both return and outdoor air dampers simultaneously to maintain constant air capacity to the assembly. When 100 % outdoor air (Economizer mode) operation is required (Return Air Damper is fully closed), a remote "exhaust/relief" control damper shall be interfaced to modulate thus maintaining space pressure control. For the related Control Damper specification see Section 15820, "Duct Accessories".
  3. Combination Filter/Mixing Box: Parallel-blade galvanized steel damper blades mechanically fastened to steel operating rod in reinforced, galvanized steel cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat permanent or throwaway filters. Provide hinged access panels or doors to allow removal of filters from both sides of unit.
- G. Air-Filters:
1. For Pre-filters and Final Air-Filters specifications, See Division 15, Section 15887 "HVAC Air-Filters and Components."

~~H. Humidification Section: For the Target Building only, provide as indicated on drawings, a suitable length of (84" unless otherwise indicated) access segment for "Fogger-Humidifier" installation within the Air handler housing in the field. Access segment shall include a moisture separator section to prevent water carry-over in the supply air stream.~~

- H. Furnish a complete Fogger Humidifier assembly ~~shipped loose~~ with the Air Handling Unit ~~ready for installation with minor modifications to the access segment housing~~. Air Handling Unit manufacturer shall coordinate modular housing length requirements prior to assembly with Fogger-Humidifier manufacturer recommendation to achieve proper water dispersion within the added space.

Fogger Humidifier assembly shall be installed by the ~~Mechanical Contractor in the field~~ manufacturer, under the Air Handling Unit manufacturer 's supervision and start-up assistance such that all warranties are maintained.

Factory fabricated assembly shall include: manifolds, tubing, fittings, nozzles, stainless-steel drain pan, control panel(s) and all required proportional controls.

Materials of construction for all wetted parts shall be compatible for low conductivity, deionized-water use.

Water and air pressure to disperse deionized (DI) water shall be provided by others, as indicated on drawings.

1. Evaporation efficiency shall not be less than 98%, prior to impinging upon any surface within the fog chamber while delivering its maximum rated capacity of fog with water supplied at 75 PSIG (to the control panel) and 95 PSIG compressed air (to the control panel). Humidification (fogging) capacities shall be no less than amounts indicated in the respective humidification schedule for each air handling system.
2. Equipment: Fogger manifolds shall be furnished complete for installation & consist of:

- a. Resonator assembly, which permits online pattern adjustment from doughnut to plume to achieve cross flow mixing with the receiving air mass, shall be of one piece and made of 316 Stainless steel. There shall be no moving parts on the resonator assemblies.
  - b. Orifice shall be interchangeable and made of 316 Stainless steel, capable of generating a pound of fog for each 0.10 SCFM of compressed air consumed at maximum scheduled humidifier capacities. Orifice and resonator shall be capable of maintaining an ultrasonic field at driving air pressures above 20 PSIG.  
The entire assembly shall have a "linear-modulation" characteristic such that as air and water pressures are modulated in parallel, the water droplets are continually reduced to 0.10 to 10.00 micron particles, even as flow for each respective fluid is changed through the action of the air and water modulating valves.
  - c. All "fogger-head" and related integral components shall all be constructed of 316 Stainless Steel.
  - d. Check valve: Fogging assemblies shall be equipped with a dedicated water check valve with a minimum cracking pressure capability at 0.33 PSIG.
  - e. Fogger-manifold: Each manifold shall be factory assembled and shall have a secondary water line for pressure stabilization, which shall run parallel to the main water line on each manifold. All manifold fittings shall be 316 SS tube fittings.
  - f. Water and Air Control valves: Deionized water and Compressed Air control valve assemblies shall be factory pre-assembled by the fogger-humidification equipment manufacturer.  
Each water system shall be equipped with a dedicated, ¼" size, capacity modulating water valve. Valve shall be ball type, 316 Stainless Steel as manufactured by Jordan. Model MK 68-8 or approved equal.  
Each compressed air valve assembly shall have a dedicated, ¼" size, 3-way actuated air valve for positive shut-off and drain-down of water when the system is off. Valve shall be ball type, 316 Stainless Steel as manufactured by Whitey, Model 43XF4-31C-1303 or approved equal.
  - g. The resonator plug and stand shall permit realignment and replacement without removal or replacement of the fogger assembly.
  - h. The fogger must have no moving parts. Any fogging device with springs or diaphragms is unacceptable.
3. Local Control Panel: Control panel shall be factory fabricated, NEMA 4, with all fittings for field connection suitably tagged and include the following:
    - a. Will wiring connections shall be numbered on a pre-wired terminal strip.
    - b. The panel shall house both regulating and proportional valves as well as the operating safeties and controls, which make the system fully automatic.
  4. Local Panel Connections:
    - a. Air and water, supply and outlets.
    - b. 120 volt operating circuit.
    - c. 24 or 120-volt circuits to remote valves and sensors.
    - d. DDC control signal interface for trouble alarm.
  5. Panel Indicators:
    - a. Power on light.
    - b. Foggers on light.
  6. Panel Operations:
    - a. On/Of switch.
    - b. Remote Air Feedback (RAF).
  7. Remote Air Feed Back (RAF):
    - a. The Remote Air Feedback (RAF) system shall continuously monitor the downstream remote air pressure at the fogger manifold(s) within the fog

