

\*\*\*\*\*  
USACE / NAVFAC / AFCEA / NASA UFGS-23 73 00.00 40 (April 2006)  
-----  
Preparing Activity: NASA Superseding  
NASA-15725S (December 2005)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are NOT in agreement with UMRL dated 01 April 2006

Revised throughout - changes not indicated by CHG tags

\*\*\*\*\*

### SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING

SECTION 23 73 00.00 40

AIR HANDLING

04/06

#### PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 GENERAL REQUIREMENTS

#### PART 2 PRODUCTS

- 2.1 GENERAL FAN REQUIREMENTS
  - 2.1.1 General
  - 2.1.2 Bearings
  - 2.1.3 Drives
  - 2.1.4 Sheaves
  - 2.1.5 Belts
  - 2.1.6 Motor Bases
  - 2.1.7 Air-Handling System Balancing Provisions
  - 2.1.8 Motor Requirements
- 2.2 POWER WALL VENTILATORS
  - 2.2.1 Type CWV-F
  - 2.2.2 Type PWV-F
  - 2.2.3 Type PWVB-F
- 2.3 TYPE TA-F TUBULAR AXIAL FAN
  - 2.3.1 Fan Casing
  - 2.3.2 Fan Inlet
  - 2.3.3 Fan Wheel
- 2.4 TYPE VA-F, VANE AXIAL FAN
  - 2.4.1 Fan Casing
  - 2.4.2 Fan Inlet
  - 2.4.3 Fan Wheel
- 2.5 TYPE TC-F TUBULAR CENTRIFUGAL FAN
  - 2.5.1 Fan Casing
  - 2.5.2 Fan Inlet
  - 2.5.3 Fan Wheel
- 2.6 TYPE CSC-F, CARBON-STEEL CENTRIFUGAL FAN

- 2.7 TYPE CCSC-F, COATED CARBON STEEL CENTRIFUGAL FAN
- 2.8 TYPE FRPC-F, FIBROUS GLASS-REINFORCED PLASTIC FAN
  - 2.8.1 FRP Laminate Requirements
- 2.9 TYPE C-F CABINET FANS
- 2.10 SHUTTERS
  - 2.10.1 General
  - 2.10.2 Type AS (Automatic Shutter)
  - 2.10.3 Type FS (Fabric Shutter)
  - 2.10.4 Type MS (Motorized Shutter)
- 2.11 GRAVITY BACKDRAFT AND RELIEF DAMPERS

PART 3 EXECUTION

- 3.1 INSTALLATION
- 3.2 VIBRATION ANALYZER
- 3.3 ACCEPTANCE
- 3.4 OPERATION AND MAINTENANCE

-- End of Section Table of Contents --

\*\*\*\*\*  
USACE / NAVFAC / AFCEA / NASA                      UFGS-23 73 00.00 40 (April 2006)  
-----  
Preparing Activity:    NASA                      Superseding  
   NASA-15725S (December 2005)

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are NOT in agreement with UMRL dated 01 April 2006

Revised throughout - changes not indicated by CHG tags

\*\*\*\*\*

### SECTION 23 73 00.00 40

#### AIR HANDLING 04/06

\*\*\*\*\*

NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This section covers ducted devices normally used in ventilation systems as well as nonducted devices. Special requirements for fans constructed of corrosion-resistant materials are included. Care should be exercised to include and differentiate among criteria applicable to specific systems.

Selectable parameters cover a wide spectrum of specification criteria to suit variable project requirements including bids on equal products, initial costs, costs, and space requirements.

Stringency of certain selectable requirements shall be reduced for intermittent-use systems.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

\*\*\*\*\*

## PART 1 GENERAL

### 1.1 REFERENCES

\*\*\*\*\*

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

\*\*\*\*\*

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

#### AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

- |          |  |
|----------|--|
| AMCA 300 | (2005) Reverberant Room Method for Sound Testing of Fans                   |
| AMCA 301 | (2005) Methods for Calculating Fan Sound Ratings from Laboratory Test Data |
| AMCA 302 | (1973) Application of Sone Ratings for Non-Ducted Air Moving Devices       |
| AMCA 99  | (2003) Standards Handbook  |

#### AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

- |              |  |
|--------------|--|
| ANSI/ABMA 11 | (1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings |
| ANSI/ABMA 9  | (1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings   |

#### AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

- |           |  |
|-----------|--|
| ASHRAE 51 | (1999; Errata, 2006) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating |
|-----------|--|

ASME INTERNATIONAL (ASME)

ASME B15.1 (2000) Safety Standard for Mechanical Power Transmission Apparatus

ASTM INTERNATIONAL (ASTM)

ASTM A 653/A 653M (2004a) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM D 2563 (1994; R 2002e1) Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts

ASTM D 2583 (1995; R 2001e1) Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor

ASTM D 638 (2003) Standard Test Method for Tensile Properties of Plastics

ASTM D 790 (2003) Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 1940-1 (2003) Mechanical Vibration - Balance Quality Requirements for Rotors in a Constant (Rigid) State - Part 1: Specification and Verification of Balance Tolerance - International Restrictions

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA MG 1 (2003) Standard for Motors and Generators

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 10 (2000) Joint Surface Preparation, Standard Near-White Metal Blast Cleaning (NACE No. 2)

SSPC SP 5 (2000) White Metal Blast Cleaning (NACE-No. 1)

1.2 SUBMITTALS

\*\*\*\*\*

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the

submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

\*\*\*\*\*

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

#### SD-02 Shop Drawings

[Fabrication Drawings](#) shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

Installation drawings shall be submitted for fans in accordance with the paragraph entitled, "Installation," of this section. Drawings shall indicate overall physical features, dimensions, ratings, service requirements, and equipment weights.

#### SD-03 Product Data

[Equipment and Performance Data](#) shall be submitted for fans in accordance with paragraph entitled, "General Fan Requirements," of this section.

Manufacturer's catalog data shall be submitted for the following items:

[Vibration Isolation](#)  
[Power Wall Ventilators](#)  
[Type TA-F Tubular Axial Fan](#)  
[Type VA-F, Vane Axial Fan](#)  
[Type TC-F Tubular Centrifugal Fan](#)  
[Type CSC-F, Carbon-Steel Centrifugal Fan](#)  
[Type CCSC-F, Coated Carbon Steel Centrifugal Fan](#)

Type FRPC-F, Fibrous Glass-Reinforced Plastic Fan  
Type C-F Cabinet Fans  
Shutters  
Dampers  
Bearings  
Drives  
Sheaves  
Belts  
Motor  
Casing  
Fan Inlet  
Fan Wheel  
Spare Parts

#### SD-04 Samples

Manufacturer's Standard Color Chart shall be submitted in accordance with paragraph entitled, "General Requirements," of this section.

