

SECTION 23 34 00 - HVAC FANS

PART I - GENERAL

Important Notes to PSC:

- *Of necessity these specifications include numerous options for inclusion or exclusion of specific features. Review carefully and edit text as appropriate for each item for each specific project.*
- *Also included herein are numerous statements such as “if indicated”, “unless indicated otherwise”, “if scheduled”, if specified” or similar. In each case edit text to clearly indicate project-specific requirements. Failure to do so has proven to be problematic.]*

1.1 SECTION INCLUDES

- A. Centrifugal Fans
 1. Housed
 2. Plenum
- B. Tubular In-line Fans
 1. Centrifugal
 2. Mixed Flow
- C. Laboratory Exhaust Fans
 1. High Plume, Induced Flow
 2. Tubular, Non-induction
- D. Laboratory Exhaust Fan Plenums
- E. Power Roof Exhausters

1.2 RELATED SECTIONS

- A. 23 73 23 - Custom Air Handling Units
- B. 23 73 13 - Modular Air Handling Units
- C. 23 09 13.43 - Control Dampers
- D. 26 60 00 - Common Motor Requirements
- E. 26 29 23 - Variable Frequency Motor Controllers

1.3 REFERENCES

- A. AMCA Standard 99 – Standards Handbook
- B. AMCA Standard 201 – Fans and Systems
- C. AMCA Standard 204 – Balance Quality and Vibration Levels for Fans
- D. AMCA Standard 211 – Certified Ratings Program – Product Rating for Fan Air Performance
- E. AMCA Standard 311 – Certified Ratings Program – Product Rating Manual for Fan Sound Performance
- F. AMCA Standard 210-95 – Laboratory Methods for Testing Fans for Aerodynamic Performance Rating
- G. AMCA Standard 260-07 – Laboratory Methods of Testing Induced Flow Fans for Rating

- H. *AMCA Fan and Air System Applications Handbook*
- I. *ASHRAE Applications Handbook – Testing Adjusting and Balancing*
- J. *AHSRAE Applications Handbook – Vibration and Noise Criteria*
- K. *ASHRAE Applications Handbook – Building Air Intake and Exhaust Design*
- L. *NFPA – 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*
- M. *ANSI/AIHA Standard Z9.5 – Standard for Laboratory Ventilation*
- N. *National Electric Code*
- O. *International Mechanical Code*

1.4 QUALITY ASSURANCE

- A. Fan shall bear *AMCA Certified Ratings Program Seal* for air performance and sound performance according to *AMCA Publication 311 and AMCA Publication 211*.
- B. Fan construction shall be compliant with *AMCA Standard 99*
- C. Products and execution shall be in compliance with all applicable codes and standards including those referenced above in section entitled *REFERENCES*.
- D. Installation, start-up and operation shall be in compliance with Manufacturer's recommendations and IOM.

1.5 SUBMITTALS

- A. Unit Data
 - 1. Fan Type, Class
 - 2. Wheel type, Size, Tip Speed
 - 3. Drive Arrangement, Discharge/Rotation
 - 4. Motor Type, Rated BHP, RPM, Electrical Characteristics
 - 5. Operating Weight
 - 6. Scaled Dimension Drawings
 - 7. Materials of Construction, Gauge/Thickness
 - a. Housing
 - b. Frame, structure
 - c. Wheel
 - d. Other components
 - 8. Finishes and Coatings
 - 9. Component Data
 - 10. Fan and component options as identified below
 - 11. Fan accessories
 - 12. Fan special features
- B. Performance data at specified operating point(s) including effect of factory-mounted airstream obstructions
 - 1. Airflow (CFM)
 - 2. Static Pressure (SP)
 - 3. Fan Speed (RPM)

- 4. Fan Power (HP)
 - 5. Motor input frequency (Hz)
 - C. Additional data for laboratory exhaust fans
 - 1. Total airflow (CFM) including induction air
 - 2. Stack discharge velocity
 - 3. Plume height at specified wind velocity; supporting calculations
 - D. Fan Performance Curves
 - 1. Series of curves indicating relationship of CFM, SP, RPM, % efficiency and BHP for variable speed applications.
 - 2. Curves for design operating conditions
 - a. Initial design operating conditions
 - b. Future design operating conditions, as applicable
 - c. Impact of *wheel width controller* shall be incorporated, as applicable
 - E. Sound Power Levels, 8 octave
 - F. Unit Data for Exhaust Plenum and Components
 - G. Unit Data for Wheel Width / Pressure Independent Control
 - H. Installation and Operation Manual (IOM)
 - I. Structural Drawings
 - 1. Curb and/or structural support drawings
 - 2. Structural drawings for access platforms, ladders and railings
 - J. Factory and field fan balance reports upon request
- 1.6 DELIVERY, STORAGE AND HANDLING
- A. Fan and associated equipment shall be delivered to job site suitably packaged and protected for overland trucking using heavy-duty protective shrink-wrap plastic.
 - B. All items shipped loose shall be suitably secured in unit or on separate pallet similarly protected.
 - C. Fan shall be stored in clean, dry environment protected from exposure to dust, debris and fluids
 - D. Fan shall not be operated during construction phase of project unless specifically indicated otherwise in project documents and approved by Owner.
- 1.7 EXTRA STOCK
- A. For each belt driven fan, replacement set of matched belts shall be provided once proper belt length has been determined by TAB Contractor.
- 1.8 APPROVED MANUFACTURERS
- A. Standard Clean Air Applications
 - 1. Twin City Fan and Blower
 - 2. Chicago Blower Corporation
 - 3. New York Blower Company
 - 4. Greenheck Fan Corporation
 - 5. Loren Cook Company

- 6. PennBarry
- 7. Nortek Air Solutions
- B. Laboratory Exhaust Applications
 - 1. MK Plastics
 - 2. Plasticair, Inc.
 - 3. Greenheck Fan Corporation
 - 4. Loren Cook Company
- C. Power Roof Exhausters
 - 1. Greenheck Fan Corporation
 - 2. Loren Cook Company
 - 3. Pennbarry

1.9 WARRANTY

- A. Assembled unit shall be warranted by manufacturer to be free from defects in material and workmanship for period of one year from date of startup or 18 months from date of delivery whichever occurs first. Manufacturer shall repair or replace unit at no cost to Owner.
- B. Unit shall be warranted by manufacturer to provide specified performance for period of one year from date of startup. Manufacturer shall adjust, repair or replace unit at no cost to Owner.

