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An American National Standard

Standard Specification for Glass-Fiber-Reinforced Polyester Underground Petroleum Storage Tanks[1]

This standard is issued under the fixed designation D 4021; 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 glass-fiber-reinforced horizontal, cylindrical, and spherical-type underground tanks for atmospheric pressure storage of petroleum based fuels and oils.

1.2 The values given in parentheses are provided for information purposes only.

1.3 The following safety hazards caveat pertains only to the test method portion, Section 8, of this specification: *This standard does not purport to address all of the safety problems, 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:*

C 33 Specification for Concrete Aggregates[2]

C 581 Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service[3,4]

C 582 Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment[4]

D 471 Test Method for Rubber Property—Effect of Liquids[5]

D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[3]

D 698 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop[6]

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[3]

D 883 Terminology Relating to Plastics[3,4]

D 1600 Terminology for Abbreviated Terms Relating to Plastics[3,4]

D 2583 Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor[7]

D 2584 Test Method for Ignition Loss of Cured Reinforced Resins[7]

D 3299 Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Chemical-Resistant Tanks[4]

F 412 Terminology Relating to Plastic Piping Systems[4]

2.2 *Other Documents:*

ANSI B2.1 American Standard Tapered Pipe Threads[8]

ANSI B16.5 Steel Pipe Flanges, Flanged Valves, and Fittings[8]

ASME Boiler and Pressure Vessel Code Section III, Division I—Sub Section ND[9]

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology D 883 and F 412, and abbreviations with Terminology D 1600, unless otherwise indicated.

3.1.1 *cylinder wall*—that portion of a tank that forms the main body of a tank, and that part that lies horizontal in the ground after installation. (See Fig. 1 for further clarification.)

3.1.2 *fill tubes*—devices attached to a tank to assist in filling. These devices normally attach to a tank top and convey the liquid to or near to the tank bottom.

3.1.3 *fittings*—openings used to provide a means to fill, extract, or vent the contents of a tank.

3.1.4 *lifting device*—hook-on type device attached to a tank to provide means of lifting a tank.

3.1.5 *manways*—entrance ways installed in a tank for the purpose of access into a tank.

3.1.6 *spherical tanks*—tanks that are spherical or near spherical in shape. These tanks may be formed in one piece or may be formed by joining two hemispherical like tank heads together.

3.1.7 *tank heads*—that portion of a tank that closes the ends of the cylinder, making a tank into a container. Each tank has two tank heads. (See Fig. 1 for further clarification.)

4. Materials

4.1 *Resin*—The resin used shall be a commercial-grade unsaturated polyester resin.

4.2 *Reinforcing Materials*—Reinforcing materials shall be commercial "E" type glass in the form of mat, continuous

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[1] This specification is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.23 on Reinforced Plastic Piping Systems and Chemical Equipment (Section D20.23.16).

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 08.01.

[4] *Annual Book of ASTM Standards*, Vol 08.04.

[5] *Annual Book of ASTM Standards*, Vol 09.01.

[6] *Annual Book of ASTM Standards*, Vol 04.08.

[7] *Annual Book of ASTM Standards*, Vol 08.02.

[8] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

[9] Available from American Society of Mechanical Engineers, United Engineering Center, 345 E. 47th St., New York, NY 10017.

