UNIVERSITY OF MICHIGAN
ARCHITECTURE, ENGINEERING AND CONSTRUCTION

ARCHITECTURE & ENGINEERING
326 East Hoover, Mail Stop B
Ann Arbor, MI 48109-1002
Phone: 734-764-3414
Fax: 734-936-3334

BuildingName
The Description of the Project
P00000000 0000

SPECIFICATION DIVISION 23

NUMBER SECTION DESCRIPTION

DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)
SECTION 233400 - FANS

END OF CONTENTS TABLE

DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)
SECTION 233400 - FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, Standard General and Supplementary General Conditions, Division 1 Specification Sections, and other applicable Specification Sections including the Related Sections listed below, apply to this Section.

B. Related Sections:

1. Section 019100/019110: Commissioning.
2. Section 220513: Motors.
3. Section 220548: Vibration Control
4. Section 233300: Air Duct Accessories and RGDs
5. Section 230593: Testing, Adjusting, and Balancing
6. Section 230900: Mechanical Systems Controls.
7. Division 26: Electrical.

1.2 SUMMARY

A. Section Includes:

1. Centrifugal Fans:
   a. Housed centrifugal fans.
   b. Utility Sets.
   c. Domed roof, up blast roof and sidewall exhaust fans.
   d. Ceiling fans.
   e. Cabinet fans.
   f. Inline fans:
      1) Square Inline Centrifugal.
      2) Tubular Inline Centrifugal.
2. Inline Fans:
   a. Propeller fans.
   b. Tube-axial fans.
   c. Vane-axial fans.
3. Specialty Use Fans:
   a. Plenum fans.
   b. High-plume induction type lab fans.
   c. Smoke purge fans.
   d. Kitchen exhaust fans.
   e. Fan Arrays

1.3 SUBMITTALS

A. Submit the following product data for each unit:

1. Static pressure, airflow (CFM), speed (RPM), system curve, outlet velocity and fan tag for each fan.
2. Certified fan curves showing fan performance with the system operating points identified on curves. Surge, or "Do not operate" line, shall also be indicated on fan curve.

3. Performance curves shall be published by the fan manufacturer and based on tests in accordance with AMCA 210. The curves shall be drawn with the fan flow rate plotted against fan total pressure and fan brake horsepower as per section 10.2.1 of AMCA 210.
4. Bearing sizing and life calculations for each similar size and type of fan. Fan bearing calculations shall be based on fan maximum operating conditions including belt pull. Calculations shall be provided for both fan bearings and motor bearings.
5. Sound power levels for each size and type of fan. Sound levels shall be provided for all 8 octave bands for discharge of fan, inlet to fan, and radiated noise through casing.
6. Dimensional data for each size and type of fan, including operating and maintenance clearances.
7. Details of vibration isolation bases including selections for vibration isolation springs.
8. Details of fan discharge flexible duct connector.
9. Details of motor and belt guards.
10. Motor ratings, electrical characteristics, and motor accessories.
11. Fan anti-corrosion coating data sheets.

1.4 QUALITY ASSURANCE

A. Manufacturers and Products: The products and manufacturers specified in this Section establish the standard of quality for the Work. Subject to compliance with all requirements, provide specified products from the manufacturers named in Part 2.

B. Reference Standards: Products in this section shall be built, tested, and installed in compliance with the following quality assurance standards; latest editions, unless noted otherwise.

1. AMCA Standard 99-0401, "Classification for Spark Resistant Construction."
2. ANSI/AMCA Standard 99-2404, "Drive Arrangements for Centrifugal Fans."
3. ANSI/AMCA Standard 99-2406, "Designation for Rotation and Discharge of Centrifugal Fans."
4. AMCA Standard 99-2408, "Operating Limits for Centrifugal Fans."
5. ANSI/AMCA Standard 210 ANSI/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."
6. ANSI/AMCA Standard 260 "Laboratory Methods of Testing Induced Flow Fans for Rating."
7. ANSI/AMCA Standard 300, "Reverberant Room Method for Sound Testing of Fans."
8. ANSI/AMCA Standard 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data."
9. ANSI/AMCA Standard 204, "Balance Quality and Vibration Levels for Fans."
10. UL-705, "Power Ventilators" (applies only for fans exposed to outdoor conditions).
11. UL-762, "Power Roof Ventilators for Restaurant Exhaust Appliances."
12. UL-793, "Standard for Automatically Operated Roof Vents for Smoke and Heat."

13. American Bearing Manufacturers Association (ABMA) Standards.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Fan manufacturer shall provide protection to insure that the interior and exterior of each fan is completely protected from dirt or weather during shipping. Openings shall be covered with sealed sheet metal, plastic or other durable means to ensure unit cleanliness is maintained.

1.6 WARRANTY

A. Provide a complete parts and labor warranty for a minimum of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

1. All fan types specified in this Section, except Vane Axial, Tube Axial, Fan Arrays, and High-Plume Induction Type Lab Fans:
   a. Loren Cook Co.
   b. Acme.
   c. Twin City.
   d. Aerovent.
   e. Greenheck.
   f. Trane.
   g. Barry Blower.
   h. Penn.
   i. Buffalo.
2. Vane-Axial and Tube-Axial:
   a. Buffalo Fan Co.
   b. Howden Buffalo, Inc.
   c. Woods.
   d. Trane.
   e. Greenheck.
   f. Cook
   g. Joy
3. High-Plume Induction Type Lab Fans:
   a. Strobic.
   b. Greenheck Vektor.
   c. Cook Hi-Plume
4. Fan Arrays:
   a. Nortek Huntair Fanwall
   b. Twin City Fan; model MPQN

2.2 GENERAL CONSTRUCTION- ALL FANS

A. Provide balanced variable sheaves for motors 7.5 HP and under and fixed sheaves for motors 10 HP and over. Size variable sheaves at midpoint of specified operating conditions to allow field adjustment up or down during balancing procedures. Where fixed speed sheaves are specified for a specific fan, provide one (1) additional sheave set, if required, for final balancing.