PART 2 – PRODUCTS

[IMPORTANT NOTE TO PSC: When specification as written states “if indicated” or “unless indicated otherwise” or “if scheduled” or “if specified” or similar, text shall be edited to clearly indicate project-specific requirements. Carefully review specification as written to identify all such occurrences.]

2.1 CENTRIFUGAL FANS – GENERAL REQUIREMENTS

- A. General
 - 1. Fan assembly shall be furnished complete with motors, wheels, drive assemblies, bearings, coatings and accessories as specified herein.
 - a. Power roof exhausters specified separately
 - 2. Fans shall be industrial grade Class 2 or Class 3 as required for application. Fan RPM at design operating point shall not exceed 80% of maximum rated RPM for fan class. Fan class shall be adequate to ensure compliance with such limitation.
 - 3. Fan housing and bearing supports shall be constructed of welded structural members and shall incorporate structural base as applicable.
 - 4. All non-galvanized steel components including hardware other than stainless steel shall be primed and painted prior to assembly.
 - 5. Fans located outdoors shall be provided with powder coat finish with UV protectant topcoat on all exposed steel components. Any scratches or defects in coating shall be touched up after installation per manufactures recommendations. Any coating substitution must be approved by PSC prior to unit construction. *[Note to PSC: Confirm with Manufacturers that specified coating is available and economically viable. Better to specify required coating prior to bid than to approve substitution after bid.]*
 - 6. Fans shall be direct drive unless indicated otherwise in project documents.
 - a. Notable exceptions, following shall be belt-driven:
 - 1) Tubular In-line fans

- 2) Laboratory in-line exhausters 3 HP and smaller
- 3) DWDI (double width double inlet) fans
- 4) SWSI fans only if available fan selections require operation outside approved motor frequency range.

[Note to PSC: Edit spec language and/or schedule to identify drive type. When application of drive type is unclear discuss with Owner.]

[Note to PSC: Given the substantial inefficiency and maintenance requirements of belt-driven systems the University has developed a preference for direct drive fans. Thus, their use is encouraged where appropriate. Standards do not currently identify an across-the-board maximum size for direct drive fans. Apparent and/or recommended exceptions shall be discussed with Owner.]

[Note to PSC: Fewer fan selections are available for housed fans than for plenum fans. Thus a suitable selection for a direct drive SWSI fan may not be available for a given performance requirement. In such case, a belt driven fan may be required.]

7. Fans complete with accessories and optional features shall be factory assembled.

B. Fan Options

1. Fan and component options from list below shall be provided as specified or indicated in schedule.
 - a. Application
 - 1) General purpose clean air
 - 2) Corrosive vapors
 - 3) Combustible vapors
 - 4) Other contaminated exhaust
 - b. Fan/housing type
 - 1) General purpose clean air
 - (a) Single width single inlet (SWSI)
 - (b) Double width double inlet (DWDI)
 - (c) Plenum
 - (d) Tubular in-line
 - 2) Laboratory/contaminated exhaust
 - (a) High plume, induced flow
 - i. Tubular in-line
 - ii. SWSI centrifugal
 - (b) Standard, non-induced flow
 - i. Tubular in-line
 - c. Fan wheel type
 - 1) Centrifugal
 - 2) Mixed flow
 - d. Fan drive type
 - 1) Direct drive
 - 2) Belt-driven

- e. Fan configuration
 - 1) Arrangement
 - 2) Rotation
 - 2) Motor location
- f. Fan and housing materials
 - 1) Steel
 - 2) Aluminum
 - 3) Stainless steel
 - 4) FRP
- g. Spark resistant construction
 - 1) AMCA type A
 - 2) AMCA type B
 - 3) AMCA type C
- h. Coating
 - 1) Primed and painted
 - 2) Powder coated
 - 3) Phenolic coated

C. Accessory Options

1. All accessory options listed below shall be provided unless indicated otherwise in project documents

[Note to PSC: It is acknowledged that certain items listed are not applicable for all fan types. Edit list accordingly.]

- a. Outlet flange
- b. Inlet flange
- c. Hinged access door or bolted panel
- d. Drain with NPT connection
- e. Shaft seal
- f. Totally enclosed shaft guard
- g. Totally enclosed belt guard
- h. Vibration isolators
 - 1) Spring, per manufacturer's recommendation
 - 2) Neoprene, per manufacturer's recommendation
 - 3) Inertia base, per manufacturer's recommendation
- i. Thrust restraints, as applicable
- j. Fan guard, for exposed fans only
- k. Weather hood, outdoor applications only
- l. Lifting lugs

D. Special Feature Options

1. Wheel Width / Pressure Independent Control Device

2. Other special features as specified or indicated in schedule

E. Selection

1. Fan shall be selected to avoid surge and yield stable operation at all operating speeds.
2. Fan shall be selected to operate at or near peak efficiency at design operating point.
3. Fan performance data shall include effect of any factory-mounted airstream obstructions such as protective screens and guards.
4. Fan performance shall include impact of any applicable "system effect".
5. Fan/motor combination shall be capable of providing design performance (100% CFM at design operating conditions) **without exceeding 90% nameplate amperage**.

Note to Contractor and Manufacturer: Do not overlook 90% nameplate amp limit. It will be factory and/or field tested per specifications.