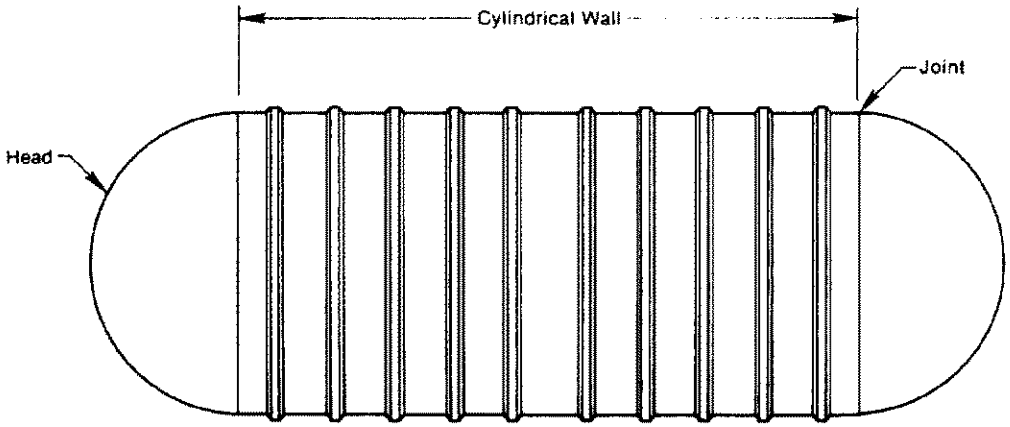


FIG. 1 Typical Tank

roving, chopped roving, or roving fabric, or combination of these, having a coupling agent that will provide a suitable bond between the glass reinforcement and the resin.

4.3 *Surfacing Materials*—If reinforcing material is used on the surface exposed to the contained substance, it shall be a commercial-grade chemical-resistant glass or organic surfacing mat, having a coupling agent that will provide a suitable bond with the resin.

4.4 *Fillers and Additives*—Fillers, when used, shall be inert to the environment and the tank materials of construction. Additives, such as thixotropic agents, catalysts, promoters, etc., may be added as required by the specific manufacturing process to be used to meet this standard. The resulting glass-fiber-reinforced plastic material must meet the requirements of this specification.

5. Manufacture

5.1 One-piece spherical-type tanks, tank cylinders, tank heads, reinforced-plastic flanged and gusseted nozzles, manways, and fill tubes shall be produced from glass-fiber-reinforced plastic, with the construction determined by the particular process of manufacture and configuration. The manufacturing process may include contact-molding, compression-molding, pultrusion, centrifugal-casting, filament-winding, etc., or combination of these processes. Manway covers or manway blinds shall be constructed from steel plate.

5.2 *Lifting Device*—Each tank shall be provided with a means of lifting, by having one or more "hook-on"-type devices attached to the tank.

5.3 *Fittings*—Each tank shall be provided with openings. These openings shall be steel-threaded, glass-fiber-reinforced plastic flanged nozzles, or fiber-reinforced plastic flanged and gusseted nozzles.

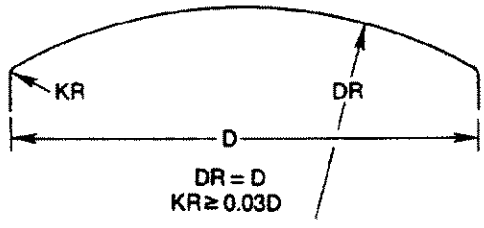


FIG. 2 Standard Dish Tank Head

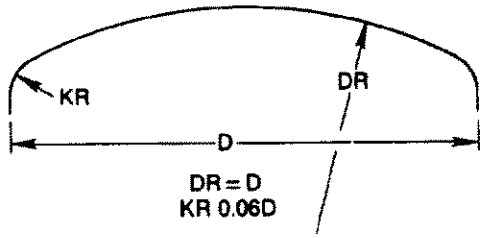


FIG. 3 ASME[12] Dish Tank Head

5.3.1 Fittings may be installed in any location on the tank except at assembly joints, and in any quantity, provided they meet all the requirements of this specification. Care shall be taken to avoid installing fittings at rib locations.

5.4 Fill tubes or other interior projections fixed at the tank "top" shall clear the tank bottom by a minimum of 3 % of the tank inside diameter.

5.5 Manways may be of any shape or size, provided the requirements of this specification are met.

5.6 *Assembly Joints*—Product segments for horizontal cylindrical- and spherical-type tanks may be joined together to form a complete tank. Allowable joint types shall be butt with overlay, and bell-spigot with overlay.

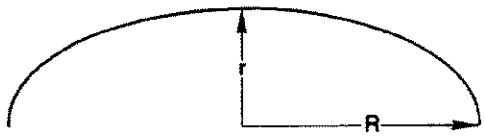
5.7 *Anchor System Loading*—Each tank shall be capable of being anchored.

NOTE 1—The tank anchor system (straps, cables, turnbuckles, etc.) should have the strength of at least 1½ times the maximum uplift force of the empty tank without backfill in place.