- chamber. The RAF is read by the signal-air biasing relay within the panel and maintains a fixed pressure differential between the air and water valves. The biasing relay is set so that a fixed pressure differential is maintained at the fogger throughout the systems' operational range.
- b. Modulation of both air and water is required. Both compressed air and water shall have their own modulating valve. The pressure differential between the compressed air and water must be constant throughout the entire modulating range. Each system shall have a modulating range of no less than 50 to 1.
8. Humidifier Manufacturer shall be Armstrong / "Cool-Fog" or equal.

### 2.42.3 ROOFTOP AIR-HANDLING UNITS

- A. General Description: Units shall be factory assembled, weather-tight construction suitable for outdoor installation, consisting of supply and return fans, economizer damper section with outdoor-air, return-air, mixing-air dampers, motor and drive assembly, coils, pneumatic damper-operators, plenums, filters, condensation drip-pan, mounted on a pre-fabricated roof curb.
- B. Cabinet / Housing.
  1. Materials: Formed and reinforced double-wall, galvanized steel panel construction, fabricated to allow removal for access to internal parts and components, with joints between sections sealed for weather-tight, outdoor operation. Panels shall be rigid construction with inside retainer capable of withstanding 6 inches positive static pressure or -4 inches negative static pressure.
  2. Provide "freeze-protection" for the coil cabinet section during emergency operations in the winter season.
  3. Economizer damper section shall be complete with outdoor-air, return-air, mixing-air dampers and operators, suitable for 100 % outdoor air (economizer mode) operation. Outdoor air intake shall include hood and moisture separator.
  4. Motors: Refer to Division 15, Section 15055 "Motors" for general requirements.
    - a. Construction: NEMA MG-1, general purpose, continuous duty, and high efficiency, Design B, mounted on adjustable base.
    - b. Enclosure: Totally Enclosed Fan Cooled (TEFC) (unless otherwise indicated).
  5. All other elements of construction shall be the same as defined above in Section 2.2 for Central Air Handling Units installed indoors.

### 2.62.4 FAN-COIL UNITS

- A. General Description: Fan-Coil Units shall be of horizontal or vertical configuration. Each assembly shall consist of a chassis, cabinet, filters, water-coils and coil section insulation (as applicable), drain pan, circulation-fan, and motor in a blow-through configuration. These equipment shall be provided as follows:
  1. Provide and install of horizontal configuration fan-coil units of size and capacity indicated on drawings ~~in the CUB Building and SCE areas of the Target Building. There are two types of Fan-coil units in the Target Building SCE areas; Fan-coil units with "Heating-only" and Fan-coil units with both "Heating and Cooling.~~
  2. ~~Provide and install of vertical configuration fan-coil units of size and capacity indicated on drawings in Stairwell No.5 of the Target Building. Fan-coil units shall be of front "toe-space" inlet type and of top "quad-grille" discharge configuration. These Fan-coil units shall be equipped with both hot water heating and chilled water cooling coils.~~
- B. Materials:
  1. Chassis: Galvanized steel with flanged edges.
  2. Cabinet: Galvanized steel with removable bottom panels. Panels shall be fastened to unit with cam fasteners and hinge. Provide safety chain and cast aluminum discharge grille(s) when opened. Cabinet finish: Provide with baked-on primer with