#### SD-05 Design Data

Design Analysis and Calculations shall be submitted for fans in accordance with paragraph entitled, "General Requirements," of this section.

#### SD-07 Certificates

Listing of Product Installations shall be submitted for fans in accordance with paragraph entitled, "Installation," of this section.

Certificates shall be submitted for following items showing conformance with the referenced standards contained in this section.

Power Wall Ventilators  
Type TA-F Tubular Axial Fan  
Type VA-F, Vane Axial Fan  
Type TC-F Tubular Centrifugal Fan  
Type CSC-F, Carbon-Steel Centrifugal Fan  
Type CCSC-F, Coated Carbon Steel Centrifugal Fan  
Type FRPC-F, Fibrous Glass-Reinforced Plastic Fan  
Type C-F Cabinet Fans  
Shutters  
Dampers  
Bearings  
Drives  
Sheaves  
Belts  
Casing  
Enclosure  
Motor  
Fan Inlet  
Fan Wheel  
Spare Parts

#### SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals shall be submitted in accordance with paragraph entitled, "Operation and Maintenance," of this section.

### 1.3 GENERAL REQUIREMENTS

\*\*\*\*\*  
NOTE: If Section 23 00 00.00 40 GENERAL MECHANICAL PROVISIONS is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph deleted. If Section 23 05 48.00 40 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT is not included in the project specification, applicable requirements therefrom should be inserted and the second paragraph deleted. If Section 26 18 39.00 40 MOTORS is not included in the project specification, applicable requirements therefore should be inserted and the third paragraph deleted.  
\*\*\*\*\*

[Section 23 00 00.00 40 GENERAL MECHANICAL PROVISIONS applies to work specified in this section.]

[Section 23 05 48.00 40 VIBRATION ISOLATION FOR AIR CONDITIONING EQUIPMENT applies to work specified in this section.]

[Section 26 18 39.00 40 MOTORS applies to this section.]

Fabrication Drawings shall be submitted for fans consisting of fabrication and assembly details to be performed in the factory.

Design Analysis and Calculations shall be submitted for fans indicating the manufacturer's recommended sound pressure level ratings, self alignment and thrust load requirements, horsepower ratings, and required system rpm's.

Manufacturer's Standard Color Chart shall indicate the manufacturer's standard color selections and finishes for fans.

## PART 2 PRODUCTS

### 2.1 GENERAL FAN REQUIREMENTS

\*\*\*\*\*  
NOTE: Fan and motor balance shall conform to ISO 1940-1 - (1986) Balance Quality Requirements of Rigid Rotors - Determination of Permissible Residual Unbalance unless otherwise noted. Motor vibration levels shall conform to NEMA Specification MG-1, Motors and Generators, Part 7 unless otherwise noted.  
\*\*\*\*\*

Equipment and Performance Data shall be submitted for fans consisting of use life, system functional flows, safety features, and mechanical automated details. Curves indicating tested and certified equipment response and performance characteristics shall also be submitted.



### 2.1.1.1 General

Performance data for all fans and spare parts shall be determined in accordance with the provisions of ASHRAE 51.

\*\*\*\*\*  
NOTE: Schedule maximum permissible dB and frequency  
criteria on drawings.  
\*\*\*\*\*

Sound pressure level ratings of ducted fans shall comply with AMCA 301 and shall be the result of tests made in accordance with AMCA 300.

\*\*\*\*\*  
NOTE: Schedule permissible sound levels on drawings.  
\*\*\*\*\*

Sound pressure level ratings of nonducted fans shall comply with AMCA 301 and shall be the result of tests made in accordance with AMCA 300. Application of sound pressure level ratings shall conform to AMCA 302. Unit construction shall conform to applicable standards contained in AMCA 99 and to requirements specified.

Safety provisions for power transmission equipment and nonducted inlets and outlets shall include guards and screens, unless other provisions are required, and shall be constructed in accordance with applicable provisions of ASME B15.1. Installation shall be such that fan vibration-isolation provisions are not negated.

Fan wheels shall be statically and dynamically balanced at the factory to ISO 1940-1, G6.3 [G2.5] [G1.0] [\_\_\_\_\_].

[Dynamic balancing shall be in two planes.]

### 2.1.1.2 Bearings

\*\*\*\*\*  
NOTE: When possible the use of sealed bearings is encouraged. One of the major causes of bearing failures is overlubrication and lubrication contamination. Using sealed bearings helps to eliminate this failure mode.  
\*\*\*\*\*

\*\*\*\*\*  
NOTE: Carefully review bearing requirements for nonducted fans to preclude conflict. Specify exceptions under respective units.  
\*\*\*\*\*

Bearings shall be antifriction ball or roller type, unless otherwise specified, with provisions for self-alignment and thrust-load requirements that may be imposed by the service. Bearings shall be constructed of vacuum degassed or processed steel alloys and shall have a certified ANSI/ABMA 9 or ANSI/ABMA 11, L-10 minimum life expectancy rating of [30,000] [50,000] [80,000] [\_\_\_\_\_] hours. Bearings shall have dusttight seals suitable for lubricant pressures encountered. Housings shall be cast iron unless otherwise specified or approved.

Bearings shall be grease lubricated. Lubrication provisions shall preclude overheating due to excess lubricant. Grease supply fittings shall be surface ball check type. Where necessary, manual or automatic grease pressure relief fittings shall be provided. Bearing and seal construction permitting, relief fittings shall be located on the side opposite the supply fitting. Relief fittings shall be visible from normal maintenance locations. Lubrication provisions shall include extension tubes where necessary.

Bearings shall be dowelled in place with AISI 18-8 corrosion-resistant steel spiral wrapped or split pins, unless otherwise specified or approved. Taper pins are not acceptable.

Factory sealed antifriction bearings which conform to above specified materials and ANSI/ABMA 9, L-10 life expectancy requirements shall be provided for fans driven by motors with a power rating of smaller than 375 watt 1/2 horsepower.

\*\*\*\*\*  
NOTE: Select the following paragraph only after  
careful consideration of bearing merits and  
application conditions which include direction of  
belt tension, shaft wear, and need for attention to  
lubrication.  
\*\*\*\*\*

Sleeve-type bearings shall be provided where indicated. Bearings shall be premounted, self-aligning, continuous-oil supply, single- or double-ring lubricated, insert type, with suitable provisions for shaft expansion and for such thrust as may be imposed by service loads. Maximum shaft surface speed shall not exceed 6 meter per second 1,200 feet per minute (fpm) without water cooling, and bearing loading pressure shall not exceed 480 pascal 70 pounds per square inch (psi) based on effective bearing area. Each sleeve bearing shall be provided with approximately 500 milliliter 16-ounce capacity constant-level oiler and oil-level gage.

#### 2.1.3 Drives

Fan drives shall be V-belt type.