6. Requirements

6.1 *Workmanship*—Since underground tanks must exhibit chemical resistance both on the interior and exterior wall, this specification requires similar workmanship for both surfaces, consistent with actual use conditions.

6.1.1 *Interior Surface*—The interior surface shall have no nonwetted or exposed reinforcements, no cracks or crazing, and no blisters. Additionally, no pits, surface porosity, pin holes, pores, chips, or scratches greater than 1/16 in. in depth are permitted; maximum frequency for these visual observations less than 1/16 in. deep shall be less than 20/ft^2. No voids



Major Axis R =
2 Minor Axis r

FIG. 4 Elliptical Tank Head

(entrapped air or bubbles) or encapsulated foreign matter greater than 1/16 in. in depth or greater than 1/2 in. in diameter are allowed.

6.1.2 *Exterior Surface*—The exterior shall have no cracks, crazes greater than 1 in., blisters greater than 1/2 in. in diameter, sharp projections, nonwetted or exposed reinforcement. Additionally, no pits, surface porosity, pin holes, pores, chips, scratches, or foreign matter greater than 1/16 in. in depth are permitted; maximum frequency for these visual observations less than 1/16 in. deep shall be less than 20/ft^2.

NOTE 2—See Specification C 582, Table 5, for definitions.

6.2 *Repairs*—Any tank may be repaired prior to shipment, provided the repaired tank meets all requirements of this specification.

6.3 *Dimensions*—The dimensions shall be as provided in this specification when measured in accordance with 8.3.1.

6.3.1 *Inside Diameter*—Nominal inside diameters shall be 48 in. (1219 mm), 72 in. (1828 mm), 90 in. (2296 mm), 92 in. (2337 mm), 118 in. (2997 mm), 120 in. (3048 mm), and 138 in. (3505 mm). Tolerance shall be ±1 % of nominal inside diameter. Other diameters, as agreed upon between the purchaser and the manufacturer, may be specified.

6.3.1.1 The cylinder wall of the tank may be tapered but shall not exceed 0.5° per side. The taper, if any, shall be additive to the nominal inside diameter.

NOTE 3—The cylinder wall of the tank may have ribs added which will increase the outside diameter substantially.

6.3.2 *Thickness*—The minimum cylinder wall thickness and minimum tank-head thickness shall be 0.20 in. (5 mm).

6.3.3 *Tank Head*—The tank head shall have a knuckle radius (KR) equal to or greater than 0.03 times the head diameter (D), but never less than 1 1/2 in. (38 mm). The tank head radius (DR or HR) shall be equal to or less than the head diameter (D). Typical tank heads are shown in Figs. 2 through 6. Other head shapes are allowed provided all other performance requirements are achieved.

6.3.4 *Steel Fitting Diameters*—Standard threaded steel (NPT) fitting diameters shall be 3/4 in., 1.0 in., 1 1/4 in., 1 1/2 in., 2.0 in., 2 1/2 in., 3.0 in., 4.0 in., 6.0 in., and 8.0 in. Typical tank fittings are shown in Fig. 7.

