

University of Houston Master Specification

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SECTION 23 3443 – LABORATORY HIGH PLUME EXHAUST FANS

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

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

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

Delete hidden text after this Section has been edited for the Project.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. The Contractor's attention is specifically directed, but not limited, to the following documents for additional requirements:
 - 1. The current version of the *Uniform General Conditions for Construction Contracts*, State of Texas, available on the web site of the Texas Facilities Commission.
 - 2. The University of Houston's Supplemental General Conditions and Special Conditions for Construction.

1.2 SUMMARY

- A. Perform all Work required to provide and install the following fans and components indicated by the Drawings and Specifications with supplementary items necessary for proper installation.
 - 1. Airfoil centrifugal wheel fans.
 - 2. Backward inclined / backward curved centrifugal wheel fans.
 - 3. Axial / backward curved mixed flow impeller bifurcated fans.
 - 4. Motors and drives.
 - 5. Fan accessories.

1.3 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:

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1. AMCA 99 - Standards Handbook.
2. AMCA Publication 111 - Laboratory Accreditation Program.
3. ANSI/AMCA Standard 210 - Laboratory Methods of Testing Fans for Rating.
4. AMCA Publication 211 - Certified Ratings Program - Product Rating Manual for Fan Air Performance.
5. AMCA Standard 260 - Laboratory method of Testing Induced Flow Fans for Rating.
6. AMCA Standard 300 - Reverberant Room Method for Sound Testing of Fans.
7. AMCA Publication 311 - Certified Ratings Program - Product Rating Manual. For Fan Sound Performance.
8. AMBA - Method of Evaluating Load Ratings of Bearings ANSI-11.
9. ANSI/AMCA Standard 204 - Balance Quality and Vibration Levels for Fans.
10. AMCA Standard 500-D-98 - Laboratory Methods of Testing Dampers For Rating.
11. AMCA Standard 500-L-99 - Laboratory Methods of Testing Louvers For Rating.
12. SMACNA - Medium Pressure Plenum Construction Standard.
13. ANSI Z9.5 – Laboratory Design.

1.4 QUALITY ASSURANCE

- A. The following quality assurance requirements apply to all fans described and furnished under this Section:
1. Performance ratings: Conform to AMCA Standard 211 and 311. Fans must be tested in accordance with AMCA 210, 260 and 300 in an AMCA accredited laboratory and the high plume exhaust fan shall be licensed to bear the AMCA seal for Certified Sound and Air Performance. Acceptable manufacturers whose equipment is not licensed to bear the AMCA seal for Certified Sound and Air Performance must submit air and sound performance tests conducted by an independent third party, and stamped by a registered professional engineer.
 2. Fans designated or classified for Type C Spark Resistant Construction must conform to AMCA 99 requirements.
 3. Each assembled fan shall be test run at the factory at the specified fan rpm with CFM per watt, and vibration signatures shall be recorded and documented. Vibration signatures are to be measured at each bearing location in the horizontal, vertical, and axial planes. The maximum allowable fan vibration shall not be greater than 0.08 inches per second at the peak velocity; filter-in reading as measured at the fan rpm. The report with documented test results shall be included with the shipment for each fan.

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4. The manufacturer shall also provide, at the Owner and Engineer's option, witness testing of fan inlet tests measured in an AMCA accredited laboratory (AMCA Publication 111-99), in accordance with AMCA 210. Witness fan discharge and entrainment airflow, using a modified AMCA 210 test set up where the fan inlet is placed in the open and the fan outlet (which includes the induction stack) is connected to the airflow test apparatus. This total fan outlet airflow test shall verify the entrainment airflow rate, which is the dilution performance by subtracting the measured fan inlet airflow rate from the fan outlet airflow rate. This performance test shall be performed as part of the product submittal phase of the Project.
 - a. **[Engineer must provide minimum plume heights, laboratory design air flow rates, static pressure requirements, and maximum motor horsepower requirements for high plume exhaust fans on equipment schedules.]**
5. Minimum design airflow rates, static pressure, and plume heights as referenced on the Drawings.
 - a. The scheduled minimum plume height shall be accomplished at the scheduled design airflow rate and analytically established from ASHRAE Laboratory Design Guide, Equation 9-2.
 - b. The plume height shall be visually indicated by inducing smoke at the fan inlet and also at the air inlet side of the induction ring.
 - c. The vertical plume height is determined and measured where the diluted smoke no longer continues a vertical path parallel with the centerline fan outlet or induction ring nozzle.