[Note to PSC: Motor HP listed in schedule shall incorporate this requirement. Thus, scheduled HP will likely be larger than HP provided by Fan Manufacturer data for specific application.]

6. VFD size/selection shall be based upon 100% of increased motor HP and associated 100% nameplate amperage. Contractor shall confirm with Fan Manufacturer that scheduled HP satisfies this requirement.
7. Traditional non-overloading selection is not necessarily required when fan is served by variable speed drive. VFD shall be configured and adjusted to prevent overloading.
8. If fan selection is based upon two different operating conditions (i.e. initial design conditions and future design conditions) selection shall yield optimized performance at both conditions to greatest degree possible.
 - a. In such case, fan selection shall comply with all requirements listed above for both operating conditions.

F. Component Requirements

1. Housing

- a. Metallic housing/scroll construction shall be continuous welded throughout. FRP housing shall be continuous molded. Housing shall be braced and supported by structural members to prevent vibration or pulsation. Housing shall incorporate structural base.
 - 1) Housing/scroll with lock seams or partially welded construction not acceptable.
- b. Fan inlet cone shall be fully streamlined, aerodynamically matched to wheel to ensure full loading of blades.
- c. Appropriate spark resistant construction shall be provided for applications with combustible vapors. Fans having spark resistant construction shall be electrically grounded.
- d. Appropriate corrosion resistant construction and/or coatings shall be provided for applications with corrosive vapors.
- e. Hinged access door with positive latch or access panel, bolted and gasketed, shall be provided for complete access to interior of fan unit for maintenance, repair or cleaning without removal of ductwork.

2. Fan wheel

- a. Fan wheel shall be airfoil, backward curved, backward inclined or mixed flow type with self-limiting horsepower characteristic. For metallic fans, blades shall be continuous welded to back plate and shroud. Airfoil fan wheels shall be seal-welded construction. For FRP fans, fan wheel shall be one piece molded

construction. Forward curved fan wheels not allowed. Radial blade fan wheels not allowed for services other than particulate handling.

3. Shaft

- a. Fan shaft shall be turned, ground, polished and ring gauged for accuracy. Shaft material shall be AISI 1040 or 1045 hot rolled steel for standard clean air applications. Shaft for laboratory exhaust applications shall be stainless steel unless indicated otherwise in schedule or project documents.
- b. Fan shaft shall be sized for first critical speed at least 1.43 times maximum speed.

4. Bearings

- a. Fan bearings shall be heavy duty grease lubricated anti-friction, ball or roller, self-aligning pillow block type fitted with external grease fittings.
- b. Fan bearings shall be selected for a minimum average bearing life (AFBMA L-10) of not less than 200,000-hrs at maximum cataloged operating speed.

5. Motor

- a. Fan motor shall satisfy requirements of Section 26 60 00 – *Common Motor Requirements*.
- b. Motor shall be TEFC, 1,800 RPM synchronous speed unless indicated otherwise in schedule.
- c. TEAO motors also approved for direct drive fan arrays.
- d. Drive inefficiencies shall be incorporated into motor selection.
- e. For direct drive fan applications motor shaft and bearings shall be conservatively designed to support overhung load of fan.
- f. For belt-driven fan applications motor shaft and bearings shall be conservatively designed to support radial load of tightly tensioned belts.
- g. Motors for belt-driven applications shall be provided with heavy duty slide bases.

6. Drive

- a. See requirements regarding drive type in section above entitled *General*.
- b. Direct drive fans shall be rigidly mounted on motor drive shaft.
- c. Only if indicated in project documents, V-belt drive shall be utilized.
 - 1) Sheaves shall be cast iron construction. Sheaves and belts shall be selected for 150% of motor nameplate HP minimum.
 - 2) For applications with motor horsepower 3 HP or less V-belt sheaves may be fixed pitch or variable pitch. For variable pitched sheave applications, sheaves and belts shall be selected such that sheaves are adjusted near midpoint with fan operating at design conditions.
 - 3) For applications with motor horsepower 5 HP or larger V-belt sheaves shall be fixed pitch type.
 - 4) V-belt drives shall have two belts minimum except fractional HP applications may have one belt. Multiple belts shall be factory matched set.
- d. Only if indicated in project documents, flat synchronous belt drive shall be utilized. Sheaves and belts shall be selected for 150% motor nameplate HP.

[Note to PSC: Edit spec language above to clearly identify drive type.]

7. Belt Guard

- a. On belt-driven fans OSHA approved protective guard shall be provided for rotating devices including but not limited to shafts, belts and sheaves.

- b. Guard shall be easily removable for replacement of belts and other maintenance procedures.
 - c. Guard shall be rigidly mounted to prevent vibration.
 - d. Rotational speed test openings with protective collars shall be provided at shaft locations.
8. Weather Cover
- a. For outdoor applications OSHA approved weather cover shall be provided in lieu of belt guard to protect motor and drive components from weather.
 - b. Weather cover shall provide personal protection from rotating devices including but not limited to shafts, belts and sheaves.
 - c. Weather cover shall be easily removable for replacement of belts and other maintenance procedures.
 - d. Weather cover shall be rigidly mounted to prevent vibration.
9. Fan Guard
- a. Fans with exposed or partially exposed wheels shall be fitted with protective screen enclosure.
 - b. Enclosure shall be sized and designed to yield no measurable system effect on fan performance.
 - c. Enclosure shall be constructed of expanded metal or heavy gauge wire screen. Enclosure shall incorporate structural elements as required for strength and rigidity.
10. Vibration Isolators
- a. Vibration isolation shall be provided with restrained spring, rubber-in-shear and/or neoprene pad isolators as recommended and selected by Manufacturer. Restrained spring type shall be provided as default if Manufacturer provides no specific recommendations.
11. Thrust Restraints
- a. Thrust restraints shall be provided by Manufacture as recommended and applicable to fan type. *[Note to PSC: Delete thrust restraint requirement if non-applicable.]*
13. Wheel Width / Pressure Independent Control
- a. Such shall be provided as indicated within project documents.
 - b. Wheel width / pressure independent control shall control both air volume and static pressure of fan system without placing fan in surge condition.
- [Note to PSC: If special features such as wheel width controller are not required delete or edit this item accordingly.]*
- 1) Mechanical, automated
 - (a) Basis of design: Airflow Equipment Company *Wheel Width Controller*
 - 2) Mechanical, non-automated (self-contained, spring actuated)
 - (a) Basis of design: Climate Craft *BalanceStream*
 - 3) Patented on-off fan controller not allowed
 - 1) e.g. Huntair *FANWALL Controller*
- [Note to PSC: Discuss potential application of wheel width or pressure independent control with Owner. Such may be utilized to accomplish the following:]*