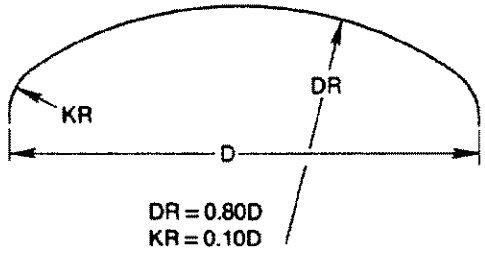


FIG. 5 80-10 Dish Tank Head

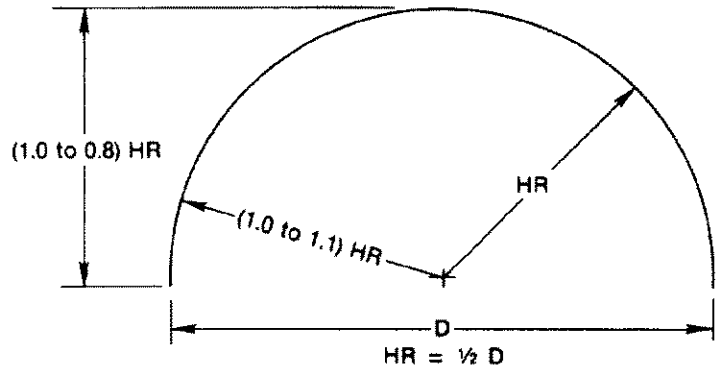


FIG. 6 Hemispherical-Like Tank Head

6.3.5 *Reinforced Plastic Fitting Diameters*—Standard fiberglass reinforced plastic (FRP) flanged fitting diameters shall be 2.0 in., 3.0 in., 4.0 in., 6.0 in., 8.0 in., 10.0 in., 12.0 in., 14.0 in., 16.0 in., 18.0 in., and 20.0 in. Typical FRP flanged fittings are shown in Fig. 7 and dimensions are listed in Tables 1 and 2.

6.4 *External Load Requirements*—The complete tank with fittings, manways, fill tube, etc. attached, shall meet the load requirements when tested in accordance with 8.4.

6.4.1 *Earth Load*—The tank when installed with a 36 ± 3 in. (914 ± 76 mm) cover on top of the tank, shall not leak, fail, or deflect more than 2 % of the unbackfilled, unloaded tank vertical diameter when measured at a fitting near the center of the tank.

6.4.2 The tank when installed with a 36 ± 3 in. (914 ± 76 mm) cover on top of the tank, and with a concentrated load of 22 400 lb (10 168 kg) applied at the surface of the cover, shall not leak, fail, or deflect more than 2 % of the unbackfilled, unloaded tank vertical diameter when measured at a fitting near the center of the tank.

6.4.3 *External Hydrostatic Pressure:*

6.4.3.1 For tanks to be installed at depths of cover to 36 ± 3 in. (914 ± 76 mm) the tank shall withstand, when installed with 36 ± 3 in. (914 ± 76 mm) of cover on top of the tank, an external water-pressure load equal to the diameter of the tank plus 36 ± 3 in. (914 ± 76 mm). This external water pressure shall be held for 24 h. The tank shall not leak, fail, or deflect more than 2 % of the unbackfilled, unloaded tank vertical diameter when measured at a fitting near the center of the tank.

6.4.3.1.1 For tanks to be installed at depths of cover to 36 ± 3 in. (914 ± 76 mm), the tank shall withstand after the 24-h hold detailed in 6.4.3.1, an external water-pressure head-load equal to the diameter of the tank plus 36 ± 3 in. (914 ± 76 mm), and an additional superimposed negative internal pressure of 5.3 in. Hg (18 kPa). The tank shall not leak or fail by other means after holding this superimposed negative internal pressure for 1 min.

6.4.3.2 For tanks to be installed at depths of cover greater than 36 ± 3 in. (914 ± 76 mm), the tank shall withstand when installed with the desired depth in inches ±3 in. (desired depth in millimetres ±76 mm) of cover on the top of the tank, an external water-pressure load equal to the diameter of the tank plus the desired depth of cover. This