V-belt drive application shall conform to the manufacturer's published recommendations.

Wattage Horsepower rating of drive shall be based on maximum pitch diameter of sheave.

Drives with motors up to and including 7500 watt 10 horsepower shall be standard belt section, variable sheave type, with a service factor of not less than 1.5.

Drives with motors over 7500 watt 10 horsepower and up to and including 30 kilowatt of power 40 horsepower shall be standard section, fixed-sheave or variable-sheave type, with a service factor of not less than 1.5.

Drives with motors over 30 kilowatt of power 40 horsepower shall be fixed-sheave, high-capacity, supertype, with a service factor of not less than 1.5.

Belt drives shall be located outboard of bearings. Drive and driven shafts

shall be aligned by the four-point method.

Belt tension shall be adjusted in accordance with the manufacturer's recommendations.

Alignment and final belt tensioning shall be performed in the presence of the Contracting Officer.

[High capacity, supertype belt drives shall be prominently identified with an identification plate containing all necessary replacement part data. Identification plate shall be stamped nonferrous metal or engraved plastic, mechanically and conspicuously attached to drive guard or equipment.]

#### 2.1.4 Sheaves

\*\*\*\*\*  
**NOTE: Variable pitch sheaves should only be used for  
system balance purposes. After balance is determined  
they should be replaced with fixed-sheaves.**  
\*\*\*\*\*

Sheaves shall be machined cast iron or carbon steel, bushing type of fixed bore, and shall be secured to the shaft by key and keyway.

Variable pitch sheaves shall be selected to provide the required balanced system revolutions per minute (rpm) with the sheave set at midpoint of the adjustment range which shall be at least 20 percent.

Companion sheaves for variable pitch drives shall have wide-groove spacing to match driving sheaves, except that standard fixed-pitch spacing shall be used, unless otherwise specified, for all two- and three-groove drives with center-to-center distances equal to or exceeding the following:

<u>BELTS</u>	<u>DISTANCE (MILLIMETER)</u>
A and B	500
C	700
D	900
<u>BELTS</u>	<u>DISTANCE (INCHES)</u>
A and B	20
C	28
D	36

#### 2.1.5 Belts

Belts shall be endless, of Dacron-reinforced elastomer construction, with cross section to suit sheave grooves.

Belts shall be matched and measured on a belt-matching machine at the factory or by a factory-authorized distributor. Selection by code numbers, sag numbers, or match numbers is not acceptable. Each belt set shall be bound with wire and tagged with equipment identification.

#### 2.1.6 Motor Bases

Motor shall be provided with adjustable motor bases, except as otherwise specified.

Motors over 5600 watt of power 7-1/2 horsepower with fixed-sheave standard belt section drives shall be provided with adjustable, pivoted motor bases wherever equipment configuration permits proper installation.

#### 2.1.7 Air-Handling System Balancing Provisions

All necessary facilities shall be provided for the adjustment of fan speed for each air-handling system during air-quantity balancing operations. Facilities provided shall be one of the following:

A variable-pitch drive with variable range to produce the fan speed necessary for proper air balance

A continuously variable drive or power unit to produce the fan speed necessary for proper air balance

A series of fixed-pitch pulleys that can be interchanged until the proper fan speed has been determined

#### 2.1.8 Motor Requirements

Motors shall conform to ANSI/NEMA MG 1, Section 26 18 39.00 40 MOTORS and the following requirements.

Motors located in unfiltered airstreams shall be totally enclosed.

\*\*\*\*\*  
NOTE: Indicate any point where exhausted air  
temperature will exceed 100 degrees F 38 degrees C.  
\*\*\*\*\*

Air-over-motor units shall be provided with NEMA-rated Class H insulation for all services where airstream temperature exceeds 38 degrees C 100 degrees F. Air velocity over motor surfaces shall be sufficient to maintain insulation temperatures within NEMA standards at maximum fan horsepower.

Motors used with variable frequency drives (VFDs) shall be rated for VFD use.

#### 2.2 POWER WALL VENTILATORS

Bearing housings shall be manufacturer's standard, unless otherwise specified.

##### 2.2.1 Type CWV-F

Centrifugal wall ventilator shall be provided, with direct drive and nonoverloading, backward-inclined wheel. Drive shall be vibration-isolated with elastomer.

Weather-exposed housing materials shall be Aluminum Association Alloy 3003 with 0.051 millimeter 2-mil dry-film coating of clear acrylic for salt-air service or high-impact plastic with fiberglass reinforcement. All metal

surfaces exposed to airstream shall be aluminum, corrosion-resistant steel, mill-galvanized steel, or cadmium- or zinc-plated carbon steel. Discharge shall be away from building wall. Wheel inlet shall be venturi type. Conduit connection shall be run through housing or through wiring post to permit within-wall electrical connections. Housing shall be removable for external access to fan assembly and other components. An elastomer gasket shall be provided around periphery of housing for watertight construction.

\*\*\*\*\*  
NOTE: Select PWV-F fans through 20 inches 500 millimeter diameter maximum, static pressures through 1/4 inch water gage 62 pascal maximum. Motors operating at speeds less than 1,725 rpm are not suitable for heavy duty.  
\*\*\*\*\*

#### 2.2.2 Type PWV-F

Propeller wall ventilator shall be provided, with square panel and panel-mounted V-belt drive.

Panel shall be painted steel with venturi inlet to wheel. Wheel shall have wide-faced blades. Relationship between drive supports, wheel speed, and number of blades shall be such that fundamental blade frequency is avoided. Drive shall be vibration-isolated with elastomers. A wire backguard constructed of 5 millimeter 3/16-inch wire with not more than 40 millimeter 1-1/2-inch spacing, and with a bright plated or enamel finish, shall be provided.

#### 2.2.3 Type PWVB-F

Propeller wall ventilator shall be provided, with square panel and panel-mounted V-belt drive.

Panel shall be painted steel with venturi inlet to wheel. Panel shall be a minimum of 1.6 millimeter 16-gage for wheel diameters to 1020 millimeter, 2.0 millimeter 40 inches, 14-gage for wheel diameters to 1270 millimeter, or 2.8 millimeter thick 50 inches, or 12-gage for wheel diameters through 1530 millimeter 60 inches. Flanging and reinforcement shall be provided to stiffen panel. Corners shall be welded. Panel and supports shall be phosphatized and finished with high-gloss enamel.

\*\*\*\*\*  
NOTE: Select blade type from the next three paragraphs to suit project requirements with respect to acceptable noise levels, static pressure requirements, and efficiency.  
\*\*\*\*\*

Wheel shall have wide-faced, fabricated, heavy-duty, corrosion-protected blades.

Wheel shall have airfoil-shaped, cast-aluminum, adjustable-pitch blades.

Wheel shall have airfoil-shaped, cast-aluminum, fixed- or adjustable-pitch blades.