1. Provide optimized efficiency at static and/or variable operating conditions in lieu of other methods.
2. Reduce number of fans required to achieve redundancy requirements.
3. Make provision for future changes while maintaining optimal efficiency for both current and future operation conditions. Using wheel width controller(s) is an ideal way to design unit for future increased airflow.]

[Note to PSC: Discuss all options related to wheel width / pressure independent control devices with AHU Manufacturer.]

F. Factory Run Test / Balance

1. All fans shall be completely assembled and test run as a unit prior to shipment at all speeds throughout allowable RPM range for particular fan construction type.
2. Each wheel shall be statically and dynamically balanced in accordance with ANSI/AMCA 204-96 "Balance Quality and Vibration Levels for Fans" to Fan Application Category BV-3 balance quality grade G6.3.
3. Balance readings shall be taken by electronic type equipment in the axial, vertical, and horizontal directions on each bearing. Records shall be maintained and written copy shall be available upon request.
4. Maximum allowable fan vibration levels
 - a. Belt-driven fans: 0.15 in/sec peak velocity, filter in
 - b. Direct drive fans: 0.10 in/sec peak velocity, filter in

2.2 HOUSED CENTRIFUGAL FANS

- A. Housed centrifugal fans shall satisfy all requirements specified above in section 2.1 *CENTRIFUGAL FANS – GENERAL REQUIREMENTS*.
- B. Additional Requirements
 1. Housed centrifugal fans shall incorporate scroll housing with configuration and arrangement as indicated in schedule or as otherwise indicated in project documents.

2.3 PLENUM FANS

- A. Plenum fans shall satisfy all requirements specified above in section entitled *CENTRIFUGAL FANS – GENERAL REQUIREMENTS*.
- B. Additional Requirements
 1. Plenum fans shall be unhooded with welded frame and heavy gauge steel inlet plate.
 2. Plenum fans may be configured in "fan array".
 - a. Individual fan(s) or fans in array shall be provided in size, number and configuration indicated on drawings. Proposed changes may be presented to PSC for review and potential approval.

[Note to PSC: Number of fans in array shall be discussed with Owner prior to final design.]

3. Dampers
 - a. Dedicated isolation damper shall be provided for each fan. With Owner approval dampers for fan arrays may be system powered (gravity) specifically designed for application. Otherwise, dampers shall be automated and shall comply with requirements of *Section 23 09 13.43 – CONTROL DAMPERS*.
 - b. Dampers shall be specifically designed and configured to yield negligible impact on fan performance.

2.4 TUBULAR IN-LINE FANS, CENTRIFUGAL AND MIXED FLOW

A. Tubular in-line centrifugal and mixed flow fans shall satisfy all requirements specified above in section 2.1 *CENTRIFIGAL FANS – GENERAL REQUIREMENTS*.

B. Additional Requirements

1. Housing mounting brackets shall be provided to allow support in multiple horizontal and vertical housing configurations to facilitate optimized motor and access door placement.
2. Continuous welded flanges shall be provided.
 - a. Companion flanges shall be provided for ducted applications.
3. Fan guard(s) shall be provided for non-ducted applications.
4. Oversized hinged access door shall be provided.
 - a. Bolted access door acceptable only if hinged door not available as standard option.

5. Tubular fans shall be belt-driven unless indicated otherwise in project documents. *[Note to PSC: Although direct drive fans are typically preferred, limited access typically makes them a poor choice for tubular fans. Exception: At least one manufacturer now offers a direct drive tubular in-line fan with adequate access opening to extract both the motor and the fan. This design will be monitored by the University as it is further developed.]*

C. Belt Driven

1. Aerodynamically shaped inner housing shall be provided to isolate shaft, bearing and sheave from airstream.
2. Inner housing shall incorporate gasketed cover and labyrinth seal to provide air tight enclosure.
3. Inner housing shall accommodate convenient removal of sheave, shaft and bearings.
4. Belt tube shall be provided between inner drive housing and external fan housing to totally enclose belts within airstream. Tube shall be continuous welded both ends.
5. Heavy duty motor mounting bracket shall be provided.
6. OSHA approved belt guard shall enclose belt and motor drive sheave.
7. Mounting rails and spring, rubber-in-shear or neoprene vibration isolators shall be provided as recommended by manufacturer for application.

2.5 LABORATORY EXHAUST FANS – GENERAL REQUIREMENTS

A. Laboratory exhaust fans shall satisfy all requirements specified above in section entitled *CENTRIFIGAL FANS – GENERAL REQUIREMENTS*.