1.5 SUBMITTALS

A. Product Data:

1. Submit data for approval for all fans of every description furnished under this Section.
 - a. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gages or thickness, finishes of materials, electrical characteristics, and connection requirements for each model of high-plume dilution laboratory exhaust fan assemblies being provided for the Project.
 - b. Fans shall be capable of operating stably at reduced capacities imposed by means of a variable frequency drive.
 - c. Product test data on sound power levels for both fan inlet and outlet at the rated design capacity.
 - d. Product data on special coatings and construction where applicable.
 - e. Product data on all fan accessories.
 - f. Provide fan curves for each fan at the specified operation point, with the flow, static pressure and horsepower clearly plotted. The recommended operating range where the fan will remain stable.

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1) [Engineer must provide wind velocity 1 percent of the time as listed Chapter 26 in Tables 1A, 2A, and 3A of ASHRAE Handbook – Fundamentals for many cities. For cities not listed the wind speed is 2.5 times the annual average hourly wind speed as recommended in Table 2, Chapter 15 of the ASHRAE Handbook – Fundamentals.]

g. Provide nozzle velocity of exhaust fan, total exhaust flow, and results of the effective discharge plume height based on the specified wind velocity of [___].

h. Strictly adhere to Quality Assurance requirements as stated in this Section.

B. Operation and Maintenance Data:

1. Manufacturer's installation instructions and operating and maintenance data.

a. Submit under provisions of Division 01.

b. Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to the Project Site under provisions of Division 01 and Section 23 0100 "Mechanical General Provisions."

B. Accept products on Site in factory-fabricated protective containers or coverings, with factory-installed shipping skids and lifting lugs. Inspect for damage.

C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

D. Check and maintain equipment on a monthly basis to ensure equipment is being stored in accordance with manufacturer's recommended practices. Additionally, during each check, fans and motors shall be rotated and greased and shafts shall be left approximately 180 degrees from that of previous month. Maintain storage records that indicate these maintenance requirements have been met.

PART 2 - PRODUCTS

2.1 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. Base fan performance at standard conditions (density 0.075 Lb/ft³).

C. Fans shall be capable of accommodating static pressure and flow variations of +/-15 percent of scheduled values.

D. The completely assembled fan shall be tested to meet the vibration limits as published in AMCA 204.

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- E. Equip each fan with fan inlet isolation damper to prevent the fan from turning in reverse rotation when the fan is off.
- F. Equip fans with stainless steel lifting lugs for corrosion resistance.
- G. When a powder coating process is used on fan and plenum, the coating shall be minimum thickness of 3 mils. Finish color shall be light gray.
- H. Fasteners exposed to corrosive exhaust shall be Type 304 or Type 316 stainless steel.
- I. Fan assembly shall be designed for a minimum of 125-mph side wind loading, without the use of guide wires.

2.2 MANUFACTURERS

- A. High Plume Dilution Blowers:
 - 1. Greenheck Fan Corporation, Model Vektor MD or CD Direct / Belt Drive.
- B. High Plume Exhaust Systems:
 - 1. M.K. Plastics Corporation, Model Axijet Direct / Belt Drive.
- C. Laboratory Exhaust Systems:
 - 1. Strobic Air Corporation, Model Tri-Stack Direct Drive.

2.3 CENTRIFUGAL HIGH PLUME EXHAUST FANS

- A. Fans shall be configured as belt driven per AMCA Arrangement 1, 9, 10 or direct drive per AMCA arrangement 8 according to the Drawings. Fans mounted on top of exhaust air plenums or are not accessible from the roof shall be equipped with jib cranes (complete with removal hoist), for motor maintenance and removal.
- B. Fan, plenum and dampers shall be coated with a minimum of 3 mils of Plastifer epoxy ES90-AS81, or Hi-Pro Polyester resin coatings. Finish color shall be light gray.
- C. Fan assemblies that use flexible connectors that can fail and cause loss of laboratory containment are not acceptable. Inlet elbow/plenum shall be attached to the fan inlet by a high strength, corrosion resistant flexible connector, or vibration isolation pad or gasket, provided by the fan manufacturer.