B. Fan selection and ratings shall be based on tests made in accordance with AMCA 210.

C. Fans shall be AMCA licensed and shall bear the AMCA seal for both sound and performance levels.

D. Fan shall be minimum Class I construction with proper UL label.

E. The specified fan RPM, outlet velocity, and tip speed are the maximum acceptable. The motor horsepower, CFM, and static pressure are the minimum acceptable.

F. Unless noted otherwise by specific fan type or per schedule, fan housing shall be heavy gauge continuous welded corrosion resistant steel construction with fan scroll and bearings supported from structural steel framework.

G. All fasteners shall be corrosion resistant type.

H. Fan housing shall be of suitable thickness and bracing required for stable and rigid construction, with no deflection, and to prevent vibration and pulsation.

I. Fans having duct-connected inlets shall be provided with a flanged inlet and/or outlet collar matching companion flange.

J. Provide OSHA belt guards on all belt driven fans.

K. Fans shall be spark-proof Type A, B or C (AMCA 99-0401) as required by application.

L. For exterior mounted fans, a weatherproof housing shall be provided with ventilation grilles to cover motor and drive assembly.

M. Provide special construction fans, such as spark-proof, explosion-proof, or specially coated fans as required by schedules or as specified herein.

N. Provide birdscreen on fans exposed to the exterior environment.

O. Provide adequate space for service of fan, motor and bearings.

P. The fan shaft shall be solid high carbon steel, accurately turned, ground and polished, and ring gauged for accuracy.

Q. Recommended bearing manufacturer tolerances shall be met in the area of the shaft in contact with the bearings.

R. Shafts must be dial indicator inspected for straightness after the keys are cut.

S. Fan shaft shall be coated with rust inhibitive coating.

T. Fan wheel assembly or propeller assembly shall be statically and dynamically balanced prior to fan assembly.

U. The entire rotating assembly shall be designed so the first critical speed is at least 25% over the maximum fan class speed.

V. Fan Shaft Bearings

1. Fan bearings shall be bolted on a rigid welded steel framework integral with the housing.
2. Bearings shall be designed and individually tested specifically for use in air handling applications.
3. Bearings shall be sized for a minimum L-10 life of 200,000 hours at the maximum fan class operating speed and horse power. Selection shall account for all operating conditions including belt pull. Bearings shall be selected in accordance with standards set forth by the American Bearing Manufacturers Association (ABMA).
4. Bearings shall be grease lubricated self-aligning ball or roller type. Provide tapered roller bearings for vertical applications.
5. Bearing housings shall be solid cast iron, pillow block or flange mount type. Provide split pillow block bearings where required by the application speed.
6. Stamped bearing housings are permitted on fans of 1/4 HP or less.
7. Bearings shall be of the type that can be re-lubricated, and shall be equipped with grease fittings.

W. Where fan bearings are not easily accessible or are installed in a hazardous exhaust airstream, provide clear plastic grease leads, properly secured to avoid damage or fatigue, routed to an accessible location.

X. Fan Drive

1. Fan drive shall be a multiple V-belt type sized for 1.65 times the fan motor horsepower. Sheaves shall be fixed or adjustable based on fan motor horsepower as specified herein before. Fan sheave shall have a tapered lock, split and keyed hub. Grove spacing on equipment and motor pulleys shall align. For fans 1/2 HP and larger, quantity of belts shall be such that if any one belt fails, remaining belts shall allow fan to continue functioning as designed. Multiple belts shall be provided as a matched set.
2. Motors shall meet requirements as specified in Motors section.
3. Motor shall be 1800 rpm maximum for belt driven or direct drive fans.
4. On OSHA approved type fan drive guard shall be provided with provision for RPM measurement at both motor and fan without removing the guard. The guard shall be made of 1/2 in., 16 gauge flattened expanded steel, wrapped around a 16 gauge channel frame suitably braced to prevent vibration. Guard shall be G-90 galvanized, or painted to match fan housing paint.
5. Fan belts shall be oil resistant 24,000-hour non-static belts.

Y. Provide thrust arrestors as required to limit movement of the fan upon start-up.

Z. Provide riveted, engraved aluminum nameplate containing pertinent, specific fan data, including manufacturer, model, serial number, and electrical data, etc.

2.3 PAINTING

A. Each fan component shall be thoroughly cleaned, degreased and deburred.

B. Prior to assembly, prime coat all non-galvanized ferrous metal parts with zinc rich primer (minimum 70 percent zinc), total dry film thickness of not less than 1.3 mils.