- manufacturer's standard paint applied to factory assembled and tested unit before shipping. Coordinate color requirements during submittal phase with CM.
3. Filters: Fan-coil unit shall be complete with, 1-inch (25 mm) thick, throwaway type, 30-35 % efficient filters in metal or fiberboard frames.
  4. Heating coils: Heating hot water coils shall be single row, copper tube complying with ASTM B 75 (ASTM B 75M), with mechanically bonded aluminum fins and with manual air vent. Fins spacing range shall be 4 to 12 Fins / Inch as required to meet design capacity requirements. Coils shall be design tested and rated according to ASHRAE 33 and ARI 410 as follows:
    - a. Working Pressure Ratings: 200 psig (1,380 kPa).
    - b. Working Temperature Ratings: 325 deg F (163 deg C).
  5. Cooling coils: Chilled-water cooling coils shall be single or multiple row as designated by capacity requirements on drawings. Coils shall be copper tube complying with ASTM B 75 (ASTM B 75M), with mechanically bonded aluminum fins and with manual air vent. Fins spacing range shall be 4 to 12 Fins / Inch as required to meet design capacity requirements. Coils shall be design tested and rated similar to heating coils above according to ASHRAE 33 and ARI 410.
  6. Coil section insulation: 1-inch (25 mm) duct liner complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916. Duct liner and adhesive shall have a maximum flame spread rating of 25 and smoke developed rating of 50 when tested according to ASTM E 84.
  7. Drain pans: Galvanized steel, with connection for drain. Drain pan shall have a removable plastic liner and be insulated with polystyrene or polyurethane insulation. Drain pan and liner shall be formed to slope from all directions to drain connection.
  8. Fan: centrifugal, with forward-curved, double-width wheels and fan scrolls made of galvanized steel, directly connected to a V-belt driven motor.
  9. Fan Motor: Belt driven electric motors shall be TEFC type with hinged mount and adjustable pulley.

#### 2.72.5 AIR COILS (HW, CHW, DX & ELECTRIC)

- A. Hot Water Coils: Heating coil face velocity shall not exceed 700 FPM maximum.
  1. General Description: Continuous circuit coil fabricated to ARI 410.
  2. Piping Connections: Threaded, on same end.
  3. Tubes: Copper, complying with ASTM B 75 (ASTM B 75M).
    - a. Tube Diameter: 0.50 inch (12.7 mm) minimum.
  4. Fins: Aluminum with fin spacing range shall be 4 to 12 Fins / Inch as required to meet design capacity requirements.
  5. Fin and Tube Joint: Mechanical bond.
  6. Headers: Seamless copper tube with brazed joints, prime coated.
  7. Frames: Galvanized-steel channel frame, 0.064 inch (1.6 mm).
  8. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
    - a. Working Pressure Ratings: 200 psig (1,380 kPa), 325 deg F (163 deg C).
  9. Source Quality Control: Test to 300 psig (2,070 kPa), and to 200 psig (1,380 kPa) underwater.
- B. Chilled Water Coils: Cooling coil face velocity shall not exceed 500 FPM maximum.
  1. Description: Continuous circuit coil fabricated to ARI 410.
  2. Piping Connections: Threaded, on same end.
  3. Tubes: Copper, complying with ASTM B 75 (ASTM B 75M).
    - a. Tube Diameter: 0.50 inch (12.7 mm) minimum.
  4. Fins: Aluminum with fin spacing range shall be 4 to 12 Fins /Inch as required to meet design capacity requirements.
  5. Fin and Tube Joint: Mechanical bond.
  6. Headers: Seamless copper tube with brazed joints, prime coated.

7. Frames: Galvanized-steel channel frame, 0.064 inch (1.6 mm).
  8. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
    - a. Working Pressure Ratings: 200 psig (1,380 kPa), 325 deg F (163 deg C).
  9. Source Quality Control: Test to 300 psig (2,070 kPa), and to 200 psig (1,380 kPa) underwater.
- C. Refrigerant DX Coils: Generally, Refrigerant DX coils are part of factory installed HVAC package equipment provided under a specific capacity selection of "Split-AC Systems" equipment. Coil specification parameters are therefore shall be the Manufacturers standard so long it meets the intended use. The DX coil specification herein shall serve as a guide to establish minimum coil criteria when no other equivalent option is available.
1. Description: Coil designed for use with R-22 refrigerant, fabricated to ARI 410, connected with soldered fittings. Refrigerant DX coil face velocity shall not exceed 500 FPM maximum.
  2. Capacity Reduction: Circuit for row control.
  3. Tubes: Copper, complying with ASTM B 75 (ASTM B 75M).
    - a. Tube Diameter: 0.50 inch (12.7 mm) minimum.
  4. Fins: Aluminum with fin spacing range shall be 4 to 12 Fins /Inch as required to meet design capacity requirements.
  5. Fin and Tube Joint: Mechanical bond.
  6. Suction and Distributor: Seamless copper tube with brazed joints.
  7. Frames: Galvanized-steel channel frame, 0.064 inch (1.6 mm).
  8. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
    - a. Working Pressure Rating: 300 psig (2,070 kPa).
  9. Source Quality Control: Test to 450 psig (3,110 kPa), and to 300 psig (2,070 kPa) underwater.
- D. Electric Coils-Electric Duct Heaters: Contrast to the water coils above, sufficient airflow must be provided across the heater in order to prevent coil overheating. Selection shall maintain minimum coil face-velocities across the electric-heater in terms of Input (kW) vs. Heater/duct face area (SF) allocation considering the entering air temperature coil.
1. Electrical Heating Coils, Controls, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  2. Coil Assembly: Comply with UL 1096
  3. Casing Assembly: Slip-in type with galvanized-steel frame
  4. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
  5. Over temperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or air handling unit.
    - a. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
  6. Control Panel: Unit mounted with disconnecting means and over current protection. Include the following controls:
    - a. Magnetic contactor.
    - b. Solid State Proportional Controllers (SCR's), or step control as indicated.
    - c. Time-delay relay.
    - d. Pilot lights; one per step.
    - e. Airflow proving switch.

