

**SECTION 237300 - AIR HANDLING UNITS**

- 1.0 ASHRAE 90.1 Compliance: University of Pennsylvania buildings shall comply with the Commercial Energy Efficiency Requirements of ASHRAE Standard 90.1-2016. The ASHRAE 90.1-2016 compliance paths shall be followed instead of the International Energy Conservation Code (IECC) requirements as permitted by 2018 IECC Section 401.2 Application.
- 2.0 The type and construction quality of AHUs shall be based on several factors, such as size, system features, building types, site restrictions, etc. The Project Engineer must carefully review the project design criteria to establish the most cost-effective equipment that provides, throughout the system life, stable and continuous operation. Major unit components shall not require replacement until the system life is realized. The following guidelines shall be utilized in the design and specification of AHUs:
  - A. Air-handling systems that are generally small in capacity (less than approximately 40,000 CFM), utilize return air, and are not serving critical program functions may be factory packaged or modular constructed components. Acceptable manufacturers are Trane, York, Carrier and McQuay.
  - B. Large, central station AHUs (greater than approximately 40,000 CFM) that are recirculating or any size unit that uses 100% outdoor air shall be a custom-designed, factory-fabricated and tested unit. All exterior mounted units shall be a custom designed factory fabricated and tested unit. Factory personnel must be present the entire time it takes to field install (set) the unit. The A/E shall not limit the selection of a custom designed unit to the above CFM ranges, but should also consider other parameters such as pressure class, criticality, or other project conditions that may warrant the use of a custom designed unit. Any AHU with EPDM roofing is to meet FM approval 190 MPH roofing system requirements and be installed by a local roofing contractor.
  - C. The Design Development report submitted by the A/E shall define the type and quality of air-handling equipment proposed for use during design. The report shall provide justification for equipment selection by the A/E.
- 3.0 Large, central station AHUs designed for installation in existing buildings where access is restricted or designed for new buildings where the construction phasing does not permit the installation of large factory fabricated sections shall be custom-designed, field erected and tested units.
- 4.0 Factory packaged or modular constructed AHUs, when approved for use, shall conform to the following criteria:
  - A. Units shall be of a modular design and have double-wall casing for all component sections.
  - B. All sections shall be double wall construction and insulated with a minimum of 2" 1-1/2 lb. insulation (foam filled preferred). The use of single wall construction is prohibited.
  - C. The unit's coil capacity must be able to handle up to 100% outdoor air when required without moisture carryover.
  - D. All unit components must have large access doors to permit inspection, routine service, and cleaning. To minimize leakage, the quantity of access doors should be limited to those locations most likely to require access for routine maintenance. Generally these locations would be for access to fans, coils, temperature sensing devices, and filters. Clearly identified removable panels should be provided at other locations (e.g., at coils for coil cleaning purposes, at damper locations, etc.). Provide access doors minimum 20