C. For interior units, finish paint all non-galvanized ferrous metal parts with alkyd enamel paint.

1. Low-luster interior enamel; total dry film thickness of not less than 2.6 mils.

D. For exterior units, finish paint all non-galvanized ferrous metal parts with alkyd enamel paint.

1. Semi-gloss exterior enamel; total dry film thickness of not less than 2.6 mils.

E. Aluminum and stainless steel parts do not require painting.

F. Special coatings for corrosive exhaust systems are specified in the exhaust fan specifications.

2.4 CENTRIFUGAL FANS

A. General

1. Centrifugal type fans shall be belt drive, unless noted otherwise
2. Fans shall be backwardly inclined, airfoil, or flat blade type with a minimum of 9 blades.
3. Fans shall have sharply rising pressure characteristics at the operating point specified and shall be quiet and stable in operation. Horsepower characteristics shall be self-limiting (non-overloading) and at peak value at the specified operating point.
4. Each fan base shall be fully assembled with motor and drive on a structural steel base.

B. Fan Base

1. Fan with motor and drive shall be mounted on a structural steel base.
2. Base shall be welded. After welding, the base shall be cleaned, primed and painted to match fan coating.
3. Base steel sizing and construction shall be sufficient to allow the entire assembly to withstand the rigors of shipping and rigging.
4. Base shall be provided with lifting lugs and motor slide rails.
5. Fans with inertia bases shall be in accordance with Mechanical Vibration Control section.
6. Bases shall be constructed with gusseted brackets to accommodate field installed spring isolators as specified in Mechanical Vibration Control section.

C. Fan Housing

1. Fans having wheel diameters 36 in. and larger shall have horizontally flanged split housings as required for installation.
2. Fan housing and inlet shall be constructed to allow the fan wheel(s) to be removed through the inlet opening when the inlet cone is removed.
3. Provide a quick opening inspection door with heavy duty latches.
4. A 1/2 in. NPT tapped 3/4 in. diameter pipe coupling drain connection shall be welded to the fan scroll at the lowest point, equipped with a pipe plug.
5. Class I and II fans shall be convertible to a minimum of 8 standard discharge arrangements.
6. Provide a Fan cut-off to deliver good pressure distribution.

D. Fan Inlet and Wheel Cone

1. Provide a precision die-spun or formed, and matched inlet and wheel cones for streamlined airflow into the wheel to ensure full loading of the blades.
2. Inlet and wheel cones shall be hyperbolic. Radial side sheets are not acceptable.
3. Inlet cone shall be heavy gauge, bolted to fan housing to allow for removal.
4. Fans that are not duct-connected shall be provided with inlet/outlet screen(s). Screen(s) shall be standard manufacturer provided screen or galvanized maximum nominal 1 in. by 1 in. mesh fabricated 10 gauge steel.
5. Hubs shall be straight bored or use taper lock bushings, keyed and set screwed to shaft for positive attachment. Hubs shall be securely riveted or bolted to the backplate or center plate. Bushed hubs are not acceptable.
6. Double-width double-inlet fans shall be a single wheel of the common center plate design or 2 single-width single-inlet wheels back-to-back, each keyed and set screwed to a common shaft.
7. Fan blades shall be continuously welded to the inlet hub and the backplate.
8. Wheel center plate or backplate shall be heavy gauge steel construction with a minimum gauge as indicated in material construction schedule.

E. Housed Centrifugal Fans

1. Housing shall be per Related Section "Custom Air Handling Units."
2. Access doors shall be per Related Section "Custom Air Handling Units."

F. Utility Set Fans

1. Utility sets shall meet all applicable centrifugal fan specification requirements.

G. Domed Roof, Up Blast Roof and Sidewall Exhaust Fans

1. General:
   a. Housing shall be constructed of heavy gauge spun aluminum with a rigid internal support structure.
   b. Fan wheel shall be backward inclined.

c. Drive frame assembly shall be constructed of heavy gauge steel.
d. Motors and drives shall be mounted on vibration isolators, out of the air stream.
e. Fresh air for motor cooling shall be drawn into the motor through a tube free or contaminants or through a space between the fan shroud and the motor cover.
f. Fan drives shall be sized for 1.5 times the motor horsepower. Pulleys shall be cast type, keyed and securely attached to the wheel and motor shafts.
g. Motor pulleys shall be adjustable for final balancing.
h. Provide a factory-installed disconnect switch, wired from the fan motor to a junction box installed within the motor compartment. Provide a conduit chase through the base to the motor compartment.
i. When backdraft dampers are installed below fan, provide a heavy gauge hinge kit to allow entire fan to tilt away from roof curb for access to dampers. Construct hinge kit with aluminum hinges and hold open cables for field installation.

2. Roof-mounted up blast exhaust fans shall have a leak proof housing constructed with a one-piece windband with an integral rolled bead, and shall be joined to the curb-cap with a continuously welded seam.
3. Sidewall mounted exhaust fans shall have a leak proof housing constructed with a one-piece windband with an integral rolled bead. Provide a mounting plate that will be attached and sealed to the wall prior to installing fan.

H. Ceiling Fans

1. Fans shall be direct drive.
2. Outlet duct collar shall include an aluminum backdraft damper and shall provide for connection to ductwork as required.
3. Grille shall attach firmly and securely to housing and shall be easily removable for access to motor.
4. Fan wheel shall be forward curved.
5. Mount motor on vibration isolators.
6. Access to wiring shall be external.
7. Motor disconnect shall be internal and of the plug-in type.
8. Sound power rating shall not exceed 5 sones.