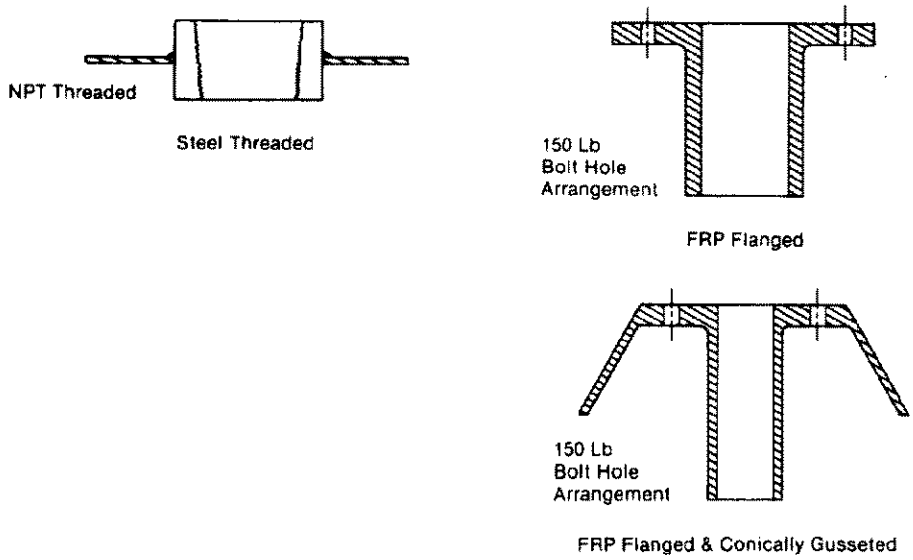


FIG. 7 Typical Tank Fittings

external water pressure shall be held for 24 h. The tank shall not leak, fail, or deflect more than 2 % of the unloaded, unbackfilled tank vertical diameter when measured at a fitting near the center of the tank. As an alternative, the tank shall withstand, when installed with 36 ± 3 in. (914 ± 76 mm) of cover on the top of the tank, an external water-pressure load equal to the tank diameter plus 36 ± 3 in. (914 ± 76 mm) and an additional superimposed negative internal pressure equal to the [(depth of cover in feet − 3 ft) × 0.8826 in. of Hg/ft] ([depth of cover in metres − 0.914 m) × 9.78 kPa/m]). This total external water pressure plus the superimposed negative internal pressure shall be held for 24 h. The tank shall not leak, fail, or deflect more than 2 % of the unbackfilled, unloaded vertical diameter when measured at a fitting near the center of the tank.

6.4.3.2.1 For tanks to be installed at depths of cover greater than 36 ± 3 in. (914 ± 76 mm) the tank shall withstand, after the 24 h hold as detailed in 6.4.3.2, an external water-pressure head equal to the tank diameter plus desired depth of cover in inches ±3 in. (desired depth of cover in millimetres ±76 mm) and an additional superimposed negative internal pressure of 5.3 in. Hg (18 kPa). The tank shall not leak or fail by other means after holding this superimposed negative internal pressure for 1 min. As an alternative, the tank shall withstand after the 24-h hold detailed in 6.4.3.2, an external water-pressure head equal to the tank diameter plus 36 ± 3 in. (914 ± 76 mm) and an additional superimposed negative internal pressure equal to the [(depth of cover in feet − 3 ft) × 0.8826 in. of Hg/ft] ([(depth of cover in metres − 0.914 m) times 9.78 kPa/m]) plus 5.3 in. Hg (18 kPa). The tank shall not leak or fail of other means after holding this superimposed internal pressure for 1 min.

6.5 *Internal Pressure*—Tanks of diameter 120 in. (3048 mm) and less shall withstand 25 psig (172.5 kPa) and tanks greater than 120 in. (3048 mm) in diameter shall withstand

TABLE 1 Pipe for FRP Fittings

NOTE—Pipe wall thicknesses, as outlined in this table, are in accordance with Specification D 3299.

Pipe Size		Minimum Wall Thickness	
in.	mm	in.	mm
Contact-Molded FRP Pipe Minimum Wall Thickness			
2	51	3/16	4.8
3	76	3/16	4.8
4	102	3/16	4.8
6	152	3/16	4.8
8	203	3/16	4.8
10	254	3/16	4.8
12	305	3/16	4.8
14	356	1/4	6.4
16	406	1/4	6.4
18	457	1/4	6.4
20	508	1/4	6.4
Filament-wound FRP Pipe Minimum Wall Thickness			
2	51	0.140	3.6
3	76	0.140	3.6
4	102	0.180	4.6
6	152	0.180	4.6
8	203	0.200	5.1
10	254	0.200	5.1
12	305	0.200	5.1

TABLE 2 Minimum Flange Thickness for FRP Fittings

NOTE 1—These values are based on flat-faced flanges with full-face gaskets suitable for petroleum-based oils and fuels.

NOTE 2—Flange dimensions (except thickness) and bolting conform to ANSI B16.5 for 150-lb steel flanges.

NOTE 2—NOTE 3—Flange thicknesses as outlined in this table are in accordance with Specification D 3299.

