



# Standard Specification for Fiber-Reinforced Plastic Fans and Blowers<sup>1</sup>

This standard is issued under the fixed designation D 4167; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last approval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope \*

1.1 This specification covers centrifugal and axial fans and blowers with airstream components fabricated of fiber-reinforced thermoset plastics (FRP) for corrosion resistance. Internal structures may include encapsulated metal fastening devices, hubs, and shafts.

1.2 Reinforcing materials other than fibrous glass may be used in the fabrication, provided the fans and blowers produced meet all the requirements of this specification.

1.3 The term “fans” as used in this specification includes fans and blowers, both centrifugal and axial.

1.4 The purpose of this specification is to provide users, system designers, specifiers, and manufacturers of FRP fans with minimum standards for fan construction and a common basis for determining safe operating speeds.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information only.

NOTE 1—There is no similar or equivalent ISO standard.

NOTE 2—Appendix X2 contains a list of documents that may be of interest to designers of fan systems.

1.6 *This standard does not pupt to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and helath practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

### 2.1 ASTM Standards:

C 582 Specification for Contact-Molded Reinforced, Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment<sup>2</sup>

D 883 Terminology Relating to Plastics<sup>3</sup>

D 2563 Practice for Classifying Visual Defects in Glass-

Reinforced Plastic Laminate Parts<sup>4</sup>

### 2.2 Other Standards:

AMCA Bulletin 210 Laboratory Methods of Testing Fans for Rating Purposes<sup>5</sup>

ANSI S2.19 Balance Quality of Rotating Rigid Bodies<sup>6</sup>

## 3. Terminology

3.1 *Definitions*—The definitions of terms used in this specification are the same as those found in Terminology D 883.

## 4. Construction of Fan Housings

4.1 *Laminate Construction* shall conform to Specification C 582. The same resin shall be used throughout a housing unless the user and manufacturer agree to use a different resin for the inner surface and interior layer than for the structural layer.

4.1.1 The inner surface exposed to the chemical environment shall be a resin-rich layer 0.010 to 0.020 in. (0.25 to 0.5 mm) thick reinforced with a suitable chemical-resistant glass-fiber surface mat or with an organic-fiber surface mat.

4.1.2 The inner surface layer shall be followed with an interior layer composed of resin reinforced only with noncontinuous glass-fiber strands applied in a minimum of two plies of chopped-strand mat equivalent to a total of 3 oz/ft<sup>2</sup> (0.92 kg/m<sup>2</sup>). As an alternative, a minimum of two passes of chopped roving of minimum length of 0.5 in. (13 mm) to a maximum length of 2.0 in. (50.8 mm) shall be applied uniformly to an equivalent weight of 3 oz/ft<sup>2</sup> (0.92 kg/m<sup>2</sup>). Each ply of mat or pass of chopped roving shall be well rolled prior to the application of additional reinforcement. The combined thickness of the inner surface and interior layer shall not be less than 0.10 in. (2.5 mm).

4.1.3 The structural layer comprises the balance of the housing laminate.

NOTE 3—Although fan housings are subject to vibrational stresses, the design considerations regarding construction of the laminate are similar to those used for static FRP process system components.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D20 on Plastics, and is the direct responsibility of Subcommittee D20.23 on Reinforced Plastic Piping Systems and Chemical Equipment.

Current edition approved Nov. 10, 2002. Published March 2003. Originally approved in 1982. Last previous edition approved in 1997 as D 4167–97.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 08.04.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 08.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 08.02.

<sup>5</sup> Available from Air Movement and Control Association, 30 West University Dr., Arlington Heights, IL 60004.

<sup>6</sup> Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

\*A Summary of Changes section appears at the end of this standard.

4.2 *Fastening Devices*, such as bolts, shall be made of material the user and manufacturer agree is at least as corrosion-resistant to the specified corrosive environment as is the laminate construction, or shall be embedded in a laminate in such a way that the laminate covering the device is reinforced with at least two layers of 1½ oz/ft<sup>2</sup> (4.57 g/m<sup>2</sup>) chopped-strand glass mat and with the same surface finish used in the housing laminate.

4.3 *Gasketing*, used where housings are constructed so that sections or inspection panels are removable, shall be of elastomeric material sufficiently resilient to seal the sections. The gasketing shall be of material the user and manufacturer agree is suitable for the corrosive environment.

4.4 *Housings*, shall have minimum inside corner radii of 0.6 in. (15 mm).