I. Cabinet Fans

1. Duct mounted fan shall be belt-driven, inline type.
2. Housing shall be rectangular, galvanized steel and shall include rectangular duct mounting collars.
3. Fan wheel shall be backward inclined or forward curved.
4. Fan drives shall be sized for 1.65 times the motor horsepower. Pulleys shall be cast type, keyed and securely attached to the wheel and motor shafts.
5. Motor pulleys shall be adjustable for final balancing.
6. Provide a hinged or removable panel in the fan cabinet of sufficient size to allow access for service to all internal fan components without dismantling cabinet.

J. Centrifugal Inline Fans

1. Tubular Inline Centrifugal

a. Fan housing shall be provided with mounting brackets at both inlet and discharge suitable for hanger rods or bolting directly to structure.
b. Fan shall be suitable for horizontal or vertical mounting.
c. Motor, drive and bearings shall be out of the airstream and housed to facilitate ease of maintenance. Motor cooling shall be through the fan drive and motor housing. Housing for motor drive and bearings shall be of same construction as the fan housing.

2. Square Inline Centrifugal
a. Fan housing shall be of bolted and welded construction utilizing corrosion resistant fasteners. Housing shall include airflow straightening vanes and integral duct flanges. Adjustable motor plate shall utilize threaded studs for positive belt tensioning. Access doors and mounting feet shall be located as required for the specified position.
b. Construct fan wheel of 100 percent aluminum, including a precision-machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency.

2.5 INLINE FANS

A. General: The aerodynamic design of the fan is such that the maximum power absorbed by the impeller occurs within the normal working range, i.e., the fan has a non-overloading characteristic.

B. Propeller Fans

1. Entire fan shall be heavy duty, industrial type construction.
2. Provide direct or belt drive fans, as scheduled.
3. Construct fan panel of heavy gauge plate steel with a die-formed or spun venturi-shaped inlet cone built into the panel.
4. Fan panel edges shall be formed back. Corners shall be welded and ground.
5. Fan wheel, motor, and bearings shall be supported from fan panel using structural channel or heavy plate steel. Bearing housings and motor base shall be shall be mounted on a heavy steel plate spanning the 2 vertical support members. All construction shall be welded or bolted.
6. Wheel shall have a minimum of 4 propeller blades, die-formed constructed of heavy gauge steel or aluminum. A reinforcing gusset shall be welded or riveted to the blades and to a machined hub.
7. Provide a protective welded-wire steel guard to completely enclose the motor/drive/fan assembly.
8. Provide heavy duty gravity operated back draft dampers made of galvanized steel, with blade and jamb seals.
9. Provide an OSHA damper guard that completely encloses the damper. Damper guard shall consist of galvanized expanded metal screen welded to a galvanized metal frame.

C. Tube-Axial Fans

1. Fans shall be Arrangement No.9 for belt drive or Arrangement No.4 for direct drive.
2. Fan casing, flanges and supports shall be of suitable thickness and bracing required for stable and rigid construction, with no deflection, and to prevent vibration and pulsation.
   a. Fans 38 in. diameter or less shall be minimum 12 gauge construction.
   b. Fans over 38 in. diameter shall be min 10 gauge construction.
3. Fan casings shall be fitted with mounting legs or hanging clips as required for the mounting arrangement indicated.
   a. Fan mounting legs shall be fabricated from steel plate suitably braced to ensure stability and rigidity.
   b. Clips for horizontal suspension shall be minimum 3/8 in. steel plate welded and mounted at fan centerline.
   c. Clips for vertical suspension shall be minimum 3/8 in. steel plate welded and mounted at center of moment of inertia of fan assembly.
4. Fans shall be provided with supports for horizontal or vertical mounting, as required. When required, inlet bell, inlet screen, acoustical diffuser and outlet cone shall be provided by the manufacturer.
5. The impeller shall be secured to the motor shaft by a key and keyway. Axial location shall be provided by a collar or shoulder on the drive shaft with a retaining washer and screw fitted into a tapped hole in the end of the shaft. The screw shall be locked in position.
6. External grease fittings with extended grease leads shall be provided for motor lubrication. Motor shall be removable from either end of the fan. Foot mount or "C" face flange mount motors are acceptable.

D. Vane-Axial Fans

1. Adjustable pitch vane-axial fans shall be direct or belt driven, as indicated, axial flow type, with fan blade angle capable of manual adjustment while fan is stopped.
2. Fans shall be Arrangement No.9 for belt drive or Arrangement No.4 for direct drive. The fan rotor shall be mounted directly on the motor shaft with the assembly enclosed entirely within the fan casing, suitable for inline duct mounting.
3. Fan casing, flanges and supports shall be of suitable thickness and bracing required for stable and rigid construction, with no deflection, and to prevent vibration and pulsation.
   a. Fans 38 in. diameter or less shall be min 12 gauge construction.
   b. Fans over 38 in. diameter shall be min 10 gauge construction.
4. Fan casings shall be fitted with mounting legs or hanging clips as required for the mounting arrangement indicated.
   a. Fan mounting legs shall be fabricated from steel plate suitably braced to ensure stability and rigidity.
   b. Clips for horizontal suspension shall be minimum 3/8 in. steel plate welded and mounted at fan centerline.
   c. Clips for vertical suspension shall be minimum 3/8 in. steel plate welded and mounted at center of moment of inertia of fan assembly.