2.4 MIXED FLOW HIGH PLUME EXHAUST FANS

- A. Mixed flow steel case fans shall be direct driven in AMCA Arrangements 2, or AMCA Arrangement 4, or belt driven in AMCA Arrangement 9. Fans systems shall be equipped with jib crane (complete with removal hoist), for motor maintenance and removal.

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- B. Fan, plenum and dampers shall be coated with a minimum of 4-6 mils of Plastifer epoxy ES90-AS81, Hi-Pro Polyester resin or Amercoat 90HS Epoxy-phenolic coatings. Finish color shall be light gray.

2.5 FAN HOUSINGS AND OUTLET

- A. Fan housings shall be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
- B. Steel fan housings shall be centrifugal involute scroll, allowing all drive components including the motor to be serviced without contact of the contaminated air stream, and manufactured of welded steel coated with a minimum of 3 mils of Hi-Pro Polyester resin, electrostatically applied and baked. Finish color shall be gray. No uncoated metal fan parts exposed to the exhaust will be acceptable.
- C. Fiberglass reinforced plastic (FRP) fan housings shall be manufactured in specifically formulated resins, for maximum corrosion resistance, UV inhibited and reinforced with fiberglass for structural strength. Fastening bolts holding the casing to the support plate are to be encapsulated in FRP. Finish color shall be light gray. Fan to be supplied with a graphite liner and grounding strap to remove static electricity, as well as a flame retardancy of 25 or less, if required. Fiberglass reinforced plastic fan housings that are fabricated shall have mechanical strength and toughness properties equivalent to steel housings, interior surfaces shall be smooth to assure corrosive or hazardous compounds cannot collect, and / or chalk and structurally degrade. Having smooth interior surfaces will also reduce collection of biological contaminants.
- D. Centrifugal fans shall be equipped with access doors shaped to conform to the housing scroll with quick opening latches and gaskets.
- E. A steel or fiberglass reinforced plastic discharge nozzle shall be supplied by the fan manufacturer, and shall be designed to efficiently handle an outlet velocity of up to 7000 FPM. The discharge nozzle shall include either bifurcated section or a discharge section surrounded with a wind band to induce ambient air.
- F. A drain shall be designed as an integral part of the centrifugal fan housing to drain rainwater when the fan is de-energized.
- G. Supply a bolted and gasketed access door for impeller inspection and service.
- H. Fan assembly shall be AMCA type C spark resistant construction minimum or as noted on the Drawings.

2.6 FAN IMPELLERS

- A. Centrifugal Type:

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1. Fan impeller for centrifugal fans shall use backward inclined or airfoil blade design wheel with non-stall characteristics. The impeller for either wheel design shall be electronically balanced, both statically and dynamically meeting or exceeding Grade 6.3 per AMCA Standards.
 2. Fan impeller shall be manufactured of welded and coated steel with a minimum of 3 mils of Hi-Pro Polyester resin, or 4-6 mils of Plastifer epoxy ES90-AS81 with a finish color of light gray.
- B. Mixed Flow Type:
1. Fan impeller for vertical inline fan shall use a combination axial / backward curve blade design wheel with non-stall characteristics. Stationary discharge guide vanes located above the impeller shall be provided to increase fan efficiencies. The impeller for either wheel design shall be electronically balanced, both statically and dynamically meeting or exceeding Grade 6.3 per AMCA Standards.
- C. Fan impeller shall be manufactured of welded and coated steel with a minimum of 3 mils of baked Hi-Pro Polyester resin or 4 mils Epoxy-phenolic coatings. Finish color shall be light gray.

2.7 EXHAUST AIR PLENUM CURBS

- A. For a constant volume exhaust system, the fan/nozzle assembly shall be connected directly to roof or roof curb and exhaust duct without need for a bypass air plenum.
- B. For a variable volume exhaust system, a bypass air plenum shall be provided as shown on Drawings. The plenum shall be provided with stainless steel modulating opposed blade bypass air damper(s) for introducing outside air at roof level upstream of the fan, complete with bypass air rain hood and bird screen. The actuator(s) to operate the bypass damper are to be supplied by the building automation system (BAS) Provider.
- C. A parallel blade fan tight shutoff isolation damper, two position actuated, fabricated of stainless steel, shall be provided as shown on the Project documents. Isolation damper shall include a factory mounted and wired actuator; complete with a mounted and wired step down transformer, wired to the fan disconnect. Transformer shall be mounted in a NEMA 3R panel, minimum, or as shown on the Drawings. The isolation damper precludes reverse rotation of the fan wheel when the fan is not energized.
- D. The plenum shall be constructed of welded cold rolled steel, and coated with minimum 3 mils of Hi-Pro Polyester resin or Epoxy-phenolic coatings.
- E. Plenums that are fabricated of plastics or resin that are combustible and have mechanical properties less than steel shall not be acceptable.
- F. The bypass air plenum shall be mounted on factory fabricated roof curb provided by the fan manufacturer, as shown on the Drawings
- G. Fan designs that use inlet flexible connectors that can leak causing loss of lab exhaust shall not be permitted.
- H. Blower / Plenum vibration isolation shall be limited to neoprene/cork vibration pads.