## 2.82.6 CENTRIFUGAL FANS

- A. Centrifugal Fans: Shall be factory-fabricated, -assembled, -tested, and -finished. Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.
- B. Housings: Shall be formed and reinforced steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and doors or panels to allow access to internal parts and components. Use galvanized steel to fabricate fans downstream from humidifiers.
1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
  2. Fabrication Class: AMCA 99, Class I.
  3. Horizontal Flanged Split Housing: Bolted construction.
  4. Plug Fans: Fabricate without fan scroll and volute housing, with steel cabinet.
  5. Tubular Centrifugal Fans: Fabricate tubular housing from formed and reinforced steel panels with welded seams and the following:
    - a. Outlet guide vanes.
    - b. Motor and disconnect switch.
    - c. Spun inlet cone with flange.
    - d. Outlet flange.
    - e. Brackets suitable for horizontal or vertical mounting.
  6. Coatings: Hot-dip galvanized.
- C. Wheels:
1. Backward-Inclined Fan Wheels: Steel, one-piece, with curved inlet flange, back plate, backward-inclined blades welded or riveted to flange and back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.
  2. Forward-Curved Fan Wheels: Black-enameled or galvanized steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; cast-steel hub swaged to back plate and fastened to shaft with set screws.
  3. Airfoil-Fan Wheels: Steel construction with smooth-curved inlet flange; heavy back plate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.
  4. Coatings: Hot-dip galvanized.
- D. Shafts:
1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
  2. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
  3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- E. Bearings:
1. Pre-lubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
  2. Ball-Bearing Rating Life: ABMA 9,  $L_{10}$  of 120,000 hours.
  3. Roller-Bearing Rating Life: ABMA 11,  $L_{10}$  of 120,000 hours.
- F. Belt Drives: Shall be factory mounted, with final alignment and belt adjustment made after installation. Service Factor Based on Fan Motor: 1.5:

1. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
  2. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  3. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
    - a. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements; 0.1046-inch- (2.7-mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
  4. Motor Mount: Adjustable for belt tensioning.
- G. Accessories:
1. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
  2. Companion Flanges: Galvanized steel, for duct connections.
  3. Inlet Screens: Galvanized steel welded grid screen, when fan inlet is open.
  4. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
  5. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
  6. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
- H. Motors:
1. General: Refer to Division 15, Section 15055 "Motors" for general requirements.
  2. Motor Construction: NEMA MG-1, general purpose, continuous duty, high efficiency, Design B, mounted on adjustable base.
  3. Enclosure: Totally Enclosed Fan Cooled (TEFC) unless otherwise indicated.

### 2.92.7 LABORATORY EXHAUST FANS

- A. In addition to Section 2.5, for laboratory exhaust applications, all parts in contact with the exhaust air stream shall be coated. Coating material shall be "PLASITE, Type 7122", (no known equal). Fan manufacturer, or their appointed representative shall apply the coating as directed by the coating manufacturer and as approved by the Construction Manager. Fan arrangement shall be as shown on drawings. Fans shall be belt driven. Fans shall be field adjusted after installation.
1. Pulleys: Cast iron with split tapered bushing; dynamically balanced at factory.
  2. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  3. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
  4. Belt Guards: Fabricated of steel frame and wire mesh screen.
- B. Motors:
1. General: Refer to Division 15, Section 15055 "Motors" for general requirements.
  2. Motor Construction: NEMA MG-1, general purpose, continuous duty, high efficiency, Design B, mounted on adjustable base.
  3. Enclosure: Totally Enclosed Fan Cooled (TEFC) unless otherwise indicated.