- inches wide by full height of casing or maximum of 60 inches. Swing doors against the air pressure.
- E. Unit casings shall be pressure rated for the total system design operating pressure plus 25%.
  - F. Fans shall be double width, double inlet (DWDI) centrifugal type fans. The Engineer shall select the most efficient fan available (i.e. airfoil, forward curved, backward inclined).
  - G. Fan sections, where possible, shall employ airfoil fans with a minimum ACMA Construction Class of II. Use Class III fan construction if the fan characteristic curve extends to within 10% of the fan's Class II selection zone.
  - H. Fan sections shall be isolated from the remaining unit and the connecting duct system to control vibration.
  - I. Solid fan shafts only will be considered.
  - J. Fan bearings are to be self-aligning, pillow block, regreaseable ball bearings rated for an average life of L-10 200,000 Hrs.
  - K. Fan shafts and fans shall be rated for continuous operation and shall be statically and dynamically balanced in all planes. Fan drives shall be selected for a 1.5 service factor.
  - L. Fan volume may be controlled using variable frequency fan drives. M. Units may be either draw-through or blow-through arrangements.
  - M. Coil drain pans shall be stainless steel and have a positive slope-to-drain connection.
  - N. Drain connections to be off the bottom of the coil rather than the side.
  - O. Provide thermal breaks in units downstream of cooling coils.
  - P. Factory filter/mixing boxes may only be utilized for low-outdoor-air units and where filtration is limited to 30% prefilters.
  - Q. Built-up filter/mixing sections utilizing high-quality low-leakage dampers and filter frames installed within insulated metal casings are required for all other units.
  - R. Each unit shall have adequate space to house, service, and maintain all ancillary equipment, controls, valves, instruments, etc.
  - S. Refer to Section 238200 "Air Coils" for coil design parameters such as maximum face velocities, fins per inch, etc.
  - T. For recirculation systems, consider eliminating the preheat coil where reheat coils can pick up the load and there is no building warm-up or outside air purge required.
  - U. Specify that variable temperature glycol systems are preferred for preheating to control to  $\pm 1$  degree F. A separate in-line-pump shall be utilized to maintain a constant flow through the preheat coil. Control to be performed via a mixing valve based on mixed air temperature if multiple systems are connected.
  - V. Drain pans shall be double wall and constructed of welded stainless steel with 1" 3/4 lb. insulation sandwiched between the pans. Drain pans shall be sloped to drain connections per ASHRAE Standard 62 most recent edition (and its approved addenda). Intermediate drain pans shall be used for stacked coils. Each pan shall be independently

drained.

- W. Approved manufacturers of modular AHUs shall be Carrier, McQuay, Trane, or York. Any other manufacturer shall require the approval of the University Engineering Department.
- 5.0 Custom-designed, factory-fabricated AHUs shall be based on A/E Contract documents and built to specific dimensions indicated thereon. The Project Engineer shall lay out, in sufficient detail, the desired arrangement of each complete unit showing all required components, access doors, casing openings, service clearances, and overall dimensions. Layouts shall include sections to define the overall height and vertical location of duct connections, dampers, louvers, etc. The factory-fabricated unit shall be capacity and pressure tested as a completed unit at the factory before shipment. Custom-designed units and related air-handling system components shall conform to the following criteria:
- A. Units shall be custom engineered and preassembled at the factory on a structural steel base. The units shall be shipped as one piece if possible or in as few sections as possible. The number of field-casing joints shall be reduced at all reasonable cost.
  - B. Casings shall be factory fabricated and double walled with structural, acoustical, and thermal performance certified by testing data. Casings generally have a solid exterior shell construction, minimum No. 14 gauge galvanized steel and an interior shell of No. 20 gauge galvanized steel or aluminum. A solid interior shell shall be provided upstream of prefilters and downstream of final filters and cooling coils. Remaining sections can have perforated interior shell as long as a tedlar or mylar insulation liner is used.
  - C. Casing access doors are required for both sides of each coil, fans, filters, dampers, sound attenuators, heat recovery devices, humidifiers, and any other component requiring routine service. Access doors where possible shall be man sized (24 inches x 72 inches), have vision panels, and seal with the air pressure. Access doors shall open fully after unit is completely piped and insulated. Filter section access doors shall be piano hinged.
  - D. All exterior units are to be custom designed with a heated service corridor as part of the unit. All controls and ancillary devices are to be accessible.
  - E. Each AHU component section shall be supplied with suitable vapor-tight lighting to permit maintenance functions. Lights are typically controlled from a pilot switch located adjacent to the access door. Lights shall be compact fluorescent type with minimum life of 20,000 hours and minimum light output of 3200 lumens. Lights shall be provided with 2-hour timers (push-button type). Provide a duplex GFCI electrical outlet inside each motor section. Outlet shall be controlled from the outside by a separate switch. All wiring shall be provided by the unit manufacturer.
  - F. Unit louvers shall be ACMA rated and selected for low-pressure drop with less than 0.14 ounces/FT<sup>2</sup> penetration at 750 FPM free-area velocity. Areaways for louvers shall have a minimum of two drainage points sized for full capacity. Areaway floors shall be sloped minimum 8% to drain.
  - G. Dampers shall be low leakage and meet the requirements of ASHRAE 90.1-2016 Table 6.4.3.4.3, and opposed or parallel blade as required to accommodate mixing of air stream. Dampers as manufactured by Tamco are preferred. Opposed blade dampers are preferred and required for mixing applications. Particular attention shall be given to achieve good mixing of outdoor and return air to minimize stratification and freezing of water coils. Air blenders shall be considered for use when airflow arrangements do not support the effective mixing of different air streams.