5. Fans shall be provided with supports for horizontal or vertical mounting, as required. Inlet bell, inlet screen, acoustical diffuser and outlet cone shall be provided by the manufacturer.
6. Fan shall have inlet and outlet static regain cone.
7. Provide discharge cone silences, as scheduled, optimized to fan discharge geometry with minimum dynamic insertion loss of 15/18 dB at 250/500 Hz at 2000 fpm duct velocity.
8. Fan blades and hubs shall have aluminum castings, alloy 356 T6 aluminum alloy. Fan blades shall be designed for maximum efficiency and be airfoil shaped, varying in twist and width from base to tip. Blade tip clearance shall be within tolerance to meet certified performance of fan. Fan hub shall be one-piece aluminum casting. The fan hub shall have the capacity to add or delete impellers in the field for final balance.
9. Fan blade pitch angle shall be individually, manually adjustable using common wrenches. Special tools shall not be required to adjust blade angle.
    a. Fan manufacturer shall install and adjust linkages for controllable and manually adjustable pitch vane axial fans in the field. Field adjustment of the pitch range shall be provided by the fan manufacturer to balance the fan to maximum and minimum conditions. Field adjustment of the adjustable pitch setting shall be provided by the fan manufacturer to balance the fan to the required conditions.
10. The impeller shall be secured to the motor shaft by a key and keyway. Axial location shall be provided by a collar or shoulder on the drive shaft with a retaining washer and screw fitted into a tapped hole in the end of the shaft. The screw shall be locked in position.
11. Provide external grease fittings with extended grease leads for motor lubrication. Motor shall be removable from either end of the fan. Foot mount or "C" face flange mount motors are acceptable.

2.6 PLENUM FANS

A. Provide single width non-overloading centrifugal type, mounted on rigidly built and braced all welded fan pedestals made of structural steel, mounted to square, flat mounting plates, and equipped with lifting lugs.

B. Provide belt driven type unless noted otherwise.

C. Wheels shall be 12 bladed air foil shaped to reduce sound and increase efficiency.

D. Wheel shall be carefully matched to inlet cone to provide precise running tolerances and maximum operating performance and efficiency.

E. Provide the fan wheel with a completely enclosing protective cage with a removable section large enough to service the fan or drive easily. Cages across the fan plenum access door are not acceptable.

F. Provide lubrication lines with Zerk fittings, extended to the exterior of the protective fan cage, securely mounted to prevent stress.

G. Provide removable fan inlet screen.

2.7 HIGH-PLUME INDUCTION TYPE LAB FANS

A. Provide exhaust fans with induction windbands that discharge air at no less than 3000 FPM at the design air volume.

B. Fans shall meet the scheduled performance requirements, including system effects from provided plenums. Manufacturer shall be responsible to account for system effects created by backdraft dampers, plenum size/aspect ratio, and connection sizes and locations at the specified connection air volumes.

C. Discharge shall include FRP nozzles with passive central stack that is capable of generating aspiration. The FRP shall be chemically and UV resistant.

D. Steel entrainment windbands shall provide secondary induction of outside air. Induction shall take place downstream of the fan impeller. Windbands shall discharge 270 percent of the design primary airflow rate, or as scheduled. Manufacturer shall certify primary and discharge (induced plus primary) air volumes, and provide these air volumes and a certification statement with the submittal.

E. Impellers shall be mounted to the motor shaft to provide a direct drive, Arrangement No.2, or No.4 type fan. Motors shall be isolated from the primary exhaust air stream and shall be visible and accessible from the fan exterior for inspection and service.

F. Mixed flow impellers shall consist of a combination of axial/backward curved blades, and shall be of welded steel construction. The impeller shall have non-stall and non-overloading performance characteristics with stable operation at any point on the fan curve.

G. Stationary discharge guide vane sections shall be provided to increase fan efficiencies.

H. Vibration isolation shall be limited to rubber-in-shear pad type isolators, unless noted otherwise.

I. Fan assemblies shall be designed for a minimum wind loading of 100 mph, and for mounting on a conventional roof curb or plenum as indicated, without the need for guy wire supports.

J. Provide sound attenuators if required to meet specified sound levels. Specified sound power levels shall not be exceeded, including impacts from bypass damper airflow noise. Provide acoustical louvers if required. Sound power levels shall be guaranteed with the attenuator installed on the fan in the specified configuration.

K. Provide fan manufacturer’s sound attenuator, installed integral as part of exhaust nozzles for each fan.

1. Maximum attenuator air pressure drop shall be 0.1 inch W.C. Provide performance data of fans de-rated for the pressure loss related to attenuator.

2. Attenuator shall provide attenuation values and fan sound pressure levels as indicated. The published insertion loss values shall be obtained from testing with the attenuator installed in the specified configuration.
3. Silencer shall be constructed of FRP, aluminum, or 316 stainless steel for both inner and outer liners.
4. Acoustical media shall be minimum 3 pcf density fiberglass, isolated from the air stream by a Tedlar film, or the attenuator design shall be packless type.
5. Silencer interior and exterior shall be coated to match fan, including color.
6. Attenuator shall be self-supporting, equipped with bracing and lifting lugs suitable to support the weight of the attenuator.
7. Flow direction shall be clearly marked on side of attenuator.
8.
9. Provide inline sound attenuator with length as indicated.
10. Maximum air pressure drop shall be 0.1 in. W.C. when installed. Provide performance data of fans de-rated for the pressure loss related to attenuator.
11. Attenuator shall provide attenuation values and fan sound pressure levels as indicated. The published insertion loss values shall be obtained from testing with the attenuator installed in the specified configuration.
12. Construct attenuator casing of FRP with minimum 3/16 in. wall thickness or minimum 14 gauge welded galvanized steel. Silencer interior and exterior shall be coated to match fan, including color. Casing shall be of welded construction.
13. Acoustic media shall be minimum 3 pcf density fiberglass. Media shall be chemically protected from air stream by a Tedlar scrim. Inner surface of media shall be covered with perforated galvanized steel. The leading edge of the perforated metal shall not be exposed to the air stream.
14. Attenuator shall be bolted to fan and discharge stack with flanges and stainless steel hardware. Attenuator shall be self-supporting, equipped with bracing and lifting lugs suitable to support the weight of the attenuator.
15. Flow direction shall be clearly marked on side of attenuator.