Bearing housing of units with power rating over 750 watt over 1 horsepower shall be cast iron.

Relationship between fan-drive supports, wheel speed, and number of blades shall be such that fundamental blade frequency is avoided.

Selection proposed at indicated system resistance shall be such that there is no danger of stalling due to slight system pressure variance.

A wire backguard constructed of 4.8 millimeter 3/16-inch steel wire with not more than 40 millimeter 1-1/2-inch spacing and with bright plated or enamel finish shall be provided, with hinges and latch to enable fan motor servicing.

## 2.3 TYPE TA-F TUBULAR AXIAL FAN

\*\*\*\*\*  
NOTE: Generally selected for static pressures from  
1/4 to 2 inches water gage (wg) 60 to 500 pascal.  
\*\*\*\*\*

Fan shall bear AMCA certified rating seal. Fan shall have a flanged, cylindrical casing with provisions for support requirements indicated.

[Construction shall be spark-resistant in accordance with AMCA 99 and the following:]

\*\*\*\*\*  
NOTE: Select one of the following three paragraphs  
if spark-resistant construction is specified, delete  
all if not applicable.  
\*\*\*\*\*

[Type A - All parts of fan in contact with the air or gas being handled shall be made of nonferrous material.]

[Type B - Fan shall have an entirely nonferrous wheel and a nonferrous ring about the opening through which the shaft passes.]

[Type C - Fan shall be constructed so that a shift of the wheel will not permit ferrous parts of the fan to rub or strike other ferrous parts.]

[Unit shall be direct drive type.]

[Unit shall be V-belt drive type with a sealed enclosure that houses drive components.]

[Weather-exposed motor shall be provided with weatherproof housing.]

[Motor pulley and belts shall be guarded.]

### 2.3.1 Fan Casing

\*\*\*\*\*  
NOTE: Select the following paragraph for type a  
construction. Rewrite to suit size selected.  
\*\*\*\*\*

Casing shall be constructed of not less than 4.3 millimeter thick 8-gage welded or fabricated aluminum.

\*\*\*\*\*  
NOTE: Select the following paragraph for all other  
than type a construction. Rewrite to suit size  
selected.  
\*\*\*\*\*

Casing shall be constructed of not less than 3.5 millimeter thick 10-gage  
welded carbon steel.

\*\*\*\*\*  
NOTE: Delete two of the following three paragraphs.  
Second paragraph is used for belt drive "spray  
booth" design. Third paragraph is used for belt  
drive "clam shell" design.  
\*\*\*\*\*

[Casing shall be fitted with a bolted-panel inspection door.]

[Casing shall be fitted with one hinged and gasketed access door secured  
with quick-acting lug-type closure devices.]

[Casing shall be fitted with two large hinged and gasketed access doors  
secured with quick-acting lug-type closure devices. Wheel, shaft, and  
bearings shall be removable as a unit from the removable, gasketed, inner  
drive enclosure.]

#### 2.3.2 Fan Inlet

\*\*\*\*\*  
NOTE: Select from or delete the following three  
paragraphs.  
\*\*\*\*\*

[Casing shall be fitted with efficient inlet and outlet cones, inlet bell,  
or vortex breaker, where indicated.]

[Fan inlet shall be fitted with a heavy-duty galvanized inlet screen.]

[Fan shall be fitted with variable-inlet vanes, manually adjustable, and  
with provisions for positive position lock.]

#### 2.3.3 Fan Wheel

\*\*\*\*\*  
NOTE: Select the following paragraph for Type A or  
Type B construction.  
\*\*\*\*\*

Wheel shall be constructed of high-strength cast aluminum and shall have  
airfoil blades.

\*\*\*\*\*  
NOTE: Select the following paragraph for Type C  
construction.  
\*\*\*\*\*

Wheel shall be constructed of carbon steel with bronze blade tips, or  
entirely of high-strength cast aluminum with airfoil blades.

\*\*\*\*\*  
NOTE: Do not select for Type C construction.  
\*\*\*\*\*

[Wheel shall be manually adjustable pitch type, constructed of high-strength cast aluminum with airfoil blades.]

[Wheel shall be fixed-pitch or manually adjustable pitch type, constructed of high-strength cast aluminum with airfoil blades.]

\*\*\*\*\*  
NOTE: For high speed fan applications, dynamically balance entire rotating element.  
\*\*\*\*\*

Wheel shall be statically and dynamically balanced to ISO 1940-1, G6,3 [G2.5] [G1.0] [\_\_\_\_\_]. Relationship between drive supports, wheel speed, and number of blades shall be such that fundamental blade frequency is avoided. Wheel hub shall be streamlined, and shaft shall be sealed at drive-enclosure penetration to prevent the entry of particulate matter. Wheel shall be keyed to shaft.

#### 2.4 TYPE VA-F, VANE AXIAL FAN

\*\*\*\*\*  
NOTE: Generally selected for static pressures from 1 inch to 6 inches wg 250 to 1500 pascal, higher efficiency than tube axial.  
\*\*\*\*\*

Fan shall bear an AMCA certified rating seal.

Fan shall have a flanged, cylindrical casing with provisions for support requirements indicated.

[Construction shall be spark-resistant in accordance with AMCA 99 and the following:]

\*\*\*\*\*  
NOTE: Select one of the following three paragraphs if spark-resistant construction is specified.  
\*\*\*\*\*

[Type A - All parts of fan in contact with the air or gas being handled shall be made of nonferrous material.]

[Type B - Fan shall have an entirely nonferrous wheel and a nonferrous ring about the opening through which the shaft passes.]

[Type C - Fan shall be so constructed that a shift of the wheel will not permit ferrous parts of the fan to rub or strike other ferrous parts.]

[Unit shall be direct-drive type.]

[Unit shall be V-belt type with an enclosure covering the drive components.]

[Weather-exposed motor shall be provided with weatherproof housing.]

[Motor pulley and belts shall be guarded.]



#### 2.4.1 Fan Casing

\*\*\*\*\*  
NOTE: Select the following paragraph for Type A construction. Rewrite to suit size selected.  
\*\*\*\*\*

Casing shall be constructed of not less than 4.3 millimeter thick 8-gage welded or fabricated aluminum.

\*\*\*\*\*  
NOTE: Select the following paragraph for all other than Type A construction. Rewrite to suit size selected.  
\*\*\*\*\*

Casing shall be constructed of not less than 3.5 millimeter thick 10-gage welded carbon steel.

Stationary, airfoil-shaped, securely attached guide vanes shall be provided behind fan wheel.

\*\*\*\*\*  
NOTE: Delete two of the following three paragraphs.  
\*\*\*\*\*

[Casing shall be fitted with a bolted-panel inspection door.]

[Casing shall be fitted with one hinged and gasketed access door secured with quick-acting lug-type closure devices.]