NOTE 2—NOTE 4—This table is based on a safety factor of 8 to 1 and a flexural strength of 20 000 psi (140 MPa).

Pipe Size		Minimum Flange Thickness	
in.	mm	in.	mm
2	51	1/2	12.7
3	76	1/2	12.7
4	102	1/2	12.7
6	152	1/2	12.7
8	203	9/16	14.3
10	254	11/16	17.5
12	305	3/4	19.0
14	356	13/16	20.3
16	406	7/8	22.2
18	457	15/16	23.4
20	508	1	25.4

15 psig (103.5 kPa) when tested in accordance with 8.5.

6.6 *Fitting Moment Load Rating*—Fittings 2 in. and smaller shall withstand, without damage, a moment load of 1000 lbf·ft (1356 N·m) and fittings greater than 2 in. shall withstand, without damage, a moment load of 2000 lbf·ft (2712 N·m) when tested in accordance with 8.6. After the test the fitting shall not leak when tested in accordance with 8.8.

6.7 *Fitting Torque Load Rating*—Each installed fitting shall withstand, without damage, the loads in Table 3 when tested in accordance with 8.7. After the test, the fitting shall not leak when tested in accordance with 8.8.

6.8 *Leakage*—When tested in accordance with 8.8, tanks of 120 in. (3048 mm) diameter and less, complete with attachments, shall not leak at a pressure level of 5 psig (34.5 kPa), and tanks greater than 120 in. (3048 mm) diameter, complete with attachments, shall not leak at a pressure level of 3 psig (20.7 kPa).

6.9 *Internal Impact Resistance*—The internal tank wall surface shall withstand, without visible damage, the impact of an 0.8-lb (0.36-kg) steel ball when tested in accordance with 8.9.

6.9.1 After impact with the steel ball as described in 6.9, the tank shall not leak when tested in accordance with 8.8.

6.10 *Lifting Lug Loading*—All lifting lugs must meet or exceed a load rating equal to two times the weight of the empty tank when tested in accordance with 8.10. The tank, as a result of the test, must not leak or suffer other damage. If the tank has more than one lifting device, the devices shall meet the requirement in combination.

6.11 *Negative Pressure*—The tank shall withstand negative pressure of −2.5 psig (−17.3 kPa) when tested in accordance with 8.11.

6.12 *Material Properties*—The following properties shall be established for each type of construction used in the tank using test specimens obtained in accordance with 8.12.

6.12.1 Material composition in percent by weight shall be determined in accordance with 8.12.1.

6.12.2 Flexural strength in the hoop and axial direction shall be determined in accordance with 8.12.2.

6.12.3 Flexural modulus in the hoop and axial direction shall be determined in accordance with 8.12.2.

6.12.4 Surface hardness shall be determined in accordance with 8.12.3. The minimum initial value shall be not less than 90 % of the resin manufacturer's minimum value for the cured resin.

6.13 *Chemical Resistance*—When tested in accordance with 8.13, the log of percent retention of each property after immersion testing, when plotted against the log of immersion time and extrapolated to 100 000 h, shall assure retention of at least 50 % of the initial properties. If at the end of the prescribed testing period, all properties except the barcol hardness meet the above criteria, extension of the testing for an additional six months is required. All properties except barcol hardness at the end of this extended testing period must retain at least 50 % of the initial properties when extrapolated to 100 000 h.

NOTE 4—Chemical testing is conducted to determine the applicability of the tank materials of construction to specific use conditions. It is not considered to be a quality control procedure.

TABLE 3 Fitting Torque Load Requirements

Fitting Size		Torque Load	
in.	mm	lbf·ft	N·m
0.75	19	167	226
1.00	25	200	271
1.25	32	242	328
1.50	38	258	350
2.00	51	275	373
2.25	64	292	396
3.00	76	300	407
4.00	102	317	430
6.00	152	350	475
8.00	203	383	519

7. Quality Control

7.1 *Examination*—Each tank component shall be examined for dimensional requirements, hardness, and workmanship.

7.2 *Leakage*—Each tank shall be tested in accordance with 8.8 to determine conformance with 6.8.