L. Fan construction shall be AMCA Spark Class C.

M. Fans shall be modular construction and capable of field assembly on roof.

N. PTFE gaskets shall be provided at all companion flange joints.

O. Fasteners shall be type 316 stainless steel.

P. A bolted access door shall be provided for impeller inspection on each fan.

Q. Fans and accessories shall have internal drain systems to prevent rainwater from entering building duct system.

R. Electric motors shall be TEFC and as specified in Motors section.

S. Provide a NEMA 3R, heavy-duty rated, non-fused disconnect switch mounted and wired to motor. Mount switch adjacent to access door. Disconnect shall include early break contacts for fans driven by variable frequency drives.

T. All steel and aluminum surfaces shall be prepared for coating by blasting or chemical etching. Prime coat with zinc rich paint (minimum 70 percent zinc). Topcoat with amine epoxy or polyester coating, non-caulking in sunlight, UV inhibited medium gray color. The minimum DFT of the coating system shall be 6 mils. The coating system shall exceed a 4000-hour ASTM B117 Salt Spray Resistance test.

U. Accessories

1. Inlet mixing plenums shall be provided by the fan manufacturer. Each plenum shall be sized to support weight and performance requirements for all fans indicated. Plenums shall be capable of supporting fans without need for guy wires or supports.
   a. Plenums shall be double wall construction with structural stiffeners or shall be continuously welded, heavy gauge single wall construction.
   b. Plenums shall include hinged access doors with heavy duty latches and screens over primary air inlets.
   c. Plenums shall be coated to match fans.
   d. Unless noted otherwise, plenums shall be suitable for mounting on roof curbs.
2. Dampers:
   a. Airfoil type, opposed blade, stainless steel construction.
   b. Stainless steel damper linkage, rods, bearings, and jamb seals.
   c. Polymer blade edge seals. Select blade edge seal material to match the chemical resistance of the fan's coating system.
   d. Damper frames shall be minimum 13 gauge stainless steel.
   e. Damper linkage shall be exposed blade-mounted type. Linkages concealed in the damper frame are not allowed.
   f. Damper drive linkage shall be set by the manufacturer and welded or bolted through the shaft to eliminate slippage; set screws shall not be used.
   g. Leakage shall not exceed 6.0 CFM/sq. ft. at 3 in. WC.
   h. Damper and actuator shall operate smoothly and without deformation affecting specified performance, at a differential pressure no less than the maximum deadhead (zero flow) pressure the fan is capable of producing.
   i. Dampers shall be accessible for maintenance. Damper actuators shall be accessible for maintenance from outside the contaminated interior parts of the plenum.
3. Bypass dampers shall be provided with all plenums for mixing outside air with primary exhaust. Provide:
   a. Louver/damper combinations, manual locking quadrant. Provide rain hood w/ birdscreen.
   b. Dampers with extended shaft for connection to an actuator. Provide rain hood with birdscreen for each damper.
4. Provide isolation (backdraft) dampers at the inlet to each fan.
5. Provide damper actuators, capable of properly throttling and tightly closing the dampers.
   a. Damper actuators shall be spring return electric.

b. Isolation damper actuators shall be factory wired (via transformer when required) to the fan disconnect switch to open when the fan is energized, close via a spring when the fan is de-energized, and open on a loss of normal power.
c. If the fan is shipped separately from the plenum, all wiring and conduit shall be factory supplied for easy connection in field.

6. Provide extended clear plastic, UV resistant motor lube lines. Extend lines to a mounting bracket located on the fan roof base with Zerk fittings for each line.
7. Provide a structural mounting pedestal for a portable jib crane as part of each fan roof base, in sufficient quantities to reach all fans.
8. Vortex breakers shall be provided on all side inlet and multiple fan plenums.
9. Inlet spray nozzle(s) shall be mounted at fan inlet to provide complete wash-down capability of fan while in operation. Spray nozzle(s) shall be suitable for water or steam output. Nozzle(s) shall be piped to exterior of fan with threaded end for field connection. Nozzle(s) and all associated piping shall be stainless steel construction.

2.8 SMOKE PURGE FANS

A. Fans for smoke purge/exhaust applications shall be rated at 500 Deg F for (4) hours continuous operation and 1,000 Deg F for 15 minutes. Fans shall be UL 705 listed (electrical components). If belt driven, fans shall have 2 belts or a minimum of 1.5 times the required number of belts, whichever is greater. Butterfly damper mechanisms shall be UL 793 listed. Motors shall have a minimum service factor of 1.15.

2.9 KITCHEN EXHAUST FANS

A. Fans shall UL 705 listed (electrical components) and UL 762 listed for electrical components and grease removal.

B. Construct spun aluminum housing of heavy gauge aluminum with a rigid internal support structure.

C. Fan wheel shall be backward inclined.

D. Construct drive frame assembly of heavy gauge steel.

E. Mount motors and drives on vibration isolators, out of the air stream.

F. Fresh air for motor cooling shall be drawn into the motor through a tube free of contaminants or through a space between the fan shroud and the motor cover.