[Casing shall be fitted with two hinged and gasketed access doors secured with quick-acting lug-type closure devices. Wheel, shaft and bearings shall be removable as a unit from removable, gasketed, inner drive enclosure.]

#### 2.4.2 Fan Inlet

\*\*\*\*\*  
NOTE: Select type of casing and inlet from the following five paragraphs, delete others.  
\*\*\*\*\*

[Casing shall be fitted with an efficient inlet bell.]

[Casing shall be fitted with efficient inlet and outlet cones.]

[Fan inlet shall be fitted with a heavy-duty galvanized inlet screen.]

[Fan inlet shall be fitted with a vortex breaker.]

[Fan shall be fitted with variable inlet vanes, manually adjustable, and with provisions for positive position lock.]

#### 2.4.3 Fan Wheel

\*\*\*\*\*  
NOTE: Select the following paragraph for Type A or

**Type B construction.**

\*\*\*\*\*

Wheel shall be constructed of high-strength cast aluminum and shall have airfoil blades.

\*\*\*\*\*

**NOTE: Select the following paragraph for Type C construction.**

\*\*\*\*\*

Wheel shall be constructed of carbon steel with bronze blade tips, or entirely of high-strength cast aluminum with airfoil blades.

\*\*\*\*\*

**NOTE: Select from the following three paragraphs to suit project conditions. Do not select for Type C construction.**

\*\*\*\*\*

Wheel shall be manually adjustable pitch type, constructed of high-strength cast aluminum with airfoil blades.

Wheel shall be fixed-pitch or manually adjustable pitch type, constructed of high-strength cast aluminum with airfoil blades.

Adjustable pitch wheels shall have blade angles factory preset to match system characteristics.

\*\*\*\*\*

**NOTE: For high-speed fan applications, rotating element shall be balanced dynamically.**

\*\*\*\*\*

Wheel shall be statically and dynamically balanced to ISO 1940-1, G6,3 [G2.5] [G1.0] [\_\_\_\_\_]. Relationship between drive supports, wheel speed, and number of blades shall be such that fundamental blade frequency is avoided. Wheel hub shall be streamlined, and shaft shall be sealed at drive-enclosure penetration to prevent the entry of particulate matter. Wheel shall be keyed to shaft.

2.5 TYPE TC-F TUBULAR CENTRIFUGAL FAN

\*\*\*\*\*

**NOTE: Generally selected for static pressures to 16 inches wg 4,000 pascal.**

\*\*\*\*\*

Fan shall bear an AMCA certified rating seal.

Fan shall have a flanged cylindrical casing with provisions for support requirements indicated.

[Construction shall be spark-resistant in accordance with AMCA 99 and the following:]

\*\*\*\*\*

**NOTE: Select one of the following three paragraphs if spark resistant construction is specified, delete**

all if not applicable.

\*\*\*\*\*

[Type A - All parts of fan in contact with the air or gas being handled shall be made of nonferrous material.]

[Type B - Fan shall have an entirely nonferrous wheel and a nonferrous ring about the opening through which the shaft passes.]

[Type C - Fan shall be constructed so that a shift of the wheel will not permit ferrous parts of the fan to rub or strike other ferrous parts.]

[Unit shall be direct drive type.]

[Unit shall be V-belt drive type with an enclosure that houses all drive components.]

[Weather-exposed motor shall be provided with weatherproof housing.]

[Motor pulley and belts shall be guarded.]

#### 2.5.1 Fan Casing

\*\*\*\*\*

NOTE: Select the following paragraph for Type A.

\*\*\*\*\*

Casing shall be constructed of not less than 4.3 millimeter thick 8-gage welded or fabricated aluminum.

\*\*\*\*\*

NOTE: Select the following paragraph for all other than Type A construction. Rewrite to suit size selected.

\*\*\*\*\*

Casing shall be constructed of not less than 3.5 millimeter thick 10-gage welded carbon steel. Stationary, airfoil-shaped, securely attached guide vanes shall be provided behind fan wheel.

[Casing shall be fitted with a bolted-panel inspection door.]

[Casing shall be fitted with a hinged and gasketed access door secured with quick-acting lug-type closures.]

#### 2.5.2 Fan Inlet

Casing shall be fitted with an efficient inlet bell.

[Fan inlet shall be fitted with a heavy-duty galvanized inlet screen.]

[Fan shall be fitted with variable-inlet vanes, manually adjustable, and with provisions for positive position lock.]

#### 2.5.3 Fan Wheel

Wheel shall be backward inclined or airfoil blade construction.

\*\*\*\*\*

NOTE: Select the following paragraph for Type A or Type B construction.

Wheel shall be fabricated from high-strength all-welded aluminum.

NOTE: Select the following paragraph for Type C construction.

Wheel shall be fabricated from carbon steel, with high-strength aluminum blade tips.

Fans with carbon-steel wheels shall be fitted with aluminum rub ring in inlet bell.

NOTE: For high-speed fan applications, balance rotating element dynamically.

Wheels shall be statically and dynamically balanced to ISO 1940-1, G6,3 [G2.5] [G1.0] [\_\_\_\_\_]. Shaft shall be sealed at drive-enclosure penetration to prevent the entry of particulate matter. Wheel shall be keyed to shaft.

## 2.6 TYPE CSC-F, CARBON-STEEL CENTRIFUGAL FAN

NOTE: Schedule maximum permissible sound-power rating on drawings.

Sound-power spectrum of fan shall be a smooth curve without peak disturbances. Excessive decibel levels in the critical 125-, 250-, and 500-hertz bands will be sufficient cause for disapproval of fan proposed.

[Duty point of each fan shall be not less than 3 percent to the right of the maximum static efficiency.]

NOTE: Select, delete, or rewrite the following paragraph which covers approximate percentage of fan efficiency: forward curve, 60 to 50; nonoverloading, 70 to 65. Rewrite if provisions for future capacity are required. Coordinate with remainder of specification.

Duty point of centrifugal scroll fans provided shall be within the following requirements:

<u>TYPE FAN WHEEL</u>	<u>PERCENT VOLUMETRIC CAPACITY</u>
Forward curve	50 to 60
Nonoverloading	65 to 75

[Residual fan-wheel imbalance shall not cause peak-to-peak displacement to .075 in/sec where measured at bearing supports of installed fan.]

Shaft first critical speed shall be not less than 20 percent higher than the specified operating fan speed.

Wheels shall be keyed in place. Bearings shall be removable without dismantling fan. Fan inlets shall be streamlined orifice type, bolted to scroll. Scrolls and wheels shall be factory primed and painted, unless otherwise specified. Scrolls containing wheels with diameters 350 millimeter 14 inches and larger shall be fitted with bolted cleanout doors, and all scrolls with wheels 300 millimeter 12 inches in diameter and larger shall be fitted with iron pipe size (ips) threaded and plugged drains.

