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An American National Standard

# Standard Specification for Fiber-Reinforced Plastic Fans and Blowers[1]

This standard is issued under the fixed designation D4167; 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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 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. It is acceptable for internal structures to include encapsulated metal fastening devices, hubs, and shafts.

1.2 Reinforcing materials other than fibrous glass are acceptable for use 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 known ISO equivalent to this standard.

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

1.6 *This standard does not purport 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 health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

C582 Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment

D883 Terminology Relating to Plastics

D2563 Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts

2.2 *Other Standards:*

AMCA 99 Standards Handbook[3]

AMCA Fan and Air System Applications Handbook (AMCA 200, 201, 202, 203)[3]

AMCA Bulletin 210 Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating[3]

AMCA 300 Reverberant Room Method for Sound Testing of Fans[3]

AMCA 301 Methods for Calculating Fan Sound Ratings from Laboratory Test Data[3]

ACGIH Industrial Ventilation: A Manual of Recommended Practice[4]

NFPA 91 Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids[5]

## 3. Terminology

3.1 *Definitions*—The definitions of terms used in this specification are the same as those found in Terminology D883.

## 4. Construction of Fan Housings

4.1 *Laminate Construction* shall conform to Specification C582. 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 non-continuous glass-fiber strands applied in a minimum of two plies of chopped-strand mat equivalent to a total of 3 oz/ft$^2$ (0.92 kg/m$^2$). As an alternative, a minimum of two passes of chopped roving of minimum length of 0.5 in. (13 mm) to a

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Air Movement and Control Association International, 30 West University Dr., Arlington Heights, IL 60004, http://www.amca.org.

[4] Available from American Conference of Governmental Industrial Hygienists (ACGIH), 1330 Kemper Meadow Dr., Cincinnati, OH 45240, http://www.acgih.org.

[5] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02269, http://www.nfpa.org.

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

maximum length of 2.0 in. (50.8 mm) shall be applied uniformly to an equivalent weight of 3 oz/ft$^2$ (0.92 kg/m$^2$). 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.

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$^2$ (4.57 g/m$^2$) 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 it is possible that liquid will 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 D2563 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$^2$ (45.7 g/m$^2$) 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 (6.1.1). To be considered acceptably conductive, the surface resistivity between all points of the airstream surface and ground shall be no more than 1 MΩ when tested with an insulation resistance tester.[6]

6.1.1 The user shall electrically ground all fan parts in order to maintain spark resistance.

## 7. Shaft-Hole Closures

7.1 It is possible that gas will flow either 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 4—The user needs to 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.

[6] The sole source of supply of the apparatus known to the committee at this time is the Danaher Corporation, 2200 Pennsylvania Avenue, NW, Suite 800W, Washington, DC 20037, to Everett, Washington. Their testers are sold by many companies and can be located on their web site: www.danaher.com. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

**TABLE 1 Allowable Defects in the Construction of FRP Fan Wheels (adapted from Practice D2563)**

| 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$^2$ (12/m$^2$) |
| Foreign inclusion (metallic) | Metallic particles included in a laminate that are foreign to its composition | 0.04-in. (1-mm) diameter and 1/ft$^2$ (12/m$^2$) |
| 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$^2$ (12/m$^2$) |
| 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$^2$ (2000/m$^2$) |
| Blister | Rounded elevation of the surface of a laminate, with boundaries 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$^2$ (2000/m$^2$) |
| 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$^2$ (12/m$^2$) |
| 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 potentially 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<br>Note—It is possible that this will 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 |

8.1.2 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.

8.2.4 Application of metal weights and fasteners covered by at least two layers of 1½ oz/ft$^2$ (45.7 g/m$^2$) 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 210, ANSI/ASHRAE 51, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.

## 10. Safe Operating Speed

10.1 The variables of cross sections, reinforcement content, resin characteristics, and bonding strength limit the applicability 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 fans); FRP; safe operating speed

# APPENDIXES

**(Nonmandatory Information)**

## X1. NFPA REQUIREMENTS

X1.1 Some fans are required to conform with NFPA 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids, depending upon the nature of the fan system. This standard 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):*[3]

X2.1.1 Bulletin 300, *Reverberant Room Method for Sound Testing of Fans*

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

X2.1.3 *Fan and Air System Applications Handbook* (AMCA 200, 201, 202, 203)

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.

X2.2 ACGIH Publicastions. American Conference of Government Industrial Hygienists

X2.2.1 Industrial Ventilation—A Manual of Recommended Practice

## X3. GAS DENSITY AT FAN INLET

X3.1 The system designer should note that fans are rated according to fan inlet density. (See AMCA 210 and AMCA 201). When actual fan inlet density varies from that used for standard ratings [usually 0.075 lb/ft$^3$ (1.20 kg/m$^3$)], it is necessary 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 selected changes to this standard since the last issue (D4167 – 97(2007)) that may impact the use of this standard. (December 1, 2015)

*(1)* Updated standards and other referenced documents.
*(2)* Eliminated obsolete documents.
*(3)* Eliminated non-mandatory language.
*(4)* Eliminated mandatory Note 4 and made it into actual standard text language.