- H. Air filters may consist of bag or cartridge-type elements; roll filters are not acceptable. Filter design face velocity shall not exceed 500 FPM nor shall manufacturers' standard nominal ratings be exceeded. The preferred filter face section dimensions are 24 inches x 24 inches. Outdoor air and return air as applicable shall pass through prefilters. Large filter banks shall have intermediate supports to prevent bank deflection at maximum design pressure differentials.
- I. Minimum 30% efficient filters shall be installed upstream of any heat recovery device.
- J. Preheat coils must be glycol. All coils shall have copper tubes with aluminum fins and galvanized casing. Coil vent and drain piping shall extend to outside the unit casing to vent and drain valves.
- K. Cooling coil velocity shall not exceed 450 FPM at maximum future and present design conditions. For new buildings coil shall be sized for a nominal face velocity not to exceed 400 FPM so that future growth can occur. Coils shall have copper tubes with aluminum fins and stainless steel casing. Intermediate stainless steel drain pans shall be provided for each coil bank more than one coil high. The cooling coil section shall have a stainless steel drain pan and a positive slope-to-drain connection. Coil connections, vent and drain piping shall extend to outside the unit casing. Since this piping is not typically fully insulated they shall be all red brass construction to prevent rusting and associated leaks / failures common to steel piping.
- L. AHU fans may be vane-axial, centrifugal (single or double width), or plenum fans as justified by life cycle costing. Use of plenum fans is strongly discouraged. Fans shall have a minimum ACMA Construction Class of II. Fan blades shall be continuously welded to wheels. Fans shall be totally isolated from the unit using inertia base and spring isolation. Refer to Section 230200 for vibration isolation criteria. Fan volume control may be achieved using VFDs or approved in-flight pitch adjustment on axial fans and variable frequency drives on centrifugal and plenum fans. Discharge dampers are not suitable for volume control. Fans may be arranged in either the blow-through or draw-through position. Redundant or parallel fans shall be installed in separate compartments and be capable of complete isolation.
- M. Where possible, if required, sound attenuators shall be integrated as a part of the AHU. The large cross-sectional area of most units results in low attenuator velocity and a corresponding pressure drop while maximizing attenuator performance. The silencer rating shall be determined in a duct-to-reverberant room test facility which provides airflow in both directions through the test silencer in accordance with ASTM Specification E477.
- N. Custom units must be designed to be totally isolated from other adjacent units so that routine maintenance can occur with the unit off and other units operational. Ultra-low leakage, industrial-quality isolation dampers shall be installed at the discharge of manifold units.
- O. Each AHU section shall be provided with drainage facilities that permit the washdown of units and contain leaks resulting from coil failures.
- P. Provide factory installed and sealed wiring sleeves for all control and power wiring that penetrate the unit casing. All power wiring shall be factory installed to a single point for power source connection on the exterior of the unit. All wiring within unit shall be enclosed in sealed moisture resistant EMT.
- Q. For AHUs serving contaminated systems, all piping and appurtenances shall be outside of the air stream.
- R. Casings shall be constructed in a water and air-tight manner. The fully assembled unit shall

have a maximum air leakage rate of 0.5 percent of the supply air volume.