G. Mount fan shafts in permanently sealed, lubricated pillow block ball bearings. Bearings shall be sized for a minimum L-10 life in excess of 200,000 hours at maximum fan class operating conditions including belt pull.

H. Size fan drives for 1.65 times the motor horsepower. Pulleys shall be cast type, keyed and securely attached to the wheel and motor shafts.

I. Motor pulleys shall be adjustable for final balancing.

J. Provide a factory-installed disconnect switch, wired from the fan motor to a junction box installed within the motor compartment. Provide a conduit chase through the base to the motor compartment.

K. Roof-mounted upblast exhaust fans shall have a leak proof housing constructed with a one-piece windband with an integral rolled bead and shall be joined to the curb-cap with a continuously welded seam.

L. Sidewall mounted exhaust fans shall have a leak proof housing constructed with a one-piece windband with an integral rolled bead. Provide a mounting plate that will be attached and sealed to the wall prior to installing fan.

M. Provide a drain connection constructed of aluminum to allow for single point drainage of grease, water and other residue. Grease trap shall include the drain connection and shall be constructed of aluminum. Unit shall collect grease and water from fan and extract grease from water for ease of disposal.

N. When dampers are installed below fan, provide a heavy gauge hinge kit to allow entire fan to tilt away from roof curb for access to dampers. Construct hinge kit with aluminum hinges and hold open cables for field installation.

O. Provide aluminum wheel coated with a non-stick coating.

P. Clean out port shall have a hole on the outside of windband and a grease repellent compression rubber fitting, allowing access to entire wheel for cleaning.

Q. If motor is installed in airstream, extend ball bearing leads through an airtight conduit to a suitably sized conduit box in accordance with NFPA and NEC, mounted on the exterior of the fan casing. External grease fittings with extended grease leads shall be provided for motor lubrication. Motor shall be removable from either end of the fan. Foot mount or "C" face flange mount motors are acceptable.

2.10 FAN ARRAYS

A. The array shall consist of multiple, direct driven, arrangement 4 plenum fans or multiple fan and motor "cubes" spaced in the airway tunnel cross section to provide a uniform airflow and velocity profile across the entire airway tunnel cross section and components contained therein. All fans shall be selected to deliver design airflow at the specified operating TSP at the specified motor speed and as scheduled. The fan array shall be selected to operate at a system TSP that does not exceed 95% of the specified fan's peak static pressure producing capability at the specified fan speed.

B. The fan array shall consist of multiple fan and motor "cubes". Each cube shall be lined with acoustic insulation protected by perforated galvanized sheet metal with vapor barrier. The acoustic insulation/perforated galvanized sheet metal shall have a minimum of 10 dB reduction in discharge sound power.

C. Each fan/motor assembly shall be removable through a 30" wide open area. Access door located on the discharge/inlet side of the array.

D. Fan Balancing/Isolation:

1. Option 1: Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, for fan application class BV-5, to meet or exceed a rotational imbalance Grade 0.55, producing a maximum rotational imbalance of 0.022" per second peak, filter in (0.55 mm per second peak, filer in). "Filter in" measurement indicates that the specified balance grade must be achieved at the submitted design operating speed for the fans(s).
2. Option 2: Statically and dynamically balance each wheel in accordance with AMCA Standard 204 "Balance Quality and Vibration Levels for Fans" to Fan Application Category BV-3, Balance Quality Grade G6.3. Test run assembled fan units prior to shipment at specified operating speed or maximum RPM allowed. Obtain balance readings by electronic equipment in the axial, vertical, and horizontal directions on each set of bearings. Motor/Fan isolation for Fan Balance Option 2: Each supply and exhaust fan array fan and motor shall be mounted on a unitary base with neoprene pad or 1" housed spring isolators. Direct mounted fans/motors are not acceptable.

E. Flow Measuring: Each fan shall be provided with airflow pressure taps for use by the Temperature Controls Contractor.

F. Wire sizing shall be determined and installed in accordance with applicable NEC, UL 1995 standards. Each fan cube shall be individually wired to a control panel containing the VFDs, as specified elsewhere, for the total connected horsepower for all fan motors contained in the array. Refer to drawing schedules for fan quantities and VFD quantities for each array.

G. All motors shall be IEEE inverter duty, premium efficiency TEAO, ODP or TEFC T-frame motors with minimum Class F insulation selected at the specified operating voltage, rpm and efficiency as scheduled on the drawings. All motors shall include permanently sealed bearings or regreasble with relief plugs and grease fittings, pre-lubricated bearings suitable for radial and thrust loads of the application and shaft grounding means to protect the motor bearings from electrical discharge machining due to stray shaft current. ODP and TEFC motors shall be provided with minimum L10 bearing life of 130,000 hours. TEAO motors shall be provided with minimum L10 bearing life of 200,000 hours. Motor shall not require external shaft slingers.