4.5 Suitable housing construction design shall be determined by running the fan at maximum-rated speed with the inlet blocked tight and with an open outlet. The design will be deemed acceptable if the test does not cause any part of the housing to move more than a distance equal to ½ of 1 % of the wheel diameter from the position with the fan not running.

4.6 Where the user determines that system design is such that liquid may collect in housings, the fan housings shall be specified with drains.

## 5. Construction of Fan Wheels

5.1 Where a history of service acceptable to the manufacturer and the user shows that resin systems and joint designs selected for use in the construction of fan wheels are acceptable, destruction tests need not be run. Where acceptable history does not exist, destruction tests shall be performed in accordance with Section 10.

5.2 Defects visible in fan wheels shall be limited to those shown in Table 1 (taken from Practice D 2563 and modified for specific use with fan wheels).

5.3 Metal hubs, fasteners, and shafts shall be made of material at least as corrosion-resistant to the specified corrosive environment as is the laminate construction, or be encapsulated with a laminate reinforced with at least two layers of 1½ oz/ft<sup>2</sup> (45.7 g/m<sup>2</sup>) chopped-strand mat with the same surface finish that is used in the laminate.

5.4 Shafts not made of corrosion-resistant alloy shall be protected by a sleeve of FRP extending out through the fan housing a minimum of 0.4 in. (10 mm) (see Section 7).

5.5 Additives that obscure visual inspection shall be used only in the final surface coat(s) for the purpose of enhancing corrosion resistance or preventing the buildup of static electricity, or both.

5.6 Acceptable surface treatments include the following: resin coating without reinforcement; resin coating with reinforcement, such as glass flakes, graphite, or surface veil; or resin coating reinforced with other materials agreed upon by the fabricator and user. Resins that exhibit air inhibition shall be paraffinated for use in the final coat.

## 6. Spark-Resistant Construction

6.1 Fans built in accordance with this specification will be spark-resistant, providing the outer surface of the wheel and the inner surface of the housing are rendered electrostatically

conductive (Note 4). To be considered acceptably conductive, the surface resistivity between all points of the airstream surface and ground must be no more than 1 MΩ when tested with an insulation resistance tester.<sup>7</sup>

NOTE 4—The user must electrically ground all fan parts in order to maintain spark resistance.

## 7. Shaft-Hole Closures

7.1 Gas flow may be into or out of the shaft holes of the fan housing, depending on pressure distribution in the system and type of fan wheel. The shaft-hole closure shall be one of the following types, as specified by the user:

NOTE 5—The user should determine the importance of restricting gas flow through the shaft holes before selecting the type of closure required.

7.1.1 Shaft encapsulated with an FRP sleeve to at least 0.4 in. (10 mm) outside the fan housing, with the shaft hole no larger than the sleeve diameter plus 0.08 in. (2 mm). (An acceptable alternative is to mount a membrane onto the housing to maintain the 0.08-in. maximum space).

7.1.2 Lubricated lip seals or stuffing boxes must ride on smooth metal shafts or shaft sleeves, necessitating the use of shafts or shaft sleeves made of material selected to withstand the corrosive environment.

## 8. Balancing and Test Running

8.1 The fan manufacturer shall perform one of the following methods of checking balance of wheel/shaft assemblies and complete fans:

8.1.1 Dynamically balance the wheel/shaft assembly as a unit in accordance with ANSI S2.19, Grade 6.3. For example: At 1000 rpm the maximum total residual unbalance of both planes is not to exceed 0.002 lb-in./lb (0.05 g-mm/g) of the total assembly weight.

8.1.2 Run the assembled fan and balance in such a way that the peak-to-peak vibration measured horizontally at the pillow blocks perpendicular to the axis of the shaft will not exceed the following:

8.1.2.1 2.5 mils (0.06 mm) up to 600 rpm,

8.1.2.2 2.0 mils (0.05 mm) up to 900 rpm,

8.1.2.3 1.5 mils (0.04 mm) up to 1200 rpm,

8.1.2.4 1.0 mils (0.025 mm) up to 1800 rpm,

8.1.2.5 0.6 mils (0.015 mm) up to 3000 rpm, and

8.1.2.6 0.5 mils (0.013 mm) above 3000 rpm.

8.2 Balance correction shall be accomplished by one or more of the following methods:

8.2.1 Removal of FRP built onto the wheel for this purpose.

8.2.2 Addition of FRP so that it becomes homogeneous with the wheel by proper surface preparation (normally by grinding away the surface to expose structural fibers) and laminating the necessary weight on so that it blends into the wheel without abrupt changes of contour.