- S. Custom-designed, field-erected AHUs shall be similar in many respects to those which are factory fabricated. These units basically arrive at the job site as individual components that must be assembled on concrete pads or curbs to form the unit. Casing construction quality and erection procedures are extremely important on these units. Poor quality casings result in excessive AHU leakage and poor system performance. Contractor-shop-fabricated casings are prohibited. The A/E shall individually review the design parameters for each field erected unit with the Office of The University Engineer.
  - T. When energy recovery equipment is used, the heating and cooling coils shall be designed to function at full load with and without energy recovery. All coil schedules shall show both entering air conditions. Units with energy recovery systems shall be designed such that devices could be out of commission without any interruption to AHU system operation.
  - U. Energy recovery wheels, when used for fume hood exhaust shall be 3 angstrom molecular sieve manufactured by SEMCO. The use of any other wheel manufacturer requires the approval of EHRS and the University Engineering Department.
  - V. Acceptable manufacturers of custom units shall be Air Enterprises, AES, Ingenia, Haakon, Buffalo and Ventrol. Depending on whether the unit is indoor or outdoor, knock down or not knock down, certain manufacturers are preferred over others. Coordinate unit selection with University Engineering Department.
- 6.0 Each custom designed unit shall be tested by the unit manufacturer prior to shipping, as follows:
- A. Factory Test: Air volume and discharge static test shall verify that the air volume is within the range of 100% to 110% of scheduled nominal CFM requirements when operating at design total static pressure. The test for airflow and static capability shall include airflow measuring devices installed in all ducts returning to or leaving the unit. These devices shall be installed in accordance with the measuring device manufacturer's recommendations. Pressures external to the unit shall be simulated using a combination of ducts and dampers. The tests shall prove design airflow and static capability of the assembled unit.
  - B. Factory Test: Casing leakage tests shall be run to prove that unit casing leakage is less than 0.5% of design flow at 1.5 x operating pressure. The duct openings in the pressure section shall be sealed and this section shall be tested at 12.0" w.c. The CFM of this fan shall be read using an approved airflow measuring device. When the static pressure developed by the test fan reaches 1.5 times the unit design static pressure, the fan CFM shall be read and this CFM will be considered the casing leakage. The casing leakage must be less than 0.5% of the design CFM. Factory casing leakage test for fully welded units may be deleted. However, leakage test must be performed at the site after joining and sealing of sections for all unit construction types.
  - C. Factory Test: The duct openings in the suction side of the unit shall be sealed and this section shall be connected to a test fan capable of developing a suction that is numerically equal to 1.5 times the design static pressure. The CFM of this test fan shall be read using an approved airflow measuring device. When the suction developed by the test fan is numerically equal to 1.5 times the unit design total static pressure, the fan CFM shall be read and this CFM will be considered the casing leakage. The casing leakage must be less than 0.5% of the section's design CFM (supply/return). Leakage across the septum wall located the discharge end of the fan shall be 0 CFM (no leakage).
  - D. Factory Test: Both the casing leakage test and the airflow and static capability test, as defined above, shall meet the required acceptance criterion without the use of any

temporary caulking at any permanent panel joints. Temporary test caulking shall be utilized at the unit shipping splits to simulate "as installed" conditions.