\*\*\*\*\*  
NOTE: Select or delete for the following paragraph  
single-wheel fans. If Section 23 09 33.00 40  
CONTROL SYSTEMS is not used, insert operator  
requirements herein.  
\*\*\*\*\*

[Automatic, variable inlet vane control shall be provided where indicated. Operator shall be provided under Section 23 09 33.00 40 CONTROL SYSTEMS.]

## 2.7 TYPE CCSC-F, COATED CARBON STEEL CENTRIFUGAL FAN

\*\*\*\*\*  
NOTE: Select the part title and the following  
paragraphs whenever coated carbon steel ducting is  
specified, unless stainless steel, PVC, or FRP fans  
are specified. Indicate or specify which are to be  
coated. Specify AMCA Class II fans for extra  
rigidity. Rewrite the following paragraph if  
material handling wheels will be used.  
\*\*\*\*\*

Fans shall be backward inclined or airfoil blade construction. Each fan shall bear an AMCA certified rating seal and shall be modified in design and construction to provide a substrate suitable for the specified system coating.

\*\*\*\*\*  
NOTE: Select or delete the following paragraph.  
Fans are frequently oversized to reduce wheel  
speeds, especially when pvc plastisols over steel  
are used to prevent coating stripping. Normally  
good 60-mil 1.524 millimeter PVC plastisol coatings  
have 100 percent safety factor over duty-point speed.  
\*\*\*\*\*

Duty point of fan shall be within a range of 65 to 75 percent of volumetric capacity, at not less than 3 percent to the right of maximum static efficiency.

Modifications in design and construction, metal preparation, and components to be finished with protective coatings shall conform to AMCA 99. Metal-surface preparation shall be in accordance with [SSPC SP 5] [SSPC SP 10].

\*\*\*\*\*  
NOTE: Select from the following paragraphs.  
Consider size of equipment and economics.  
\*\*\*\*\*

Shaft shall be AISI Type 316 corrosion-resistant steel and shall be coated. Tetrafluoroethylene (100 percent) packing gland shall be provided at housing penetration.

Shaft first critical speed shall be not less than 25 percent higher than specified operating range of fan.

Preliminary dynamic balancing shall be performed at the factory after coating; final dynamic balancing shall be performed at the job site after systems pressure testing and airflow balancing. Protective coating shall be intact after dynamic balancing.

[Residual and wheel imbalance shall not cause peak-to-peak displacement to .075 in/sec where measured at bearing supports of installed fan.]

Wheels and drive sheaves shall be keyed in place. Bearings shall be removable without dismantling fan. Fan inlets shall be streamlined orifice type, bolted to scroll. Scrolls and wheels shall be factory primed and painted, unless otherwise specified. Scrolls containing wheels with diameters 315 millimeter 12-1/2 inches and larger shall be fitted with bolted cleanout doors and ips threaded and plugged drains.

[Automatic, variable inlet vane control shall be provided where indicated, and shall be coated as specified for fan interior.]

## 2.8 TYPE FRPC-F, FIBROUS GLASS-REINFORCED PLASTIC FAN

\*\*\*\*\*  
NOTE: It is necessary to use proprietary resin descriptions since no standards cover these materials. Burning rate, strength, and chemical resistance characteristics of resins specified are critical to safe construction. Specified resins are available off-the-shelf. Review manufacturers published chemical-resistance literature to assess suitability for use intended, keeping in mind that fabricators modify basic resins to suit their procedures and thus affect resin characteristics.

Following specification is based on buffalo forge fans and cannot be complied with by manufacturers whose fan construction is based on large size, low-speed, low-strength FRP philosophy. There is essentially no published information specifically related to fan laminate design, characteristics, and techniques to accommodate speed, vibration, etc. No manufacturer publishes results of spin tests to destruction.

\*\*\*\*\*

Fans shall be nonoverloading type, with backward curved or airfoil blade construction. Each fan shall bear an AMCA certified rating seal.

### 2.8.1 FRP Laminate Requirements

Fan scroll and wheel shall be solid fibrous glass-reinforced plastic (FRP).

Fibrous glass-reinforced plastic shall be formed by any combination of methods including molding, filament winding, and hand layup to produce a laminate conforming to requirements specified herein.

Resin used for housing construction shall have a burn rating not in excess of 4.0 millimeter per minute 0.15 inch per minute. Resin used for wheel construction shall be chemical resistance to [\_\_\_\_\_] and physical-strength properties that parallel specified values. Low-burning rate of wheel resin may be relaxed in exchange for superior physical strength and chemical resistance. Original manufacturer's resin formulation may be modified to suit the manufacturing process except that: not more than 5 percent of antimony trioxide shall be used; not more than 10 percent of styrene resin, by weight, may be added; and no dyes or pigments shall be added that reduce or tend to reduce the translucency of laminate, thus hindering in-depth inspection. Resin to fibrous glass ratio, by weight, shall be such that the following minimum laminate physical characteristics are provided for service at 79 degrees C 175 degrees F:

<u>TEST METHOD</u>	<u>PROPERTY</u>	<u>VALUE (MEGA pascal)</u>
ASTM D 790	Flexural strength	200
	Compressive strength	16.5
ASTM D 790	Modulus of elasticity flexural	124 by 69
ASTM D 2583	Barcol hardness-45	
<u>TEST METHOD</u>	<u>PROPERTY</u>	<u>VALUE (PSI)</u>
ASTM D 638	Tensile strength	15,500
ASTM D 790	Flexural strength	29,000
	Compressive strength	2,400
ASTM D 790	Modulus of elasticity flexural	18 by 10
ASTM D 2583	Barcol hardness-45	

In general, laminate shall be smooth, dense, and uniform in texture, color, and cross section, and without apparent or latent defects including foreign inclusions, cracks, crazing, pin holes, striations, unsaturated and resin-poor areas, and excessive resin-rich areas. Wheel-laminate acceptable visual defects shall conform to ASTM D 2563, Level 1.

