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An American National Standard

Standard Specification for Contact-Molded "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Corrosion Resistant Pipe and Fittings[1]

This standard is issued under the fixed designation D6041; 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 pipe and fittings fabricated by contact molding, for pressures to 150 psi and made of a commercial-grade polyester resin. Included are requirements for materials, properties, design, construction, dimensions, tolerances, workmanship, and appearance.

1.2 This specification does not cover resins other than polyester, reinforcing materials other than glass fibers or fabrication methods other than contact molding.

NOTE 1—For the purposes of this specification, the term polyester resin will include both polyester and vinylester resins.

1.3 This specification does not cover the design of pipe and fittings intended for use with liquids heated above their flash points.

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

1.5 The following precautionary caveat pertains only to Section 10, the test methods portion, of this specification: *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.*

NOTE 2—There is no similar or equivalent ISO Standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C581 Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service

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

D618 Practice for Conditioning Plastics for Testing

D638 Test Method for Tensile Properties of Plastics

D883 Terminology Relating to Plastics

D1599 Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2583 Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor

D2584 Test Method for Ignition Loss of Cured Reinforced Resins

D3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

D3681 Test Method for Chemical Resistance of "Fiberglass" (Glass–Fiber–Reinforced Thermosetting-Resin) Pipe in a Deflected Condition

D5421 Specification for Contact Molded "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Flanges

F412 Terminology Relating to Plastic Piping Systems

2.2 *ANSI Standards:*

B16.1 Cast Iron Pipe Flanges and Flanged Fittings[3]

B16.5 Pipe Flanges and Flanged Fittings[3]

B18.22 Type "B" Narrow Washers[3]

2.3 *National Sanitation Foundation Standard:*

NSF Standard 61 Drinking Water System Components—Health Effects [4]

3. Terminology

3.1 *Definitions:*

3.1.1 *General*—Definitions are in accordance with Terminology D883 and Terminology F412 and abbreviations are in

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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 American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, http://www.nsf.org.

accordance with Terminology D1600, unless otherwise indicated. The abbreviation for reinforced thermosetting resin pipe is RTRP.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *contact molding, n*—a process for molding reinforced plastics in which reinforcement and resin are placed on an open mold or mandrel by either the "hand lay-up"(where resin and glass mat are applied by hand), or the "spray-up" manufacturing processes (where resin and chopped glass fibers are sprayed under pressure), or a combination of the two. The resulting laminate is then consolidated by rolling and cured without the application of pressure.

3.2.2 *fiberglass pipe, n*—a tubular product containing glass fiber reinforcements embedded in or surrounded by cured thermosetting resin. The composite structure may contain granular or platelet fillers, thixotropic agents, pigments, or dyes. Thermoplastic or thermosetting liners may be included.

3.2.3 *polyester, n*—resins produced by the polycondensation of dihydroxy glycols and dibasic organic acids or anhydrides, wherein at least one component contributes ethylenic unsaturation yielding resins that can be compounded with styrol monomers and reacted to give highly crosslinked thermoset copolymers.

3.2.4 *vinyl ester, n*—resins characterized by reactive unsaturation located predominately in terminal positions that can be compounded with styrol monomers and reacted to give highly crosslinked thermoset copolymers.

4. Materials and Manufacture

NOTE 3—Specification C582 provides additional information on the materials and manufacturing of contact–molded laminates.

NOTE 4—Fiberglass pipe intended for use in the transport of potable water should be evaluated and certified as safe for this purpose by a testing agency acceptable to the local health authority. The evaluation should be in accordance with requirements for chemical extraction, taste, and odor that are no less restrictive than those included in National Sanitation Foundation (NSF) Standard 61. The seal or mark of the laboratory making the evaluation should be included on the fiberglass pipe.

4.1 *Resin System:*

4.1.1 The resin used shall be a commercial grade, corrosion-resistant polyester that has been determined to be acceptable for the service either by test, (see Practice C581), or by previous documented service. Where service conditions have not been evaluated a suitable resin may also be selected by agreement between manufacturer and purchaser.

4.1.1.1 The use of one resin in the corrosion barrier and a different resin in the structural layer (see Section 6) is permitted with the acceptance of the purchaser.

4.1.2 *Additives*, such as additional styrene, fillers, dyes, pigments, or flame retardants may be used when agreed upon between the fabricator and purchaser. Thixotropic agents may be added to the resin for viscosity control.

NOTE 5—The addition of fillers, dyes, pigments, flame retardants, and thixotropic agents may interfere with visual inspection of laminate quality.