H. Each fan applied in multiple fan applications shall be provided with an integral backflow prevention device that prohibits recirculation of air in the event a fan, or multiple fans, become disabled. The system effect for the submitted backflow prevention device shall be included in the calculation to determine the fan TSP for fan selection purposes and shall be indicated as a separate line item SP loss in the submitted fan selection data. Manufacturers other the basis of design being submitted must provide independent lab certification of fan testing that indicates the system effects attributed to the submitted backflow prevention device in the submitted close coupled mounting arrangement at the inlet of the fan. Fans submitted with discharge dampers will not be accepted. Backdraft damper performance data that is based on an AMCA ducted inlet and ducted discharge mounting configuration will not be accepted. Submitted backflow prevention device data must be reflective of close coupled mounting at the intake of the fans per the project design documents. Motorized dampers or other motorized devices submitted for backflow prevention will not be accepted.

I. Fan Array Electrical: Provide a complete electrical system required to run the fan array system, including all variable frequency drives, motor protection, disconnects, equipment, material, electrical enclosure and electrical components. Variable frequency drives must fully comply with Section 220514. Motors shall fully comply with Section 220513.

J. Motor Current Protection: All motors in the fan array shall be provided with individual circuit breakers for each fan in the array located in a motor control panel (MCP). The MCP shall include a main disconnect with early break contacts and shall be mounted within sight of the access door to the fan section. All motor circuit protectors shall be located in the MCP. Provide the scheduled quantity of variable frequency drives. The variable frequency drives shall be sized accordingly to start and hold all motors in the fan array. Refer to drawing schedules for fan quantities and VFD quantities for each array.

2.11 SOURCE QUALITY CONTROL

A. Run test all fans 1 HP and larger at the factory before shipment. Testing shall be conducted at the maximum fan class speed.

B. Statically and dynamically balance each fan per AMCA procedures. Perform electronic vibration analysis at the maximum fan class speed for all fans over 5 HP.

C. Unless noted otherwise, the installed maximum allowable RMS velocity at maximum fan class speed measured at each bearing shall not exceed 0.09 inches/sec in vertical, horizontal, and axial directions.

D. Fans may be field tested after installation by an independent third party. Any fan found to exceed specified vibration limits shall be corrected to perform within those limits without cost to the Owner.

E. High-plume Induction-Type Lab Fans: One fan of each size shall be factory tested and certified to have achieved the specified primary and secondary induction air volumes. Provide certified reports. Owner's representative shall be permitted to witness factory testing.

PART 3 - INSTALLATION

3.1 FAN INSTALLATION

A. Coordinate the fan arrangement with project conditions prior to ordering the fan.

B. Receive and inspect fans for defects. All defective or damaged fans shall be replaced at no cost to the Owner.

C. Openings shall remain protected during storage. Immediately after installation and assembly, all factory protection shall be restored. Unit shall remain protected until just prior to final acceptance by Owner.

D. Use spreader bars on lifting cables when hoisting fans from lifting lugs to prevent cable damage to housing or components. Rig fans per fan manufacturer's recommendations.

E. Fans shall be installed as shown on drawings, in accordance with details, approved submittals and the fan Manufacturer's installation requirements and recommendations. Ensure fans are installed to allow easy accessibility for service or removal of fan components.

F. Provide and install supplemental steel, supports, isolators and hangers necessary to hang or mount fans. Coordinate final location and placement of intermediate steel and ductwork connections in field. Install suspended fans with supports attached to structural members.

G. Install any associated motors, drives, or other components that have been shipped loose. Fan shall be installed, made fully operation, and tested.

H. Install flexible inlet and discharge couplings to prevent vibration transmission to ductwork.

I. Inlet and discharge ductwork shall have a minimum straight run of two (2) fan diameters upstream and downstream of the fan.

J. Just prior to final acceptance fan shall be thoroughly cleaned of all grease, dirt, and dust, etc. Apply touch-up paint or touch-up coating after final cleaning to repair any damage to the finish.

K. Provide or coordinate the scope of work associated with the installation of fans as specified in the following sections:

1. Roof curbs
2. Concrete Housekeeping Pads
3. Vibration isolation
4. Sheet Metal accessories
5. Interconnection wiring and conduit from power source to fan connection (starter).

L. Perform the following tests and inspections prior to fan operation:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices, and that connections to ducts and electrical components are complete.
3. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. Inspect fan scroll for debris or water.
6. Remove guards. Align and adjust belt tension, verify that fan wheel and motor rotate freely, and that bearing operation is smooth. Re-install belt guards.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication of bearings and other moving parts. Use proper bearing venting procedures, in particular at motor bearings. Use only grease type specifically recommended by fan mfr. Do not over-grease. Fill extended grease lines if not already filled, using mfr. recommended grease and proper venting procedures.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. Verify proper motor and fan rotation.
11. Remove and replace malfunctioning units and retest as specified above.

M. Temporary Use of Fans

1. Contractor shall thoroughly clean unit of all grease, dirt, and dust, etc. and perform manufacturer's pre-start protocol and commissioning activities just prior to being placed into temporary service.
2. During temporary service, perform all of manufacturer's required routine maintenance procedures. Continuously maintain a log of all such procedures. Store log at unit during temporary use period and include log as part of the final O&M manual.
3. Contractor shall thoroughly clean unit of all grease, dirt, and dust, etc., lubricate bearings, align and tighten belts and perform manufacturer's pre-start protocol and commissioning activities after unit has completed temporary service, and install a new, complete set of filters just prior to final acceptance by Owner.

3.2 FIELD QUALITY CONTROL

A. Each fan shall be field tested. Any deficiencies related to performance, manufacture or installation shall be corrected without cost to Owner.

3.3 COMMISSIONING

A. Perform the commissioning activities as outlined in the Division 01 Section Commissioning and other requirements of the Contract Documents.

END OF SECTION 233400