B. Additional Requirements

1. Laboratory exhaust fans shall satisfy all requirements of *ANSI/AIHA Z9.5 – Standard for Laboratory Ventilation*.
2. Laboratory exhaust fans shall be designed for outdoor installation, roof-mounted.
3. Exhaust fan assembly shall be self-contained factory-fabricated. Fan assembly shall not be field fabricated system (e.g. utility set with fabricated stack) unless indicated as such in project documents. *[Note to PSC: A self-contained unit is typically preferred over a utility set with contractor fabricated and assembled discharge stack.]*
4. Laboratory exhausters shall be induced flow or non-induction type as required to satisfy exhaust dispersion requirements. Type shall be as indicated in schedule or on drawings. *[Note to PSC: Dispersion requirements shall be determined by PSC based upon criteria presented below in section entitled Discharge Performance. Dispersion*

requirements typically dictate induced flow type for larger applications. Non-induction type is typically limited to smaller applications.]

5. Laboratory exhaust fans shall be tubular in-line type or SWSI centrifugal type as indicated in schedule or on drawings.
6. Tubular in-line fans shall satisfy following requirements:
 - a. Fan motor shall not exceed 3 HP.
 - b. Fan shall be in-line centrifugal type.
 - c. Fan shall be belt-driven.
 - b. Motor and belt drive components shall be replaceable without requiring fan impeller removal.
 - c. Motor and drive maintenance shall not require access to contaminated exhaust components.
 - d. Fan assembly shall be configured for direct mounting upon curb or plenum.
7. SWSI centrifugal fans shall satisfy following requirements:
 - a. Fan shall be direct drive with impeller mounted directly on fan shaft.
 - 1) Fan shall be belt driven only if available fans require selection outside approved motor frequency range.
 - b. Fan shall be configured for mounting upon curb or platform with inlet duct connection to side of exhaust plenum.
 - c. SWSI fans have no motor HP limitations.

[Note to PSC: Indicate fan type and configuration. As stated, in-line exhaust fans are limited to smaller sizes given motor replacement for this type of unit is typically more difficult than for base mounted SWSI fans. For this reason larger fans must be SWSI whereas smaller fans may be either SWSI or in-line. Tubular in-line fans must be belt driven to facilitate motor and drive maintenance and replacement. Motor replacement is difficult to accomplish on direct drive tubular fans of any type. As stated, SWSI fans shall be belt driven only if available fans require selection outside approved motor frequency range.]

C. Discharge Performance

1. Fan shall, under all operating conditions, maintain minimum effective plume rise indicated in project documents.
 - a. Effective plume rise calculation shall be based upon current edition of *ASHRAE Laboratory Design Guide*, Equation 9-2.
 - 2) Wind speed used in calculation shall be 27.5 MPH (1% annual mean extreme at University of Illinois Willard Airport).

[Note to PSC: Required plume rise for a specific exhaust fan location shall be determined by wind tunnel or mathematical modeling of actual installed condition. A simple mathematical model "Geometric Method for Estimating Stack Height" can be found in "ASHRAE Applications Handbook – Building Air Intake and Exhaust Design" Once determined, minimum required plume rise shall be identified in specifications or indicated on drawing schedule.]

- b. Per *ANSI/AIHA Z9.1* referenced above exhaust stack discharge velocity shall be 3,000 FPM minimum.
- c. Clarification: Discharge velocity = velocity of exhaust air as it leaves last element of exhaust system. Not to be confused with nozzle velocity.

E. Components

1. Housing and Discharge Stack
 - a. Fan shall be configured with vertical upward discharge.
 - b. Per *ANSI/AHI Z 9.1* referenced above...
 - 1) Stack height of installed unit shall be 10 ft. minimum above adjacent roof level.
 - c. Fan stack shall incorporate concentric discharge nozzle.
 - 1) Nozzle shall not utilize stack cap nor hinged cover.
 - d. Fan nozzle shall be rated for 6000 FPM discharge air velocity minimum.
 - e. Installed fan assembly shall be rated for 125 MPH wind velocity without guy wires or other structural support.
 - f. Fan arrangement shall be as indicated in schedule or on drawings.
 - g. Hinged or bolted access door shall be provided. Access door size and placement shall permit convenient access to fan impeller, motor, drives and bearings as applicable.
 - h. All exposed fasteners and hardware shall be type 316 stainless steel construction.
 - i. Drain with NPT connection shall be provided as applicable.
 - j. Lifting lugs shall be provided.
2. Impeller
 - a. Impeller shall be airfoil, backward curved or backward inclined centrifugal type or mixed flow type as scheduled or otherwise indicated in project documents.
3. Drive
 - a. Direct drive fans shall have impeller firmly attached directly to motor shaft.
 - b. Belt-driven fans shall have motor located outside exhaust airstream.
 - c. Fan shaft shall be stainless steel unless indicated otherwise in project documents.
 - d. Where required to prevent shut down of fan for lubrication, extended stainless steel lube lines shall be provided. Otherwise extended lube lines shall be avoided.
- D. Materials of construction / surface treatment of components exposed to contaminated air stream shall be based upon service as follows:
 1. Chemical fume exhaust, acidic
 - a. Corrosion resistant materials
 - 1) Type 316 stainless steel
 - 2) FRP
 - 3) Phenolic coated
 2. Noxious or toxic vapor exhaust
 - a. Materials appropriate for wash-down
 - 1) Same as chemical fume exhaust
 - 2) Epoxy coated also approved
 3. Radioisotope fume exhaust
 - a. Materials appropriate for wash-down
 - 1) Same as noxious or toxic vapor exhaust
 4. Biological exhaust system

- a. Materials appropriate for wash-down
 - 3) Same as noxious or toxic vapor exhaust
 - 4) HEPA filtration may be required
- 5. Combustible vapor exhaust
 - a. Spark resistant construction
 - 1) AMCA type A
 - 2) AMCA type B
 - 3) AMCA type C
- 6. Perchloric acid exhaust
 - a. Special fan/system, not specified herein

2.6 HIGH PLUME EXHAUSTERS – INDUCED FLOW TYPE

- A. High plume induced flow exhaust fans shall satisfy all requirements specified above in section entitled *LABORATORY EXHAUST FANS – GENERAL REQUIREMENTS*.
 - 1. Induced flow exhaust fans shall incorporate high dilution nozzle and wind band.
 - (a) Air induction discharge nozzle shall be supplied by fan manufacturer, integral to fan body design
 - 2. Induced flow exhaust fans shall induce ambient air up to 200% at specified primary airflow.