### 2.102.8 POWER VENTILATORS

- A. Utility Set Fans:

1. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
  2. Housing: Fabricated of galvanized steel with side sheets fastened with a deep lock seam or welded to scroll sheets.
    - a. Housing Discharge Arrangement: Adjustable to eight standard positions.
  3. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.
    - a. Blade Materials: Steel.
    - b. Blade Type: Backward inclined.
  4. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
  5. Shaft Bearings: Pre-lubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L<sub>50</sub> of 200,000 hours.
  6. Motors: Refer to Division 15, Section 15055 "Motors" for general requirements.
    - a. Construction: NEMA MG-1, general purpose, continuous duty, high efficiency, Design B, mounted on adjustable base.
    - b. Enclosure: Totally Enclosed Fan Cooled (TEFC) (unless otherwise indicated).
  7. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
    - a. Service Factor Based on Fan Motor: 1.5.
    - b. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
    - c. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
    - d. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
  8. Accessories:
    - a. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades and felt edges in steel frame installed on fan discharge.
    - b. Access Doors: Gasketed doors with latch-type handles.
    - c. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
    - d. Inlet Screens: Removable wire meshes.
    - e. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing.
    - f. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
  9. Coatings: Hot-dip galvanized.
- B. Centrifugal Roof Ventilators:
1. Description: Belt-driven or direct-driven as indicated on drawings, centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
  2. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
    - a. Up blast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
  3. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
  4. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
    - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
    - b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    - c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
    - d. Fan and motor isolated from exhaust air stream.

5. Motors: Refer to Division 15, Section 15055 "Motors" for General Requirements.
    - a. Construction: NEMA MG-1, general purpose, continuous duty, high-efficiency, Design B, mounted on adjustable base.
    - b. Enclosure: Totally Enclosed Fan Cooled (TEFC) unless otherwise indicated on drawings.
      - c. For Hydrogen Room ventilation equipment in the Target Building, provide "Explosion-proof" motor enclosures for Roof Exhaust Fans EF-TA-13, EF-TA-14 & EF-TA-15.
  6. Accessories:
    - a. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
    - b. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
    - c. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
  7. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
    - a. Configuration: Built-in raised cant and mounting flange.
    - b. Overall Height: 12 inches (300 mm).
    - c. Sound Curb: Curb with sound-absorbing insulation matrix.
    - d. Hinged Sub base: Galvanized steel hinged arrangement permitting service and maintenance.
- C. Axial Roof Ventilators:
1. Description: Belt-driven or direct-driven axial fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
  2. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base.
  3. Fan Wheel: Steel hub and blades.
  4. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
    - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
    - b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    - c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
  5. Motors: Refer to Division 15, Section 15055 "Motors" for general requirements.
    - a. Construction: NEMA MG-1, general purpose, continuous duty, high efficiency, Design B, mounted on adjustable base.
      - b. Enclosure: Totally Enclosed Fan Cooled (TEFC) (unless otherwise indicated).
  6. Accessories:
    - a. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
    - b. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
    - c. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
  7. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
    - a. Configuration: Built-in raised cant and mounting flange.
    - b. Overall Height: 12 inches (300 mm)
    - c. Sound Curb: Curb with sound-absorbing insulation matrix.
    - d. Hinged Sub-base: Galvanized steel hinged arrangement permitting service and maintenance.

- D. Centrifugal Wall Ventilators:
1. Description: Belt-driven or direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
  2. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle & venturi inlet cone.
  3. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.
  4. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
    - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
    - b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    - c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
    - d. Fan and motor isolated from exhaust air stream.
  5. Motors: Refer to Division 15, Section 15055 "Motors" for general requirements.
    - a. Construction: NEMA MG-1, general purpose, continuous duty, high efficiency, Design B, mounted on adjustable base.
      - a. Enclosure: Totally Enclosed Fan Cooled (TEFC) (unless otherwise indicated).
  6. Accessories:
    - a. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
    - b. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
    - c. Wall Grille: Ring type for flush mounting.
- d. Motorized Dampers: Parallel-blade dampers mounted in wall with electric actuator; wired to close when fan stops.
- E. In-line Centrifugal Fans:
1. Description: In-line, belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
  2. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
  3. Motors: Refer to Division 15, Section 15055 "Motors" for general requirements.
    - a. Construction: NEMA MG-1, general purpose, continuous duty, high efficiency, Design B, mounted on adjustable base.
      - a. Enclosure: Totally Enclosed Fan Cooled (TEFC) (unless otherwise indicated).
  4. Direct-Driven Units: Motor encased in housing outside of air stream, factory wired to disconnect switch located on outside of fan housing.
  5. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
  6. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
  7. Accessories:
    - a. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
    - b. Companion Flanges: For inlet and outlet duct connections.
    - c. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
    - d. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
- F. Propeller Fans:
1. Description: Belt-driven or direct-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.