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- I. Exhaust system manufacturer shall supply a structural support curb for the plenum, of specified height, as shown on the Drawings.
- J. Curb shall be fabricated of a minimum of 12 gage corrosion resistant coated steel and structurally reinforced.
- K. Vertical exhaust inlet plenums shall have curbs that are insulated. Horizontal exhaust inlet plenums shall have un-insulated plenums.
- L. The plenum shall have integral drain connections to drain water that may condense on the inner wall of the plenum.
- M. When properly anchored to the roof structure, the standard curb / plenum / blower assembly shall withstand wind loads of up to 125 mph without additional structural support.

2.8 FAN MOTORS AND DRIVES

- A. Motors shall be premium efficiency, standard NEMA frame, 900, 1200, or 1800 rpm, TEFC, and compatible with variable frequency drives as scheduled. Refer to Section 20 05 13. Provide a factory mounted NEMA 3R disconnect switch, mounted and wired, for each fan.
- B. Direct drive arrangement shall be AMCA Arrangement #2, utilizing a direct mount coupling connecting the motor shaft and fan impeller shaft. Exhaust fan systems with direct drive Arrangement #4 where the fan wheel is connected directly to the shaft of the motor, will require a tight shut-off isolation damper at the fan inlet to allow the fan to be removed for motor replacement. Fan shaft shall be Type 316 stainless steel.
- C. Belt drive arrangement shall be AMCA Arrangement 1, 9, 10. Drive belts and sheaves shall be sized for 200 percent of the fan operating brake horsepower, and shall be readily and easily accessible for service. Fan shaft shall be 316 stainless steel or ANSI C-1045 steel and be protected with TECTYL protective coating. If the fan is not scheduled to be operating in conjunction with a variable frequency drive, then include an additional set of drives for each fan to be used for final adjustments. After correct speed has been determined with variable sheave, provide fixed sheaves.
- D. Belt Guard: All belt drives shall be furnished with belt guards. Fabricate to SMACNA Low Pressure Duct Construction Standards; of 12 gage 3/4-inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
- E. Fan shaft bearing(s) shall have a key-way, and shall be milled and machine polished, Type 316 stainless steel.
- F. Mechanical shaft seals are to be either neoprene or Teflon (but only when required).
- G. Fan shaft bearings shall be ball or roller pillow block type and be sized for a requirement of L-10 life of no less than 200,000 hours. Bearing(s) shall have extended lube injection lines Zerk grease fittings and lube relief lines with caps.

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- H. Motor, coupling, and bearing shall all be outside the contaminated exhaust air pathway.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. Install fan systems in accordance with manufacturer's instructions and the Drawings and Specifications. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings are lubricated, and the fan has been test run under observation.
- C. Install fans with resilient mountings and flexible electrical leads. Refer to Section 23 0548 "Vibration Isolation."
- D. Install flexible connections specified in Section 23 0548 "Vibration Isolation" between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one-inch flex between ductwork and fan while running.
- E. Install fan restraining snubbers as required. Refer to Section 23 0548 "Vibration Isolation." Adjust snubbers to prevent tension in flexible connectors when fan is operating.
- F. Pipe centrifugal fan housing and/or plenum drain to the nearest drain.

3.2 PAINTING

- A. Provide fans with factory finish in accordance with the manufacturer's standard. Touch up scratches and marks from handling and placement of equipment with masking enamel to match manufacturer's color.
- B. Where exhaust fans are required to have polyester, epoxy or Heresite coating, have units factory finished with required number of coats prior to shipping to the Project Site.
- C. Refer to Division 09 for Site-applied finishes.

END OF SECTION 23 3443