2.7 TUBULAR CENTRIFUGAL EXHAUSTERS, NON-INDUCTION TYPE

- A. Tubular centrifugal exhausters shall satisfy all requirements specified above in section entitled *LABORATORY EXHAUST FANS – GENERAL REQUIREMENTS*.
 - 1) Fan shall be in-line centrifugal.
 - 2) Exhauster shall incorporate high velocity discharge cone, factory fabricated.
 - 3) Stack shall be extended as required to satisfy stack height requirements.
 - 4) Fan shall be configured for direct mounting upon curb or plenum.

2.8 EXHAUST AIR PLENUMS

- A. Design Criteria
 - 1. Exhaust plenums shall comply with requirements of *Section 23 73 13 – Modular Air Handling Units* **or** *Section 23 73 23 Custom Air Handling Unit* specifications based upon criteria presented below. For clarity, some requirements have been duplicated herein. However, requirements not specifically referenced shall not be diminished.

[Note to PSC: Exhaust air plenums shall be designed and constructed as application-specific air handling units.]
 - 2. Exhaust air plenums with design airflow no greater than 5,000 CFM shall satisfy, at minimum, all requirements for *Outdoor Air Handling Units* per *Section 23 73 13 – Modular Air Handling Units*. As stated, such requirements shall include all referenced requirements within overall document.
 - 3. Exhaust air plenums with design airflow greater than 5,000 CFM shall satisfy all requirements for *Outdoor Air Handling Units* per *Section 23 73 23 – Custom Air Handling Units*. *Again*, such requirements shall include all referenced requirements within overall document.
 - 4. Note: In certain cases plenums with design airflow 5,000 CFM or less may require compliance with *Custom Air Handling Unit* specifications to satisfy requirements not readily achievable with *Modular Air Handling Units*. Such requirements include:

- Increased R value to satisfy more demanding interior and/or exterior ambient conditions
 - Non-standard unit configurations
 - Non-standard materials of construction or coatings
 - Incorporation of custom heat recovery and/or auxiliary device requirements
5. Contact PSC for clarification of Design Criteria as required.

[Not to PSC: Identify plenum design criteria for specific project and reference appropriate AHU spec. Edit language as required.]

B. General

1. As stated, exhaust plenums shall satisfy all requirements for outdoor air handling units. Selected items are repeated herein.
2. As with outdoor air handling units, exhaust plenums shall consist of sectionalized casing panels and flooring mounted upon a structural base. Units shall incorporate fans, heat recovery devices, filters, dampers and other components as indicated within project documents. Casing panels shall be insulated double wall construction.
3. Exhaust air plenums shall be specifically designed for outdoor application. As such it shall be designed for exposure to harsh weather conditions, including high wind, heavy snow loading, torrential rain and UV exposure. At minimum, requirements shall comply with all applicable design and construction standards for geographic location.
4. Exhaust air plenums for variable flow exhaust systems shall incorporate automated dilution air control as shown on drawings or otherwise indicated in project documents.
5. Exhaust air plenums for constant flow systems may incorporate automated, manual or no automated dilution air control. Dilution air control shall be provided as shown on drawings or otherwise indicated in project documents.

[Note to PSC: Clarify dilution air control requirements for specific project. Edit language accordingly.]

C. Materials of Construction

1. Modular AHU and Custom AHU specifications currently identify coated steel, aluminum and stainless steel as approved materials of construction.
2. FRP shall be included as approved material for exhaust plenums. FRP construction shall provide, at a minimum, equal strength and rigidity as other approved materials.

D. Interior Components

1. Materials of construction and/or surface treatment of interior components exposed to contaminated air stream shall be based upon service as identified above in section entitled *LABORATORY EXHAUST FANS – GENERAL REQUIREMENTS*. Type 304 stainless steel is also an approved option for plenum liner material unless indicated otherwise in project documents. *[Note to PSC: Although type 304 stainless steel is not listed as an approved option for exhaust fan construction in the referenced section it is typically adequate as a liner material for exhaust plenums and shall be treated as default. If type 304 stainless steel is deemed inadequate edit spec language above accordingly.]*

E. Support

1. As stated in AHU specifications, plenums shall be designed for mounting upon curb or structural support system.
2. As applicable, plenums shall be designed to support top-mounted exhaust fan assemblies in configuration shown on drawings.