<u>WHEEL DIAMETER (MILLIMETER)</u>	<u>RPM (MAXIMUM)</u>
300	4,400
380	3,600
430	2,970
530	2,470

<u>WHEEL DIAMETER</u> <u>(MILLIMETER)</u>	<u>RPM</u> <u>(MAXIMUM)</u>
600	2,135
700	1,800
790	1,630
890	1,445
970	1,350
1070	1,200
1250	1,000
1420	900

\*\*\*\*\*  
 NOTE: The following requirements increase basic fan  
 cost by 35 to 40 percent. These fans are classed by  
 buffalo as high-speed design and construction.  
 \*\*\*\*\*

<u>WHEEL DIAMETER</u> <u>(INCHES)</u>	<u>RPM</u> <u>(MAXIMUM)</u>
12	4,400
15	3,600
17	2,970
21	2,470
24	2,135
28	1,800
31	1,630
35	1,445
38	1,350
42	1,200
49	1,000
56	900

<u>WHEEL DIAMETER</u> <u>(MILLIMETER)</u>	<u>RPM</u> <u>(MAXIMUM)</u>
300	4,400
380	3,600
430	2,970
530	2,470
600	2,135
700	1,800
790	1,630
890	1,445
970	1,350
1070	1,200
1250	1,000
1420	900

<u>WHEEL DIAMETER</u> <u>(INCHES)</u>	<u>RPM</u> <u>(MAXIMUM)</u>
300	5,000
380	4,140
430	3,355
530	2,790
600	2,400
700	2,070



WHEEL DIAMETER (INCHES)	RPM (MAXIMUM)
790	1,800
990	1,670
970	1,530
1070	1,390
1250	1,170
1420	1,020

## 2.9 TYPE C-F CABINET FANS

\*\*\*\*\*  
**NOTE: Select the following paragraph for low- and medium-pressure (AMCA Class A and Class B) cabinets.**  
 \*\*\*\*\*

Unit cabinet shall be suitable for pressure class indicated and shall have leaktight joints, closures, penetrations, and access provisions. Cabinet shall not expand or contract perceptibly during starting and stopping of fans, and cabinet shall not pulsate during operation. Surface deflections in excess of 1/240th of unsupported span shall be additionally reinforced prior to acceptance by the Contracting Officer. Pulsating panels which produce low-frequency noise due to diaphragming of unstable panel walls shall be stiffened to raise natural frequency to an easily attenuated level. Enclosure shall be fabricated from mill-galvanized or primed and painted carbon-steel sheet of required thickness. Mill-galvanized sheet metal shall conform to **ASTM A 653/A 653M** and shall be coated with not less than **380 gram of zinc per square meter 1.25 ounces of zinc per square foot** of two-sided surface. Mill-rolled structural steel shall be hot-dip galvanized or primed and painted. Cut edges, burns, and scratches in galvanized surfaces shall be corrosion-protected. Primed and painted black carbon-steel cabinet construction shall comply with requirements specified herein.

\*\*\*\*\*  
**NOTE: Select the following paragraph for high-pressure (AMCA Class C) cabinets.**  
 \*\*\*\*\*

Unit cabinet shall be suitable for pressure class indicated, and shall have leaktight joints, closures, penetrations, and access provisions. Cabinet shall not expand or contract perceptibly during starting and stopping of fans, and cabinet shall not pulsate during operation. Surface deflections in excess of 1/360th of unsupported span shall be additionally reinforced prior to acceptance by the Contracting Officer. Pulsating panels which produce low-frequency noise due to diaphragming of unstable panel walls shall be stiffened to raise natural frequency to an easily attenuated level. Enclosure shall be fabricated from mill-galvanized or primed and painted carbon-steel sheet of required thickness. Mill-galvanized sheet metal shall conform to **ASTM A 653/A 653M** and shall be coated with not less than **380 gram of zinc per square meter 1.25 ounces of zinc per square foot** of two-sided surface. Mill-rolled structural steel shall be hot-dip galvanized or primed and painted. Cut edges, burns, and scratches in galvanized surfaces shall be corrosion-protected. Primed and painted black carbon-steel cabinet construction shall comply with requirements specified herein.

\*\*\*\*\*

NOTE: All Carrier Corp. AH units use forward curved blade fans through 22-inch 560 millimeter wheel sizes for pressures to 6 inches wg 1500 pascal. Duty points are selected to the left of the second peak static pressure from shutoff.

Coordinate with drawings schedule.

\*\*\*\*\*

Cabinet fans shall be forward-curved or nonoverloading centrifugal-scroll type, unless otherwise specified. Cataloged fan capacity shall have been determined with fan installed within cabinet. Nonoverloading type shall be backward curved or single- or double-skin airfoil-blade type. Fans shall be selected to avoid instability in service, and shall be constructed so that the relationship of wheel diameter to outlet area conforms to AMCA 99. Forward-curved-blade fans shall, in addition, conform to the following requirements:

Duty point shall be to the right of the second-peak static-pressure point from shutoff and at approximately 60 percent overall efficiency.

\*\*\*\*\*

NOTE: Schedule filter operating pressure range.

\*\*\*\*\*

Forward-curved fans shall operate in a stable manner when filters are dirty and when system dampers respond to automatic environment controls.

[Forward-curved-blade fans shall be used only where fan-wheel diameter is less than 310 millimeter 12-1/4 inches.]

\*\*\*\*\*

NOTE: Outlet area of two fan units is approximately 10 percent greater than equivalent single fan. Review space requirements.

\*\*\*\*\*

Two forward-curved fans shall not be substituted where a single fan is specified or indicated.

[For fan wheel sizes 690 millimeter 27 inches and larger, blades shall be airfoil type.]

Fan wheels, on shafts supported by flanged bearings mounted on the cabinet, shall be balanced after mounting in cabinet.

\*\*\*\*\*

NOTE: Select, delete or rewrite the following paragraph for units which may be subject to mild moisture corrosion.

\*\*\*\*\*

Fan scroll shall be fabricated from mill-galvanized steel. Wheel shall be fabricated from aluminum or mill-galvanized steel and coated with the manufacturer's standard corrosion-protection coating.

## 2.10 SHUTTERS

### 2.10.1 General

\*\*\*\*\*

NOTE: Following materials are suitable for light-duty, normal airstream wall service only. Rewrite or supplement for corrosive airstreams to suit chemical vapors being handled. Schedule types on drawings if more than one selection is made.

Refer to paragraph entitled, "Gravity Backdraft and Relief Dampers," in this section for heavy-duty equipment.

\*\*\*\*\*

Shutters shall be provided where indicated. Shutter frames shall be sealed construction with gaskets and elastomer calk as necessary to prevent bypass.

Minimum distance between fan wheel and shutter shall be 200 millimeter 8 inches, unless otherwise recommended by the manufacturer.

Shutter effective-opening size shall be coordinated with fan wheel size to ensure maximum operating efficiency.

### 2.10.2 Type AS (Automatic Shutter)

Type AS shall be an automatic shutter, opened by fan pressure and closed by gravity, consisting of frame, blades, and linkage. Shafts shall be 4.8 millimeter 3/16-inch diameter, full-blade length. Shaft bearings shall be oil-impregnated bronze or graphite-impregnated nylon. Maximum blade width shall be 100 millimeter 4 inches and maximum blade length shall be 760 to 915 millimeter 30 to 36 inches. Blade edges shall have mechanically retained edge seals. Frames shall be 1.8 millimeter 15-gage mill-galvanized steel.