8.2.3 Application of metal weights, where the weights and necessary fasteners are compatible with the corrosive environment.

<sup>7</sup> Available from Amprobe Instrument, Division of Core Industries Inc., 630 Merrick Rd., Lynbrook, NY 11563 and from Yokogawa Corp. of America, 2 Dart Rd., Shenandoah Industrial Park, Newnan, GA 30265-1094.

**TABLE 1 Allowable Defects in the Construction of FRP Fan Wheels (adapted from Practice D 2563)**

Type of Defect	Definition	Degree Allowed
Chip	A small piece broken off an edge or surface	None permitted
Crack	An actual separation of the laminate, visible on opposite surfaces, and extending through the thickness	None permitted
Crack, surface	Crack existing only on the surface of the laminate	None permitted
Crazing	Fine cracks at or under the surface of a laminate	None permitted
Delamination, edge	Separation of the layers of material at the edge of a laminate	None permitted
Delamination, internal	Separation of the layers of material in a laminate	None permitted
Dry spot	Area of incomplete surface film where the reinforcement has not been wetted with resin	0.4-in. (10-mm) diameter and 1/ft <sup>2</sup> (12/m <sup>2</sup> )
Foreign inclusion (metallic)	Metallic particles included in a laminate that are foreign to its composition	0.04-in. (1-mm) diameter and 1/ft <sup>2</sup> (12/m <sup>2</sup> )
Foreign inclusion (nonmetallic)	Nonmetallic particles of substance included in a laminate that seem foreign to its composition	0.04-in. (1-mm) diameter and 1/ft <sup>2</sup> (12/m <sup>2</sup> )
Fracture	Rupture of laminate surface without complete penetration	None permitted
Air bubble (void)	Air entrapment within and between the plies of reinforcement, usually spherical in shape	0.04-in. (1-mm) diameter and 200/ft <sup>2</sup> (2000/m <sup>2</sup> )
Blister	Rounded elevation of the surface of a laminate, with boundaries that may be more or less sharply defined, somewhat resembling in shape a blister on the human skin	None permitted
Burned	Showing evidence of thermal decomposition through some discoloration, distortion, or destruction of the surface of the laminate	None permitted
Fish-eye	Small globular mass that has not blended completely into the surrounding material and is particularly evident in a transparent or translucent material	None permitted
Lack of fillout	An area, occurring usually at the edge of a laminated plastic, where the reinforcement has not been wetted with resin	None permitted
Orange peel	Uneven surface somewhat resembling an orange peel	None permitted
Pimple	Small, sharp, or conical elevation on the surface of a laminate	None permitted
Pit (pinhole)	Small crater in the surface of a laminate, with its width approximately of the same order of magnitude as its depth	0.02 in. (0.5 mm) and 200/ft <sup>2</sup> (2000/m <sup>2</sup> )
Porosity (pinhole)	Presence of numerous visible pits (pinholes)	None permitted
Pre-gel	An unintentional extra layer of cured resin on part of the surface of the laminate. (This condition does not cover gel coats.)	None permitted
Resin pocket	An apparent accumulation of excess resin in a small localized area within the laminate	0.125 by 0.250-in. (3 by 6 mm) and 1/ft <sup>2</sup> (12/m <sup>2</sup> )
Resin-rich edge	Insufficient reinforcing material at the edge of molded laminate	None permitted
Shrink mark (sink)	Depression in the surface of a molded laminate where it has retracted from the mold	None permitted
Wash	Area where the reinforcement of molded plastic has moved inadvertently during closure of the mold resulting in resin-rich areas	None permitted
Wormhole	Elongated air entrapment that is either on or near the surface of a laminate and may be covered by a thin film of cured resin	None permitted
Wrinkles	In a laminate, an imperfection that has the appearance of a wave molded into one or more plies of fabric or other reinforcement material	None permitted
Scratch	Shallow mark groove, furrow, or channel caused by improper handling or storage	None permitted
Short	In a laminate, an incompletely filled out condition Note—This may be evident either through an absence of surface film in some areas, or as lighter unfused particles of material showing through a covering surface film, possibly accompanied by thin-skinned blisters.	None permitted

8.2.4 Application of metal weights and fasteners covered by at least two layers of 1½ oz/ft<sup>2</sup> (45.7 g/m<sup>2</sup>) chopped-strand glass mat with the same surface finish that is used in the laminate.

8.3 In all cases, FRP exposed as in 8.2.1 or applied as in 8.2.2 and 8.2.4, shall be given the same surface treatment as was used in constructing the wheel.