- E. Field Pressure Test: Pressurized leak testing shall be performed in the field after assembly of the unit sections by the HVAC Contractor, under the direction of the unit manufacturer, by running the fans and soap bubble testing all field joints and penetrations to ensure unit tightness. The unit manufacturer shall correct and pay for the repair of all deficiencies found during testing, except for unit section joints leaks, which shall be the responsibility of the HVAC Contractor. The HVAC Contractor shall provide all field labor necessary to join the unit sections, including all electric and drain splits after they are delivered to the site and set in place. All fieldwork shall be provided under the direct supervision of a qualified engineer employed by the unit manufacturer. Rigging for unit sections shall be provided by the HVAC Contractor.
- F. Factory Test Sound:
1. System sound levels shall be measured in all nine (9)-octave bands (31.25 Hz through 8000 Hz) at system design operating conditions. Airborne sound levels at all openings shall be read in the test ductwork 5'-0" from the openings. Transmitted sound levels shall be read 5'-0" from the outside of the fan section.
  2. Sound tests shall be conducted while the unit is running at design conditions. An octave band sound pressure level reading shall be taken at outside louver, exhaust louver, supply discharge opening, return air opening, economizer opening and adjacent to each fan section outside of the unit casing.
- G. Factory Test Vibration: Each individual fan shall be tested for vibration in X-Y-Z directions at the fan manufacturer's facility before shipment to the unit manufacturer to assure that specified fan balancing criteria is adhered to.
- H. Test Procedures
1. A complete test procedure shall be submitted to the Architect for approval detailing the methods, equipment, and techniques to be employed for each specific test. Equipment will not be considered approved until written approval of testing procedures is attained.
  2. As hereinbefore specified, the preceding airflow/static, sound and vibration tests shall be required for all AHUs specified in this Section and shall be witnessed by designated representatives of the Engineer and Owner (total [3] people). All unit sections shall be leak tested at the field after installation. The unit manufacturer shall notify the engineer and the University of Pennsylvania Department of Physical Plant Project Engineer for their approval. The unit manufacturer shall pay for all air and ground transportation, lodging, and meals for the designated witnesses to attend the testing. If multiple trips are required, they shall all be paid for by the unit manufacturer.
  3. Any deficiencies in unit performance must be corrected by the unit manufacturer in the manufacturing plant prior to shipping.
- I. Electrical Interface/Work
1. The unit manufacturer shall furnish and install a complete factory wired electrical system for each unit, so as to allow single-source responsibility and to ensure proper selection and installation of all electrical components.
  2. The unit manufacturer shall provide prewired and switched non-corroding vapor-tight fluorescent lights in each compartment with an access door and in the service corridors as follow:
    - a) Lights shall be equal to Appleton 4' -0' FR Series, suitable for use in wet and

- damp locations.
  - b) Lighting, internal wiring, switching mounted in bell boxes, and all other electrical wiring associated with the lighting shall be provided by the unit manufacturer, at the Factory.
  - c) Lights shall have 120-volt cold weather (-20 F) ballasts and shall comply with UL 1598 and shall carry the UL label.
  - d) Unit manufacturer shall provide (2) 120 volt, single-phase electric connections for the lights and receptacles, via junction boxes with circuit breakers for connection in the field by Electrical Contractor (20 amperes power supply).
- 7.0 Humidifiers for central station AHUs shall be of the dry-steam, manifold-jacketed type with a minimum insulating value of R-0.5 and be located in the AHU up-stream of the Chilled Water coil. Ductwork within the absorption range of the humidifier shall be fully welded stainless steel and pitched to drain. Smoke detectors at air handling units shall take the absorption distance into consideration. Steam lines serving humidifiers shall have an automatic isolation valve and be dripped to remove condensate prior to manifold. The isolation valve shall be closed during cooling mode to prevent additional heat gain in the duct system. A high-limit humidity controller must be provided for each humidifier.
- 8.0 Coils installed in either factory-packaged or custom-designed units, if not properly engineered, will not be serviced and will eventually fail to perform. The A/E shall ascertain that all components are serviceable.
- 9.0 The following issues shall be specifically addressed for all coil installations:
- A. Refer to Section 238200 for design standards relating to coils integral with air handling units. Size all air handling unit (AHU) system components and duct mains to allow for future expansion and renovations in accordance with specific criteria furnished by the Office of the University Engineer.
  - B. Individual coils must be fully accessible on both the upstream and downstream sides to permit inspection and cleaning.
  - C. The cooling-coil face velocity must be limited to 450 FPM across the entire face area to prevent carryover at maximum future and present design conditions. Air distribution plates should be considered for use upstream of coils, but plates must not induce a high pressure drop.
  - D. Moisture eliminators may be considered where carryover presents a problem; however, eliminators must not impede service access to the coil surface for cleaning.
  - E. Multiple coils are often required to provide the total capacity of individual units. The maximum coil depth shall be 8 rows with no more than two coils in series. Coils shall be a maximum of 10 feet long by 3 to 3 1/2 feet high and be capable of replacement without major rigging. Individual coils within a coil bank must be removable without disturbing pipe headers or other coils.
  - F. Multiple coils shall be valved separately so that, if any individual coil fails, it can be isolated and drained while the remaining coils stay in operation. Return header for multiple-stacked coils shall be piped reverse return to assist a balanced water flow at all load conditions. Staggered coil arrangements and V-coil arrangements are prohibited. Piping within the airstream shall be minimized.
  - G. All coils shall have integral vent and drainage ports. Steam coils shall be nonfreeze vertical tube where installation is possible and provided with steam vacuum breakers, not check valves located outside of the air stream.