F. Safety Grating

1. As stated in AHU specifications, safety grating shall be provided over air inlet or outlet opening in floor. Grating shall support service personnel while maintaining minimal impact on system air flow. Material shall be based upon service as previously addressed. *[Note to PSC: Ensure that velocity across grating is low enough to minimize pressure drop. This is a common oversight.]*
- G. Connections
1. Flanged bell mouth opening(s) shall be provided for duct or fan connections.
- H. Dilution Intake
1. One or more intake opening(s) with weather hood, bird screen and dilution control damper shall be provided for plenum as applicable and as shown on drawings.
 2. Hood size and configuration shall comply with special requirements of *Outdoor Air Handling Unit* specification.
 3. Intake opening shall be positioned to optimize performance of heat recovery devices and fan(s).
 4. Damper(s) shall be sized for project specific optimal control.
- I. Fan Isolation
1. Isolation damper shall be provided for each individual fan.
 - a. Damper shall be specifically designed and configured to yield negligible impact on fan performance. *[Note to PSC: Considerable losses typically occur at this juncture. Steps shall be taken to minimize these losses.]*
- J. Damper Construction
1. Dampers shall satisfy all requirements of paragraph entitled *AIRFOIL DAMPERS, HEAVY DUTY STAINLESS STEEL* in *Section 23 09 13.43 CONTROL DAMPERS*.
 2. Dampers shall be constructed of type 304 or type 316 stainless steel. *[Not to PSC: Indicate material for specific project.]*
 3. Dampers may be FRP construction pending approval of PSC. Shop drawings shall be provided to PSC for approval prior to unit construction. FRP dampers shall satisfy all applicable requirements for specified stainless steel dampers.
 4. Fan isolation dampers shall be parallel blade type.
 5. Dampers shall be automated or manual as noted in schedule or otherwise indicated in project documents.
 6. Damper actuators shall be located outside of contaminated air stream. Damper actuators exposed to weather shall be NEMA 4, designed for application.
- K. Heat Recovery
1. Provide heat recovery devices and associated systems as specified and scheduled.
 2. Heat recovery coils including glycol water coils and heat pipes shall satisfy requirements in *Section 23 82 16 - Air Coils*.
 3. Energy recovery wheels shall satisfy requirements in *Section 23 73 23 - Custom Air Handling Units*.
- L. Fasteners
1. All fasteners and hardware shall be type 316 stainless steel
- J. Vestibules and Enclosures
1. As with outdoor air handling units, vestibules and enclosures shall be provided as shown on drawings. *[Note to PSC: Show on drawings or delete this requirement.]*
- M. Platforms

1. As specified for outdoor air handling units, OSHA approved platforms, ladders and railings shall be provided as specified and shown on drawings. Such shall provide safe, convenient access to plenum and exhaust fan assembly. Platforms shall be configured to facilitate removal of motors and/or impellers. Installing Contractor shall coordinate with Electrical Contractor to ensure path for component removal is not impeded by electrical panels or devices.

[Note to PSC: As stated for outdoor AHUs, if external structure is required, show on drawings. If structure is substantial it may be appropriate to retain services of Structural Engineer and assign work to General Contractor. In such case, structural requirement shall be removed from AHU spec.]

2.9 POWER ROOF EXHAUSTERS

A. Description

1. Power roof exhauster shall be spun aluminum, roof mounted, direct driven centrifugal exhaust ventilator.
 - a. Fan shall be down-blast or up-blast as indicated in schedule.

[Note to PSC: The University endeavors to minimize use of drive belt assemblies due to drive losses and maintenance requirements. Thus, direct drive has become default design for most rotating equipment. However, if it is determined that a particular roof exhauster should be belt-driven, high quality pillow block bearings and an automatic belt tensioning system shall be provided.]

B. Fan Selection

1. Fan shall be selected to avoid surge and yield stable operation at all operating speeds.
2. Fan shall be selected to operate at or near peak efficiency at design operating point.
3. Fan performance data shall include effect of any factory-mounted airstream obstructions such as protective screens and guards.

C. Housing

1. Motor cover, shroud, curb cap, and lower wind band shall be constructed of heavy gauge aluminum.
2. Components shall be bolted to a heavy aluminum support structure.
3. Aerodynamic aluminum inlet cone and baffle shall be provided for maximum performance and efficiency.
4. Top cap assembly shall provide weather protection for motor and drive components.
5. Removable access cover shall be provided with quick release fasteners.
6. Motor shall be separated from exhaust airstream, ventilated with outdoor air.
7. Curb cap base shall have continuously welded corners.
8. Integral conduit chase shall be provided through curb cap into motor compartment.
9. Unit shall bear engraved aluminum nameplate indicating design CFM and static pressure.

D. Wheel

1. Wheel shall be non-overloading centrifugal backward inclined.
2. Wheel shall be constructed of aluminum including machined cast aluminum hub.
3. Wheel shall be balanced in accordance with *AMCA Standard 204 – Balance Quality and Vibration Levels for Fans*.
4. Wheel shall mounted directly upon motor shaft.

E. Motor

1. Motor shall be NEMA design B, insulation class B, rated continuous duty, furnished at scheduled voltage, phase and enclosure.
2. Motor shall have heavy duty permanently lubricated sealed ball bearings conservatively designed for vertical direct drive fan application.
3. Motors ¾ HP and smaller shall be electronically commutated (EC) furnished with factory mounted potentiometer speed controller.
 - a. Unit shall be provided with disconnect switch, factory-mounted within enclosure.
 - b. Remotely located starter provided by others.
4. Motors 1 HP and larger shall be AC induction type, three phase, suitable for use with variable speed drive.
 - a. Disconnect switch provided by others.
 - b. Remotely located VFD provided by others.

F. Accessories

1. Bird screen shall be provided, factory mounted.
2. Hinged base with restraint cable shall be provided.
3. Motorized backdraft damper shall be provided, field installed.

G. Curb

1. Roof mounting curb shall be provided if scheduled or shown on drawings
2. Curb shall be 16 gauge stainless steel or .080" aluminum construction.
3. Curb shall place fan 18" minimum height above roof surface.
3. Curb shall be double wall metal construction with no exposed insulation.
4. Curb shall incorporate wood nailer and damper shelf.
5. Gasket shall be provided to ensure tight seal between fan and curb.

PART 3 - EXECUTION

3.1 General

A. Floor-supported Fans

1. Fan shall be placed upon and firmly anchored to steel reinforced concrete pad.
2. Pad shall be anchored into concrete floor.
3. Pad shall be 4" minimum thickness and shall extend 6" minimum beyond fan support frame on all sides.
4. Pad construction shall be coordinated with General Contractor.
5. Spring supported inertia base shall be provided if indicated in project documents.

[Note to PSC: Clearly indicate requirement for project. Edit text accordingly.]

- a. Inertia base shall be steel construction with welded-in reinforcing bars and concrete ballast.
- b. Inertia base dimensions, weight and spring design shall be sized by vibration isolator manufacturer.