NOTE 6—Chemical resistance can be affected by the catalyst/promoter system, diluents, dyes, fillers, flame retardants, or thixotropic agents used in the resin.

NOTE 7—Antimony compounds or other fire-retardant agents may be added to halogenated resins for improved fire resistance, if agreed upon between the manufacturer and the purchaser. These compounds do not improve the flame retardancy of non-halogenated resins.

4.1.3 *Ultraviolet Absorbers* may be added for improved weather resistance when agreed upon between the manufacturer and the purchaser.

4.1.4 *Resin Pastes*, used where necessary to fill crevices at joints prior to applying the joint laminate shall not be subject to the limitations of 4.1.3. Pastes shall be made with resin and fillers. The resin used in the paste must be compatible with the resin used in the pipe and fittings.

4.2 *Fiber Reinforcements:*

4.2.1 *Surfacing Mat (Veil)* is a thin mat of fine fibers used primarily to produce a smooth and corrosion–resistant resin––rich surface on a reinforced plastic laminate.

4.2.1.1 Veils are made from chemical resistant (type "C") glass or organic fiber. The use of an organic-fiber surface mat is recommended for environments that attack glass. The veil used in a laminate shall be determined to be acceptable for the chemical service either by Practice C581 or by verified case history.

4.2.1.2 The veil shall be a minimum of 10 mils in dry thickness and produce a thickness of 0.010 to 0.020 in. (0.25 to 0.50 mm) when saturated with resin.

NOTE 8—The primary chemical resistance of the RTR pipe is provided by the resin. In combination with the cured resin, the surfacing veil helps determine the thickness of the resin-rich layer, and reduces microcracking.

4.2.2 *Chopped-strand Reinforcements* shall be "E"-type or "ECR"-type glass fibers 1 to 2 in. (25 to 50 mm) long applied in a uniform layer with random orientation. The fibers shall have a sizing compatible with the selected resin. Chopped strand reinforcements may be purchased and applied as a mat or as continuous strand roving which is chopped into short lengths and sprayed onto the laminate in a process known as "spray up." Either form is most commonly applied in layers weighing 1½ oz/ft ^{2}(450 g/m^2) although other weights are available and may be used.

4.2.3 *Woven Roving*, shall be "E"-type or "ECR"-type glass roving, woven into a fabric. The sizing on the roving shall be compatible with the resin. The most common woven roving has a 5 by 4 weave and a weight of 24 oz/yd^2 (832 g/m^2).

4.2.4 *Non-woven Roving* "E type or "ECR" glass reinforcing fabrics such as biaxials and uni-directionals may be used in special applications such as reinforcing tees and other fittings or to improve the physical properties of the laminate in a specific direction.

4.2.5 *Multiple Layer Reinforcements* are fabrics composed of two or more layers of reinforcement combined into one fabric. The most common form is one layer of 1 ½ oz/ft^2 chopped strand mat combined with one layer of 24 oz/yd^2 woven roving. The pipe manufacturer must use extra caution to ensure proper laminate quality is maintained when using multiple layer reinforcements.

5. Design

5.1 *Design Basis:*

5.1.1 *Class A*—For pipe to be manufactured using Type I or Type II laminates as described in Specification C582, the Ultimate Tensile Stresses shown in Specification C582 may be used for the design basis.

5.1.2 *Class B*—For pipe manufactured with other than Type I or Type II laminates (in accordance with Specification C582), or for Ultimate Tensile Stresses greater than those shown in C582, testing in accordance with 10.5 or 10.6 is required to establish a design basis for each laminate type used by the pipe manufacturer. Testing shall be performed on a sample laminate or pipe of the same type and construction as will be used on the actual pipe and fittings. The thickness of the laminate sample will be ⅜ in. (9.5 mm) or the maximum thickness to be provided in the pipe and fittings, whichever is less. If testing in accordance with 10.6, testing is required in both directions if the reinforcement is not applied equally in both directions. The laminate sample shall not include a corrosion barrier. Laminates greater than ⅜ in. (9.5 mm) thick are to be constructed with standard repeating sequences of reinforcement such as those described in Specification C582. Results from previously tested laminates may be used provided that such laminates were manufactured with the same resin, laminate type, and thickness within the previous five years.

NOTE 9—Reinforcements such as 24 oz/yd^2(832 g/m^2) produced with a 5 by 4 weave are considered equal in both directions for the purpose of 5.1.2.