2. Housing: Galvanized steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.
  3. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
  4. Fan Wheel: Replaceable, extruded-aluminum, airfoil blades fastened to cast-aluminum hub. Blade pitch angle shall be factory set.
  5. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
    - a. Service Factor Based on Fan Motor: 1.4.
    - b. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
    - c. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
      - Ball-Bearing Rating Life: ABMA 9,  $L_{10}$  of 120,000 hours.
    - d. Pulleys: Cast iron with split tapered bushing; dynamically balanced at factory.
    - e. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
    - f. Belts: Oil resistant, non-sparking, and non-static; matched sets for multiple belt drives.
    - g. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
  6. Motors: Refer to Division 15, Section 15055 "Motors" for general requirements.
    - a. Construction: NEMA MG-1, general purpose, continuous duty, high efficiency, Design B, mounted on adjustable base.
    - a. b. Enclosure: Totally Enclosed Fan Cooled (TEFC) (unless otherwise indicated).
  7. Accessories:
    - a. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
    - b. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
    - c. Wall Sleeve: Galvanized steel to match fan and accessory size.
    - d. Weather-shield Hood: Galvanized steel to match fan and accessory size.
    - e. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
- G. Powered Smoke Ventilators:
1. Description: The fan housing shall be constructed of heavy gauge aluminum with a rolled bead and a rigid internal support structure. Exhaust fan shall be centrifugal, backwardly inclined, constructed of steel with inlet cone. Wheel shall be statically and dynamically balanced. Fan shall bear the AMCA Certified Ratings Seal for sound and air performance. Smoke exhaust fan shall be designed for continuous operation at 500°F smoke exhaust air temperature.

Size and capacity as indicated on drawings. The fan shall be activated manually, by fusible-link or by a central smoke detection system as indicated on smoke control drawings.
  2. Belt drive arrangement orientation shall mount the motor out of the air-stream. Belts, bearings, pulleys and shaft shall be enclosed and protected. Belts shall be heat resistant as per Industrial Risk insurers' (IRI) standards and shall be supplied with a minimum of two belts. Drive and frame assembly shall be constructed of heavy gage steel. Motors and drive shall be readily accessible for maintenance.
  3. Bearings: Provide permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L-10) life in excess of 100,000 hours at maximum cataloged operating speed.

4. Fan shall be Underwriters Laboratory (UL) listed for electrical components and UL Listed for Emergency Smoke Control Systems.
5. Provide a factory installed local disconnect switch complete in a non-fused, rain-tight, NEMA 3R enclosure mounted on the curb panel and wired to the fan motor.
6. Pre-fabricated roof curb: Provide an 8 inch minimum high, pre-fabricated roof curb, constructed of 18 gauge-galvanized steel.
7. Smoke exhaust fans shall be wired to the Emergency Power system.
8. Motors: Refer to Division 15, Section 15055 "Motors" for general requirements.
  - a. Construction: NEMA MG-1, general purpose, continuous duty, high efficiency, Design B, mounted on adjustable base.
  - a. b. Enclosure: Totally Enclosed Fan Cooled (TEFC) (unless otherwise indicated).

a-b.

I.H. General: Coordinate specified voltage, phase and enclosure, requirements for each electric motor supplied with any of Power Ventilators specified above. Motors shall be specifically matched to each fan type and load requirements as indicated on drawings.

#### 2.142.9 CABINET UNIT HEATERS (HOT WATER OR ELECTRIC)

- A. General Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with horizontal, adjustable louvers in blow-through configuration.
- B. Materials:
  1. Casing: Galvanized steel, with removable panel
  2. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer and manufacturer's standard paint applied to factory-assembled and -tested propeller unit heater before shipping.
- C. Hot-Water Coil: Copper tube, 0.031-inch (0.78-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1,380 kPa) and a maximum entering water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 375 psig (2,690 kPa) underwater.
- D. Electric-Resistance Heating Elements:
  1. Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium-oxide insulating refractory and sealed in high-mass steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch (4 mm). Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F (288 deg C) at any point during normal operation.
    - a. Circuit Protection: One-time fuses in terminal box for over current protection and limit controls for over temperature protection of heaters.
    - b. Wiring Terminations: Match conductor materials and sizes indicated.
- E. Fan: Propeller with aluminum blades directly connected to motor.
- F. Motors:
  1. Refer to Division 15, Section 15055 "Motors" for general requirements.
  2. Construction: NEMA MG-1, general purpose, continuous duty, high efficiency, Design B.
  3. Motors, ½ hp and Smaller: Permanent-split capacitor, multi-speed motor with integral thermal-overload protection.
  4. Motors, ¾ hp and Larger: Totally enclosed with permanently lubricated ball bearings

- G. Accessoires:
  - 1. Horizontal Configuration: Louver fin diffuser.
  - 2. Vertical Configuration: Louver cone diffuser.
- H. Source Quality Control:
  - 1. Test propeller unit heater coils according to ASHRAE 33.