- H. Even and consistent airflow across the entire coil surface is extremely important. Upstream mixing and the use of air blenders shall be carefully considered.
  - I. Coil bank supply and return mains or steam and condensate mains shall have manual isolation valves so that the entire unit can be drained.
  - J. Control and balancing valves shall be installed on the return line for water coils. Balancing valves shall be specifically designed for balancing and have integral memory stops. Combination balancing, shutoff, and flow meter devices are not acceptable.
  - K. One-third and two-thirds steam control valve arrangements with a manual bypass valve should be considered for large steam coils to improve control and operating efficiency. Steam mains shall be dripped prior to control valves. Steam control valves used on integral face and bypass coils shall be controlled to the full open position when the inlet air temperature is 32 degrees or less, and to modulate in response to the setpoint temperature when the inlet air is above 32 degrees.
  - L. Float traps shall be used on steam coils. Trap bypass lines shall not be used; dual traps may be considered.
  - M. Steam coils must be piped for complete gravity drainage and fitted with vacuum breakers. Vacuum breakers shall be located external to the air-handling casing. Condensate shall not be lifted downstream of modulating valves for steam coils. Condensate lines shall not be designed to discharge under pressure. There shall be a hydraulic head between the coil and steam trap of 18 inches minimum. Steam coils are not to be used as preheats. If this is the only choice then the coil shall be of the face-and-by-pass type.
  - N. Glycol preheat coils shall be designed for parallel flow-circuiting. Glycol flow shall be maintained through the unit by a run around loop with mixing valve pump system.
  - O. 100% OA units design parameters are as follows: 11F (0F for vivaria) EAT winter and 8F WB – 96F DB Summer.
- 10.0 The A/E shall give careful consideration to the location of the supply air fan with respect to coil banks. Excessive air velocity stratification across the face of a coil may affect the capacity, pressure drop, and water carryover characteristics. Thus, the location of the fan with respect to the coil bank is very important. Generally, if the air velocity across the coil does not vary by more than +/- 10% of nominal, essentially full capacity will be achieved and water carryover will not be a problem. However, if the air velocity stratification is greater than this, capacity reduction, carryover, and freeze-up problems could occur. When space limitations dictate that the fans be placed in close proximity to the heating or cooling coils, the following criteria should be used to determine the minimum distance between fan and coil for field built-up systems:
- A. Draw-through System: For single-width fans, the distance between the fan intake and coil should be a minimum of one wheel diameter. For double-width fans, the distance between the fan intake and coil should be a minimum of 1/2 wheel diameter.
  - B. Blow-through System: Most problems occur in this type of system. To minimize space requirements, it is desirable to place the coil as close to the fan as possible without causing excessive air velocity stratification across the face of the coil. The minimum distance for satisfactory operation is a function of the dimensional relationship of fan to coil, the fan outlet velocity, coil face velocity, and coil pressure drop. Where extreme limited physical space conditions exist, the use of a carefully designed baffle plate between the fan discharge and the coil may be considered. The Contract documents should specifically address the placement of the fan with respect to the coil.