## 9. Fan Aerodynamic Rating and Testing

9.1 Fans shall be tested and rated in accordance with AMCA Bulletin 210.

## 10. Safe Operating Speed

10.1 The variables of cross sections, reinforcement content, resin characteristics, and bonding strength limit the applicabil-

ity of methods such as the use of strain gages, the use of brittle lacquer, and the calculation of wheel stresses. Where a history of service, acceptable to the manufacturer and user, shows that resin systems and joint designs selected for use in the construction of fan wheels are acceptable, destruction tests need not be run. Where a history of service, acceptable to the manufacturer and user, is not available, representative wheels shall be tested to destruction to determine actual failure speeds (see 5.1). Application of a safety factor defines safe operating speed (see 10.1.4).

10.1.1 The test method is performed by running the wheel at slowly increasing speed until failure occurs. Because the major destructive stresses are centrifugal, and not related to fan horsepower, tests can be run in a vacuum for the sake of convenience.

10.1.2 Destruction speed is defined as the speed at which the test is discontinued because of complete or imminent failure.

10.1.3 The failure speed so determined is established in reference to the specific size, construction, and resin system used in the test wheel at 68°F (20°C).

10.1.4 The safe 68°F (20°C) operating speed is a maximum of 58 % of the failure speed. (This is one-third failure stress, or a safety factor of 3:1 on stress.)

10.1.5 The safe operating speed at other temperatures is the speed at 68°F (20°C) multiplied by the square root of the ratio

of the flexural modulus at the elevated temperature to the flexural modulus at 68°F (20°C).

## 11. Nameplates

11.1 Nameplates shall be permanently fastened to the fans and shall carry the following information:

11.1.1 Identification of the fan manufacturer,

11.1.2 Serial or other identifying number, and

11.1.3 Fan size and model.

## 12. Keywords

12.1 axial blowers; centrifugal blowers; fan balancing; fan housing; fan wheel; fiber-reinforced plastic fans (frp); safe operating speed

## APPENDIXES

### (Nonmandatory Information)

#### X1. NFPA REQUIREMENTS

X1.1 Fans may have to conform with National Fire Protection Association (NFPA) Bulletin 91, Blower and Exhaust Systems, Section 510 (available from the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA

02269-9101) depending upon the nature of the fan system. This bulletin should be studied prior to the design of reinforced-plastic duct systems.

#### X2. DOCUMENTS OF POSSIBLE INTEREST TO DESIGNERS OF FAN SYSTEMS

X2.1 *Air Movement and Control Association (AMCA):*<sup>4</sup>

X2.1.1 Bulletin 300, Test Code for Sound Rating Air Moving Devices.

X2.1.2 Bulletin 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.

X2.1.3 Bulletin 201, AMCA Fan Application Manual—Fans and Systems.

X2.1.3.1 Section One defines the usually unmeasurable adverse effects of fan inlet and outlet connections that are other

than those used for rating purposes and which should be included in the system designer's calculations of fan pressure.

X2.1.4 Bulletin 99, Standards Handbook.

X2.1.4.1 Includes definitions of, and standard terminology for, rotation and discharge, drive arrangements, and motor position.

X2.1.5 Standard AMS-2002, Metric Dimensions for Industrial Centrifugal Fans.

X2.1.6 Standard 2402, Sizes for Industrial Centrifugal Fans.

#### X3. GAS DENSITY AT FAN INLET

X3.1 The system designer should note that fans are rated according to fan inlet density. (See AMCA Bulletins 210 and 201). When actual fan inlet density varies from that used for standard ratings [usually 0.075 lb/ft<sup>3</sup>(1.20 kg/m<sup>3</sup>)], it is neces-

sary to make density corrections for fan selection purposes. Gas-stream density may vary because of temperature or system resistance on the inlet side of the fan (the normal situation for FRP fans) and because of chemical composition.

#### **X4. RESIN SELECTION FOR CORROSION RESISTANCE**

X4.1 The selection of resin for corrosion resistance is similar to that for other corrosion-resistant devices, but it should be recognized that the gas-stream surfaces of fans are scrubbed by fumes (perhaps with entrapped or condensed liquid droplets).

#### **SUMMARY OF CHANGES**

Committee D20 has identified the location of the following changes to this standard since the last issue (D 4167-91) that may impact on the use of this standard.

- (1) Added Note 1.
- (2) Added 1.6.

*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or [service@astm.org](mailto:service@astm.org) (e-mail); or through the ASTM website ([www.astm.org](http://www.astm.org)).*