#### 2.142.10 INDUSTRIAL CEILING FANS

- A. These fans are intended to re-circulate entrapped hot air within the facility by forcing the accumulated hot air from higher elevations to floor level.
  - 1. Description: Heavy-duty 3-blade fans are powered by totally enclosed, neoprene sealed, three (3) speed motor, permanently lubricated ball bearings with self-resetting thermal overload protection. 120Volt, Single Phase, 60 Cycle. Size and capacity as indicated on drawings.
  - 2. Motor and blades have corrosion resistant epoxy powder paint electro-statically applied as an undercoat and white epoxy paint finish coat.
  - 3. Neoprene shielded top boot and lower spay deflector, 12" long down rod and fan guard that shall mount directly to the fan rod.
  - 4. UL listed. . Comply with UL specifications for low blade application, and shall be balanced for wobble-free operation
  - 5. Metal Fan Blades shall have 3/8" rolled edges.

#### 2.142.11 HOT WATER UNIT HEATERS

- A. Provide and install propeller fan assisted hot water unit heaters of horizontal delivery, size, capacity and voltage as indicated on drawings. Unit heaters shall be the manufacturer's package equipment complete with 120 Volts single-phase manual starter with thermal overload elements sized to carry the full-load AMP rating of the motor.
  - 1. Electric motor shall be continuous fan-duty type Totally Enclosed (TE) as per NEMA standards.
  - 2. Thermostat: With each Unit Heater, provide a line voltage, heavy-duty type thermostat with contacts sized to carry the full-load AMP rating of the motor or motor starter coil. Heater shall be complete with all code required wiring and controls.
  - 3. Condenser coil shall be of serpentine design with horizontal tubes, vertical fins, center supply connection at bottom and center return connection at bottom of unit. Tube joints shall be brazed and all tubes shall have individual expansion bends. Provide pipe unions and shut-off valves to and from the heater, balancing valve, drain valve and an automatic air vent at high point. Both supply and return branch piping shall pitch down toward the heater. Provide adequate pipe hangers and supports, or anchors to secure the piping system independently of the unit heater.

#### 2.142.12 ELECTRIC BASEBOARD HEATERS

- A. Provide and install electric baseboard heaters of type, size, capacity and voltage as indicated on drawings Size, type and capacity as indicated on drawings. Baseboard heater shall be a manufacturer's package equipment, ready for installation. Baseboard Unit shall carry a UL label and shall be complete with all code required wiring, and controls, including a 2-pole self-contained thermostat, thermal overload protection, disconnect-switch and a suitable wall bracket to support the heater.
  - 1. Enclosure: back and top shall be of one piece. Front panel shall be 18 gage steel, extending up from the air intake opening to the top of the element. Heavy-duty steel grille shall be attached to the outlet air discharge area. Back top and front panel shall be phosphatized and painted with baked enamel finish.
  - 2. Electric Heating elements shall consist of nickel chromium alloy resistance wire embedded and swaged in a corrosion resistant aluminum sheath. Fins shall be

mechanically locked to the sheath. The electric heating element shall carry a 5-year limited warranty. Enclosures and components shall carry a limited one-year warranty minimum.

3. Thermostat: With each Baseboard Heater, provide a line voltage, heavy-duty type thermostat with contacts sized to carry the full-load AMP rating of the heater or heater starter coil. Heater shall be complete with all code required wiring and controls.

### 2.152.13 GRAVITY ROOF VENTILATORS (INTAKE OR RELIEF)

- A. Provide and install Gravity Roof Ventilators of size and capacity as indicated on drawings. Ventilator shall be of low silhouette, extruded aluminum, louvered penthouse design for both Outdoor air Intake and Exhaust / Relief functions. The unit shall be factory made and assembled of side sections with interior bird-screen, curb-cap, cover, all vertical supports and louvers required for the capacity specified for the application. Jobsite assembly of larger units is acceptable provided that each unit is complete with all required fasteners and assembly instructions without any special tools. Provide a corrosion resistant powdered epoxy coat finish that is fused to the metal surfaces on all units.
  1. Pre-fabricated roof-curb: Provide an insulated roof-curb to match both size and finish, for both the relief and intake hoods. Roof curbs shall be complete with nailing strips and insulation liner firmly attached to the inside of curb wall.
  2. Control damper: Relief ventilators shall be complete with Damper Operator. Damper shall be opposed blade design, size to match the relief ventilator. Damper operator shall be part of the assembly provided. Damper operator(s) force requirements shall be suitable for the specific size of damper assigned.
  3. Damper operator shall be pneumatic type.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and conditions to receive equipment, for compliance with installation tolerances and other conditions affecting performance of central-station air-handling units.
- B. Examine roughing-in of steam, hydronic, condensate drainage piping, and electrical to verify actual locations of connections before installation.
- C. Do not proceed with installation until unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install all HVAC equipment, such as air-handling units, fans, heaters & coils, level and plumb, according to manufacturer's written instructions.
  1. Floor-Mounted Units: Support on concrete housekeeping bases using neoprene pads. Secure units to anchor bolts installed in concrete housekeeping base.
- B. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- C. Install suspended fan coil units in accordance with manufacturer's and SMACNA requirements.