- 11.0 Fans shall be individually selected for their specific application. Many different fan types and arrangements exist in the marketplace from a large variety of manufacturers. The Project Engineer has the responsibility to select the fan and specify its requirements to meet the functional needs of the system while providing stable, efficient, and quiet operation. Fan selections shall be based on the lowest reasonable speed while optimizing efficiency. Fan selections shall consider longevity of components, especially bearing life at maximum design conditions.
- 12.0 All fans must be fully accessible for service and routine maintenance. Fan motors and drives shall not be located within hazardous or contaminated exhaust air streams. All drives shall be exterior to air handling units. Fan bearings where possible shall be serviceable outside of hazardous or contaminated exhaust airstreams. Inline fans with motors or drive exposed to exhaust air streams are not permitted.
- 13.0 Fan systems designed for parallel or manifold operation shall be protected against backward rotation of fan wheels. Anti-rotation devices, motor brakes, or other approved methods shall be considered for use on these systems. Solid fan shafts shall be furnished whenever possible as an option.
- 14.0 Specify fans having a certified sound and air rating based on tests performed in accordance with AMCA Bulletins 210, 211, and 300. See AMCA Standard 99, *Standard Handbook*, for definitions of fan terminology. If specific sound data for the selected fan is not available, certified testing for fan sound data shall be required. The arrangement, size, class, and capacity of all fans shall be scheduled on the contract drawings for permanent records.
- 15.0 All fans shall be statically and dynamically balanced by the manufacturer and shall be provided with vibration isolation. Fans shall not transmit vibration to the duct system or building structure. All fans shall also be dynamically balanced in the field by the manufacturer after the installation is complete.
- 16.0 Diffuser cones and inlet bells are not permitted in rating a fan unless they are an integral part of the fan design.
- 17.0 Inlets and outlets of fans not duct connected, including fans in plenum chamber or open to the weather, shall have heavy OSHA-approved guard screens to protect personnel. Guard screens shall not impair fan performance and, when bolted to equipment, will permit their removal for fan service and cleaning.
- 18.0 Complete fan lubrication facilities shall be provided, such as oil reservoirs, sight glasses, grease and relief fittings, fill and drain plugs, pipe connections, etc. The facility shall be placed in a readily and safely accessible location so that after installation they will perform the required function without requiring the dismantling of any parts or stopping equipment. For fans located within contaminated air streams, lubrication facilities shall be piped to the exterior casing wall. For supply and return air systems, lubrication facilities are not required to be piped to the equipment exterior.
- 19.0 Fans shall be specifically addressed, as the air stream may contain excessive moisture, fumes, corrosive vapors, or contaminated or hazardous particles. Special consideration shall be given to those fans handling explosive vapors or radioactive material.
- 20.0 Certified performance data including acoustical data shall be submitted for each fan at maximum design conditions. Data shall include published sound power levels based on actual tests on the fan sizes being furnished and conducted in accordance with current AMCA standards. Such data are to define sound power levels (PWL) (10 -12 W for each of the eight frequency bands). The acoustical design of the fan system must conform to the space noise criteria. Fan curves shall be submitted which will depict static pressure, total pressure, brake horsepower, and mechanical efficiency plotted against air volume. Fan curves shall include estimated losses for field

installation conditions, system effect, and actual installed drive components. All included losses shall be defined on the fan curves. Data may also be submitted in tabular form, but tables are not a substitute for actual performance curves.