[Note to PSC: Spring supported inertia base shall be provided as deemed appropriate for specific application. Provision of inertia base may be advisable for large equipment, installation on upper floors and/or installation where sensitive lab equipment could be impacted. If inertia base is deemed unnecessary delete associated text above. If required, show on drawings.]

B. Ceiling-suspended Fans

1. Adequately sized hanger rods and/or structure firmly attached to ceiling or structural steel shall be provided.
 - a. Support system shall provide restraint to limit movement of fan housing.
 - b. Thrust restraints shall be provided as required.

C. Roof-mounted Fans

1. Fan shall be firmly mounted upon enclosed and insulated roof curb or enclosed and insulated structural support system. Exposed structural support members not allowed.
2. Curb / support system shall be of adequate strength and rigidity to support full operating weight of unit.
3. Curb / support system shall place fan at 18" minimum height above roof surface.
4. 36" minimum clearance shall be provided between finished roof and open support structure.
5. Fan shall be anchored and self-supporting such that guy wires or cables not required.
6. Flashing shall be provided as shown on architectural drawings.
7. For power roof exhauster, motorized damper shall be properly located and firmly mounted within curb.
8. Continuous welded stainless steel cap shall be provided for curb, 16 gauge minimum.
9. Curb / enclosure shall be flashed into roofing system. Roof membrane termination and two piece flashing shall be provided as specified and detailed elsewhere within project documents and in compliance with published *UIUC Facilities Standards*.
10. Roof curb or support system construction shall be coordinated with Installing Contractor as applicable.

[Note to psc: Review applicable UIUC Standards and ensure that all requirements have been incorporated into project documents.]

D. Fans within air handling units

See Section 23 73 23 – Custom Air Handling Units or 23 73

1. Vibration Isolation
 - a. Vibration isolators shall be provided for each fan as recommended by manufacturer.
 - 1) Fans/isolators shall be firmly attached to curb or overhead support system.
 - 2) Isolators shall be adjusted as recommended by Manufacturer.
2. Flexible Connection
 - a. For spring supported fans, flexible fabric duct material shall be provided at each duct or plenum connection to minimize transfer of vibration.
 - b. Material shall be rated for application.
 - c. Ductwork shall be supported independently of fan housing to prevent loading on flexible connectors.
3. Configuration
 - a. Fans and associated ductwork, plenums and housings shall be configured to prevent pressure losses that negatively impact performance/efficiency.
 - b. For housed fans, ductwork at fan inlet and outlet shall be configured to prevent system effect in compliance with *AMCA Publication 201 – Fans and Systems*.

4. Access
 - a. Fan assemblies shall be installed with adequate clearance and accessibility to facilitate maintenance and component removal, including fan wheel and motor.
 - b. Fan shall be oriented to facilitate such maintenance and removal.
- B. Laboratory Exhaust Air Plenums
1. Location
 - a. Laboratory exhaust fans and plenums shall be located outdoors, roof-mounted.
 2. Support
 - a. As specified for outdoor AHUs, plenum shall be firmly mounted upon enclosed and insulated roof curb or enclosed structural steel support system. Exposed structural members not allowed.
 3. Fan Mounting
 - a. Tubular in-line centrifugal exhauster (3 HP or smaller) shall be rigidly mounted directly upon curb or plenum.
 - b. SWSI exhaust fan(s) shall be mounted adjacent to exhaust plenum and shall be supported upon restrained spring, rubber and/or neoprene vibration isolators. Isolators shall be as recommended by Manufacturer.
 - c. Installed fan assembly shall withstand wind loads of up to 125 MPH without additional structural support.
 4. Plenum Connection
 - a. Exhaust duct connection to plenum shall incorporate conical transition or oversized bell-mouth fitting to minimize air pressure losses.
 - b. Flexible fabric duct material shall be provided at each duct or plenum connection to minimize transfer of vibration. Material shall be rated for application.
 5. Impellor Access
 - a. For SWSI lab exhaust fans, if design does not accommodate convenient extraction of motor-mounted impellor through back of fan housing, provision shall be made to facilitate extraction of impellor through inlet side of fan housing.
- C. Platforms, Field Fabricated
1. OSHA approved platforms, ladders and railings shall be provided as specified and shown on drawings. Such shall provide safe, convenient access to plenum and exhaust fan assembly.
 2. Platforms shall be constructed of aluminum, stainless steel or epoxy coated steel.
 3. Platforms shall be configured to facilitate maintenance and replacement of internal components and shall be adequate in strength and dimension to handle heaviest component.
 4. Installing Contractor shall coordinate with other contractors to ensure that path for component removal is not impeded. *[Note to PSC: As with outdoor AHUs, show field fabricated structure on drawings. If structure is substantial it may be appropriate to retain services of Structural Engineer and assign work to General Contractor. In such case, structural requirement shall be removed from AHU spec.]*
- D. Alternate designs that fully achieve intent of specifications may be submitted to PSC for review and potential approval.
- E. Field Balance
1. Field balance not required unless, if in judgment of PSC or Owner, vibration level is deemed questionable or unacceptable. In such case, vibration analysis and balancing

shall be performed by qualified technician as specified above in section entitled *Factory Run Test / Balance*.

- a. Referenced section indicates maximum allowable fan vibration level as follows:
 - 1) Belt-driven fans: 0.15 in/sec peak velocity, filter in
 - 2) Direct drive fans: 0.10 in/sec peak velocity, filter in

G. Startup

1. Prior to startup
 - a. Bearings shall be properly lubricated.
 - b. Belts shall be properly aligned and tensioned.
 - c. Fans shall be turned by hand to ensure free rotation.
 - d. Proper installation of electrical wiring/components and proper motor rotation shall be confirmed.
 - e. Proper operation of dampers shall be confirmed.

END OF SECTION 23 34 00

This section of the *U of I Facilities Standards* establishes minimum requirements only.

It should not be used as a complete specification.