### 3.3 HOUSEKEEPING BASES

- A. Coordinate size of housekeeping bases with actual unit sizes provided. Construct base 4 inches (100 mm) larger in both directions than overall dimensions of supported unit.
- B. Form concrete bases with framing lumber with form-release compounds. Chamfer top edge and corners of base.
- C. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves to facilitate securing units.
- D. Place concrete and allow to cure before installing units. Use Portland cement conforming to ASTM C 150, 4,000-psi (27.6-Mpa) compressive strength, and normal-weight aggregate.

### 3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specified connection requirements:
  - 1. Install piping adjacent to machine to allow service and maintenance.
  - 2. Connect condensate drain pans using 1-1/4 inch NPS (DN32), Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
  - 3. Hot- and Chilled-Water Piping: Conform to applicable requirements of Division 15 Section 15106, "Chilled Water, Condenser, Water, Cooling Tower Water, Heating Hot Water, Condensate & Process Water piping, including Hydronic Specialties.". Connect to supply and return coil tappings with shutoff or balancing valve and union or flange at each connection.
  - 4. Refrigerant Liquid (RL) and Refrigerant (gas) Suction (RS) tubing specification connecting Outdoor and Indoor AC units shall be as per Section 15125, "DX Refrigerant piping System & Accessories.
- B. Duct installation and connection requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangements of ducts and duct accessories. Make final duct connections with flexible connections.
- C. Electrical: Conform to applicable requirements of Division 16 Sections.
  - 1. Connect fan motors to wiring systems and to ground. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. When manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
  - 2. Temperature control wiring and interlock wiring is specified in Division 17.
  - 3. Temperature control wiring and interlock wiring for the Center for Nanophase Materials Science ~~Office Building~~ (CNMSLO) is specified in Division 15, Section 15950 "Direct Digital Control System."

### 3.5 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

### 3.6 CLEANING

- A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

- B. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

### 3.7 COMMISSIONING

- A. Manufacturer's Field Inspection: Engage a factory-authorized service representative to perform the following:
  - 1. Inspect field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.
  - 2. Prepare a written report on findings and recommended corrective actions.
- B. Final Checks before Startup: Perform the following before startup:
  - 1. Verify that shipping, block, and bracing are removed.
  - 2. Verify that unit is secure on mountings and supporting devices and those connections for piping, ductwork, and electrical are complete. Verify that proper thermal overload protection is installed in motors, starters, and disconnects.
  - 3. Perform cleaning and adjusting specified in this Section.
  - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
  - 5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
  - 6. Set zone dampers to fully open position for each zone.
  - 7. Set face-and-bypass dampers to full face flow.
  - 8. Set outside-air and return-air mixing dampers to minimum outside-air setting.
  - 9. Comb coil fins for parallel orientation.
  - 10. Install clean filters.
  - 11. Verify that manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in fully open position.
- C. Starting procedures for central-station air-handling units include the following:
  - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
    - a. Replace fan and motor pulleys as required to achieve design conditions.
  - 2. Measure and record motor electrical values for voltage and amperage.
  - 3. Manually operate dampers from fully closed to fully open position and record fan performance.
- D. Refer to Division 15, Section 15990 "Testing, Adjusting, and Balancing" for air-handling system testing, adjusting, and balancing.

### 3.8 DEMONSTRATION

- A. Engage the services of a factory-authorized service representative to train operating and maintenance personnel as identified by the Construction Manager (CM) on procedures and schedules related to operations, startup, shutdown, troubleshooting, servicing and preventative maintenance.
  - 1. Review data in the Operation and Maintenance (O&M) manuals. Refer to closeout requirements in General and Supplementary General Conditions.
  - 2. Schedule training with Construction Manager (CM), with at least 7 days' advance notice.

**END OF SECTION 15501**