For velocities to 9 meter per second 1,800 fpm, blades shall be 0.7 millimeter thick, 0.051 millimeter 24-gage, 2-mil dry-film clear acrylic coated, Aluminum Association Alloy 5052 or 6063 aluminum; linkage shall be provided at midpoint of the blade.

For velocities to 13 meter per second 2,500 fpm, blades shall be 0.08 millimeter thick, 0.051 millimeter 22-gage, 2-mil dry-film clear acrylic coated, Aluminum Association Alloy 5052 or 6063 aluminum; two sets of linkage shall be provided for each blade.

### 2.10.3 Type FS (Fabric Shutter)

Type FS shall be fabric shutter, automatically opened by fan pressure and closed by gravity, consisting of frame and two-side chloroprene-coated nylon fabric. Frame shall be not less than 1.6 millimeter 16-gage mill-galvanized steel.

Fabric shall be not less than 0.33 millimeter 0.013 inch thick for velocities to 3 meter per second 500 fpm.

Fabric shall be not less than 0.64 millimeter 0.025 inch thick for velocities between 3 and 6 meter per second 500 and 1,000 fpm.

\*\*\*\*\*  
NOTE: Coordinate type MS selection with Division  
16, "Electrical."  
\*\*\*\*\*

#### 2.10.4 Type MS (Motorized Shutter)

Type MS shall be a motorized shutter, opened and closed by electric motor, consisting of frame, blades and linkage. Shafts shall be 4.8 millimeter 3/16-inch diameter, full-blade length. Shaft bearings shall be oil-impregnated bronze or graphite-impregnated nylon. Maximum blade width shall be 100 millimeter 4 inches and maximum blade length shall be 915 millimeter 36 inches. Blade edges shall have mechanically retained edge seals. Frames shall be 2.0 millimeter thick 14-gage mill-galvanized steel.

For velocities to 9 meter per second 1,800 fpm, blades shall be 0.70 millimeter thick, 0.051 millimeter 24-gage, 2-mil dry-film clear acrylic coated, Aluminum Association Alloy 5052 or 6063 aluminum.

For velocities to 13 meter per second 2,500 fpm, blades shall be 0.08 millimeter thick, 0.0508 millimeter 22-gage, 2-mil dry-film clear acrylic coated, Aluminum Association Alloy 5052 or 6063 aluminum.

Linkage shall preclude distortion of blades under operation.

[Motorized shutters shall be provided for all supply fans. Shutter operating circuit shall have a time-delay relay complete with motor-controller interlocks to ensure full-open shutter position before fan starts.]

#### 2.11 GRAVITY BACKDRAFT AND RELIEF DAMPERS

\*\*\*\*\*  
NOTE: The following specification does not cover  
light-duty equipment.  
\*\*\*\*\*

Frame shall be constructed of not less than 40 by 100 millimeter 1-1/2- by 4-inch, adequately reinforced, 1.6 millimeter 16-gage galvanized carbon steel. Frames and mullions shall be solidly secured in place and sealed with elastomer calking against air bypass.

Blade maximum width shall be 230 millimeter 9 inches, and maximum length shall be 915 millimeter 36 inches. Blade material shall be 1.6 millimeter 16-gage galvanized steel, 2.0 millimeter thick 14-gage Aluminum Association Alloy 6063 or 5052 aluminum, or 1.3 millimeter thick 18-gage AISI 18-8 corrosion-resistant steel. Blades shall be provided with mechanically retained seals and 90-degree limit stops.

Dampers used for relief service shall have blades linked together to open not less than 30 degrees on 12 pascal 0.05-inch water gage differential pressure.

Shaft bearings shall be graphite-impregnated nylon or oil-impregnated bronze.

Counterbalanced dampers shall be equipped with fixed and adjustable counterbalancing weights.

Gravity backdraft dampers in sizes 450 by 450 millimeter 18 by 18 inches or smaller, when furnished integral with air moving equipment, shall be equipment manufacturer's standard construction.

## PART 3 EXECUTION

### 3.1 INSTALLATION

Equipment shall be installed as indicated, as specified herein, and in accordance with manufacturer's recommendations.

Laminates of fans with duty-point operating speeds that do not exceed the wheel diameter and rpm relationship tabulated hereunder shall be classed as standard design and shall be tested and inspected in accordance with the manufacturer's standard procedures. Directly proportional interpolation for different wheel sizes is permissible.

Laminates of fans with duty points that exceed standard design wheel diameter and rpm relationships tabulated above but do not exceed the same relationships tabulated hereunder shall be classed as high-speed design, and in addition to the manufacturer's standard construction, testing, and inspection, shall be subject to minimum special requirements which include: ultrasonic or dye checking of wheel laminates; high tensile filament winding of high-stress wheel areas; and visual inspection of wheel with high intensity light. Proportional variations in wheel sizes are permissible.

Listing of Product Installations shall be submitted for fans showing a minimum of 5 installed units, similar to those proposed for use, that have been in successful service for a minimum period of 5 years. List shall include purchaser, address of installation, service organization, and date of installation.

### 3.2 VIBRATION ANALYZER

Contractor shall use an FFT analyzer to measure vibration levels. It shall have the following characteristics: A dynamic range greater than 70 dB; a minimum of 400 line resolution; a frequency response range of 5 Hz-10 KHz(300-600000 cpm); the capacity to perform ensemble averaging, the capability to use a Hanning window; auto-ranging frequency amplitude; a minimum amplitude accuracy over the selected frequency range of plus or minus 20 percent or plus or minus 1.5 dB.

An accelerometer, either stud-mounted or mounted using a rare earth, low mass magnet and sound disk(or finished surface) shall be used with the FFT analyzer to collect data. The mass of the accelerometer and its mounting shall have minimal influence on the frequency response of the system over the selected measurement range.

### 3.3 ACCEPTANCE

Prior to final acceptance, dial indicator gages shall be used to demonstrate that fan and motor are aligned as specified.

Prior to final acceptance, vibration analysis shall verify conformance to specifications. Vibration levels shall not be more than .075 in/sec at 1 times run speed and at fan/blade frequency, and .04 in/sec at other multiples of run speed.

Final test reports shall be provided to the Contracting Officer. Reports shall have a cover letter/sheet clearly marked with the System name, Date, and the words "Final Test Reports - Forward to the Systems Engineer/Condition Monitoring Office/Predictive Testing Group for inclusion in the Maintenance Database."

#### 3.4 OPERATION AND MAINTENANCE

Contractor shall submit [6] [\_\_\_\_\_] copies of the [Operation and Maintenance Manuals](#) 30 calendar days prior to testing the fan assemblies. Data shall be updated and resubmitted for final approval no later than 30 calendar days prior to contract completion.

Operation and Maintenance Manuals shall be consistent with manufacturer's standard brochures, schematics, printed instructions, general operating procedures, and safety precautions. Test data shall be legible and of good quality.

-- End of Section --