7.3 *Negative Pressure*—Each tank shall be tested in accordance with 8.11 to determine conformance with 6.11.

7.4 *Composition Control*—Controls on glass, resin, fillers, and additives shall be maintained for all manufacturing processes and for each portion of tank fabrication. Records shall be maintained of these control checks. Proper composition may be shown by glass usage checks, by glass and resin application rate checks, or in accordance with the material composition test in 8.12.1.

NOTE 5—Weighing of finished parts and periodic testing for material properties may provide additional assurance of quality.

8. Test Methods

8.1 *Conditioning*—Conditioning of the test specimen is not required unless otherwise specified by the test method referenced. When required, conditioning of the specimen prior to test shall be at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 40 h, in accordance with Procedure A of Methods D 618.

8.2 *Test Conditions*—Tests shall be conducted at ambient temperatures without any special controls on temperature or humidity, unless otherwise specified in the test method referenced.

8.3 *Dimensions:*

8.3.1 Measure dimensions other than thickness with a

TABLE 4 Test Media for Chemical Resistance Test

Interior Surface
ASTM Reference Fuel C (as specified in Method D 471)
Commercial unleaded premium gasoline
Unleaded gasoline, ethyl alcohol 90 to 10 % blend gasohol
No. 2 Fuel Oil
Distilled water
Sodium carbonate-sodium bicarbonate solution (pH = 10)
Potassium biphthalate buffer (pH = 4)
Material to be contained in the tank if other than above.
Exterior Surface
Sodium chloride, saturated solution
Sodium carbonate-sodium bicarbonate solution simulating alkaline soil (pH = 10)
Potassium biphthalate buffer simulating acidic soil (pH = 4)

steel tape with graduations of ⅛ in. (3 mm) or less.

8.3.2 *Thickness*—Measure to the nearest 0.01 in. (0.25 mm) with a micrometer, caliper, gage, or other suitable instrument. Make a minimum of one thickness determination in each 10 ft^2 (1 m^2) of tank wall surface and tank head surface. Through regions of taper, make sufficient checks to establish actual thickness.

8.4 *External Load Tests:*

8.4.1 *Tank Sample*—Test tanks of each diameter used. In the case of tanks with the equal diameter, but of different lengths, testing of the longest tank shall confirm performance of shorter lengths provided the wall thickness is constant. If wall thickness varies with length, test each tank to prove conformance.

8.4.2 *Test Preparation*—Install the tank in a pit large enough to allow a minimum of 12 in. (305 mm) distance from the sides of the pit and the tank surface. The pit may be one with rigid walls, such as concrete, or may be an excavation in the ground with a soil-bearing pressure capacity of greater than 3500 lbf/ft^2 (168 kPa). Determine the depth of the pit by adding to the tank diameter a backfill bed of 12 in. (305 mm) and a backfill cover of 36 ± 3 in. (914 ± 76 mm).

8.4.2.1 The bed, side support, and cover material shall be a naturally rounded aggregate with particle size not less than ⅛ in. or more than ¾ in. (3.2 to 19.0 mm) in diameter and shall be classified as free flowing. As alternatives, either an angular material, clean and free flowing, with particle size not less than ⅛ in. or more than ½ in. (3.2 to 13 mm) in diameter or a clean, well-graded sand with maximum particle size of ⅛ in. (3.2 mm) with no more than 8 % fines passing a 200-mesh sieve may be used. In the case of sand, take care to compact the material to a density of at least 85 % of the maximum, as determined by Test Method D 698. These materials shall meet the requirements of Specification C 33 for quality and soundness.

8.4.2.2 Place the tank on a 12-in. (305-mm) bed composed of the material described in 8.4.2.1. Take care to ensure that the tank is no closer than 12 in. (305 mm) to the sides of the pit.

8.4.2.3 Anchor the tank to prevent float-out during testing. Place the anchoring at the positions provided on the tank.

8.4.2.4 After anchoring, place the material described in 8.4.2.1 around the tank uniformly around to the top of the tank. Take care to ensure that the material is placed under the tank and tank heads.