- 21.0 Direct drive fans are preferred to reduce maintenance costs and improve reliability. Where factory-designed and assembled belt drives are proposed to be furnished, OSHA-approved mesh-type guards shall be provided for all belt drives, and the drives shall comply with the following:
- A. Each drive shall be selected according to the rating and recommendations of the manufacturer for the service with which used, giving proper allowance for sheave diameter, center distance, and arc of contact less than 180 degrees. The motor shall have a nameplate rating of not less than 5% above the total of actual fan brake horsepower and drive loss at specified capacity.
  - B. Belts shall be constructed of endless reinforced cords of long staple cotton, nylon, rayon, or other suitable textile fibers imbedded in rubber. The belt shall have the correct cross section to fit the sheave grooves properly. Belts shall be matched carefully for each drive. Extended-horsepower belts are not acceptable.
  - C. Motor sheaves shall be adjustable pitch type for fans under 25 hp, selected so that the required fan rotational speed will be obtained with the motor sheave set approximately in midposition and have the specified pitch diameter in that position. Fixed-pitch "initial" sheaves shall be installed on fans 25 hp and larger. All multiplex belt drive assemblies regardless of horsepower shall be fixed-pitch type. When correct "final" sheave size has been determined by Testing and Balancing Agency, furnish and install a permanent fixed-pitch sheave for motor to replace variable-pitch and "initial" motor sheaves. Turn over variable-pitch and "initial" motor sheaves to the University.
  - D. Fan motors shall have the capacity needed to operate the equipment at the specified mid-position operating condition. Where non-overloading motors are specified, the motor capacity rating at the most closed position of the motor sheave shall be selected. In no case shall motors be a smaller size than that required to operate without overload. Refer to Section 220500 for detailed motor requirements.
  - E. Fan sheaves shall not be smaller in diameter than 30% of the fan wheel diameter.
  - F. Sheaves shall be constructed of cast iron or steel, bored to fit properly on the shafts, and secured with keyways of proper size. Keyways shall be secured with set screws (no set screws may be omitted for sheaves having ½ inch or smaller bores, where set screws may be used).
- 22.0 Fans shall be furnished complete as a package with motors, drives, curbs, bases, and inlet and outlet fittings. Detached vibration isolation devices may be provided separately.
- 23.0 Wherever possible, units should be floor mounted within Mechanical Rooms. Ceiling mounted and rooftop units are strongly discouraged. Any necessary deviation from this standard dictated by site conditions, shall be reviewed and pre-approved by the University Engineering Department.
- 24.0 Each air handling unit shall be provided with a filter section(s) capable of housing the filters specified in Section 234000 and a mixing box designed to prevent stratification. If mixing of air cannot be assured due to unit configuration, the use of an air blender section should be considered. All dampers and actuators shall be fully accessible for lubrication.
- A. Coil sections shall be provided with tracks, extended the full length of the unit to provide for the removal of the coil or an individual coil in a bank of coils.
  - B. All units in excess of 2,000 CFM must be provided with a return air fan (for return air systems). The return air fan can be a single width single inlet centrifugal fan set, integral or

independent cabinet fan, or in-line centrifugal type fan and must be mounted to permit servicing without the use of a ladder. Units which are not floor mounted and are mounted in excess of 6'-0" above the floor must be provided with stable catwalks constructed of structural grade steel and steel grating. Access ladders shall be integral with the catwalk.

- 25.0 Fans serving variable air volume systems shall be provided with a variable frequency drive (VFD). (Refer to Section 230500 for VFD motor requirements and 262900 for VFD requirements). Inlet vanes and discharge dampers are not permitted.
- 26.0 All damper motors and actuators shall be located outside of the unit casing and be fully accessible for removal and repair. Damper linkages shall be fully accessible (not enclosed).
- 27.0 The Engineer will ascertain that adequate service space exists for the removal of coils, fans, fan shafts etc. without disturbing surrounding equipment. Piping drops to AHU coils shall be arranged to facilitate coil removal without removing large sections of pipe.
- 28.0 Field erected air handling units must meet the above requirements and shall be constructed in accordance with SMACNA standards. Integral unit fans or independent fan sets may be used.
- 29.0 The Engineer will review the noise and vibration levels of the units and provide isolation equipment as required to meet acceptable levels. Sound attenuators shall be provided where fan noise will be transmitted to interior spaces or exterior areas in excess of the levels permitted in Section 230000 for interior spaces. On a project by project basis, exterior installations of fans shall be evaluated against local site noise level goals and criteria. Refer to Part I, General Section XI.
- 30.0 Safety control components such as smoke detectors and/or smoke dampers shall be provided per code requirements. Smoke dampers at air handling units on emergency power shall be on UPS power or powered pneumatically to avoid the fan shutting down on high pressure after a power loss.
- 31.0 Central station units shall be designed to function as a smoke removal system in all buildings required by code to contain such.
- 32.0 Multiple fans provided in AHUs and exhaust fans for redundancy purposes shall be provided in separate compartments with inlet isolation dampers to facilitate maintenance without taking the unit out of service.
- 33.0 The design of fan inlet and outlet conditions should consider the impact of system effects on the fan performance. Where possible, follow the recommendations shown in SMACNA Duct Design Manual for fan inlet and outlet arrangements.
- 34.0 The design of mixing sections must consider proper mixing of outside air and return air airstreams. Outside air intake location is critical. Where proper mixing may be difficult, air blenders shall be considered.