5.2 *Wall Thickness*—The required wall thickness due to internal pressure shall be determined by the following formula. Other loads such as thermal expansion and bending between supports should also be considered. The minimum wall thickness shall be the greater of 0.18 in. (4.5 mm) or 1 % of the pipe inside diameter.

$$t = \frac{(P*ID)}{(2 * S - P)}$$

where:

t = calculated wall thickness, in. (mm) (see 6.1.2.3),
P = design pressure, psi (kPa),
ID = inside diameter of the pipe, in. (mm),
S = allowable stress (not to exceed 1/6 of the design basis), psi (kPa).

5.3 Standard pressure classes are 25, 50, 75, 100, 125, and 150 psi, however, custom classes are allowed.

NOTE 10—Special design consideration should be given to pipe and fittings subject to vacuum or superimposed mechanical forces, or both, such as earthquakes, wind load, or burial loads, and to pipe and fittings subject to service temperature in excess of 180°F (82°C).

6. Laminates

6.1 *Laminate Construction*—The laminate comprising the pipe wall shall consist of a corrosion barrier comprised of an inner surface and interior layer, a structural layer, and an outer surface.

6.1.1 The *Corrosion Barrier*, consisting of the inner surface and interior layers, shall be included in the total thickness for all design calculations unless otherwise specified.

6.1.1.1 *Inner Surface*—The inner surface exposed to the chemical environment shall be resin-rich and reinforced with at least one layer of a suitable surfacing veil in accordance with 4.2.1. Some chemical environments may warrant the use of a second layer of surfacing veil. This resin-rich inner surface will contain less than 20 % by weight of reinforcing material and have a thickness between 0.010 and 0.020 in. (0.25 to 0.50 mm)

6.1.1.2 *Interior Layer*—The inner surface layer shall be followed with a layer composed of resin reinforced only with noncontinuous glass-fiber strands. This reinforcement shall be applied as chopped strand mat or as chopped roving (spray up process) (either in accordance with 4.2.2) resulting in a minimum reinforcement weight of 1 ½ oz/ft^2(459 g/m^2). The combined thickness of the inner surface and interior layer shall not be less than 0.05 in. Depending on the chemical environment, multiple 1 ½ oz/ft^2(459 g/m^2) layers of chopped strand applied as mat or spray up may be required. Two layers are most commonly used with as many as four or five layers occasionally used in severe environments. When multiple layers are used, each ply of mat or pass of chopped roving shall be well rolled to eliminate all trapped air prior to the application of additional reinforcement. Glass content of the inner surface and the interior layer combined shall be 27 ± 5 % by weight, when tested in accordance with 10.4.

6.1.2 *Structural Layer*—Subsequent reinforcement shall be Type I or Type II or "other" as described below. Types I and II are described in further detail including laminate sequences and thicknesses in Specification C582.

6.1.2.1 *Type I* laminates consist of multiple layers of 1.5 oz/ft^2(0.46 kg/m^2) chopped strand mat or equivalent weight of chopped roving as required to achieve the thickness as calculated according to Section 5. Each successive ply or pass of reinforcement shall be well-rolled prior to the application of additional reinforcement. The exterior surface shall be relatively smooth with no exposed fibers or sharp projections and enough resin shall be present to prevent fiber show.

6.1.2.2 *Type II* laminates consist of multiple layers of 1.5 oz/ft^2(0.46 kg/m^2) chopped strand mat or equivalent weight of chopped roving alternating with layers of 24 oz/yd^2(814 g/m^2) woven or non-woven roving as required to achieve the thickness as calculated according to Section 5. Each successive ply or pass of reinforcement shall be well-rolled prior to the application of additional reinforcement. The exterior surface shall be relatively smooth with no exposed fibers or sharp projections and enough resin shall be present to prevent fiber show.

6.1.2.3 *Other* laminates may consist of similar layers to those used in Types I and II except for the use of different configurations and weights of reinforcements. A common example is the use of ¾ oz/ft^2(230 g/m ^{2}) chopped strand mat in a Type II laminate. Other options include the use of reinforcements listed in 4.2.4 and 4.2.5. Each successive ply or pass of reinforcement shall be well-rolled prior to the application of additional reinforcement. The exterior surface shall be relatively smooth with no exposed fibers or sharp projections and enough resin shall be present to prevent fiber show.

6.1.2.4 With all types of laminate, the first and last layer must be chopped strand mat or spray up, 1 ½ oz/ft^2(460 g/m^2). Interruption of the laminating process to allow the resin to exotherm and cool shall only follow a mat layer and lamination must restart with a mat layer. Adjacent layers of roving reinforcements such as woven or unidirectional roving must be