8.4.2.5 Use the material described in 8.4.2.1 as the cover for the tank and place it to the ground surface or top of the pit. The depth of the cover shall be 36 ± 3 in. (914 ± 76 mm).

8.4.2.6 The tank shall be fitted with a vent, fill tube, and outlet prior to beginning the test.

8.4.3 *Cover Load Test*—Subject the tank to a load imposed by the cover over the top of the tank as described in 8.4.2.5. Measure the change in vertical tank diameter at a fitting near the center of the tank before and after cover.

8.4.4 *Concentrated Load Test*—Subject the tank to a concentrated load of 22 400 lb (10 168 kg). Apply this load to a load-bearing plate 20 by 20 in. (500 by 500 mm) at the top of the cover material. Measure the change in vertical tank diameter at a fitting near the center of the tank.

8.4.5 *External Hydrostatic Pressure Load Test:*

8.4.5.1 For tanks to be installed with 36 ± 3 in. (914 ± 76 mm) of cover, flood the pit with water to a distance 36 ± 3 in. (914 ± 76 mm) above the top of the tank. The tank shall be empty and anchored. Leave the tank in the fully flooded pit for 24 h. Measure the change in vertical diameter at a fitting near the center of the tank.

8.4.5.1.1 For tanks to be installed with 36 ± 3 in. (914 ± 76 mm) of cover, flood the pit with water as described in 8.4.5.1. After the 24 h have elapsed, superimpose a negative internal pressure of 5.3 in. Hg (18 kPa) on the tank and hold for 1 min. At the end of the 1-min hold, terminate the test.

8.4.5.2 For tanks to be installed at depths of cover greater than 36 ± 3 in. (914 ± 76 mm), install the tank in a pit deep

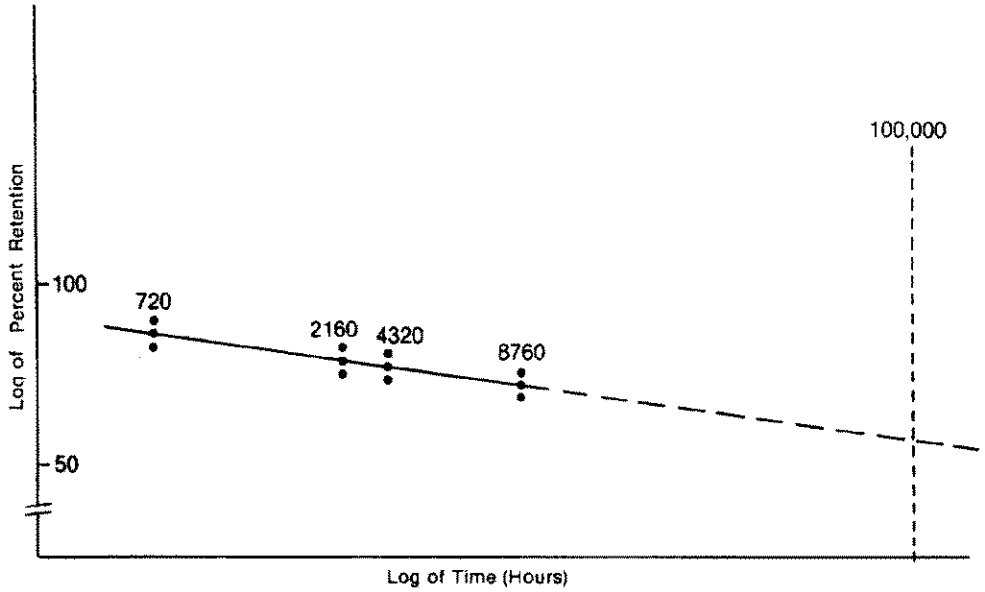


FIG. 8 Chemical Resistance Test Property Retention

enough to allow for the pit to be flooded with water to a height above the top of the tank equal to the depth of cover desired. In this test, the pit should be deep enough to allow for a bed, as described in 8.4.2, plus the depth of cover desired. The tank shall be empty and anchored. Flood the pit with water to a distance equal to the depth of cover desired ± 3 in. (±76 mm). Leave the tank in the fully flooded pit for 24 h. Measure the change in vertical diameter at a fitting near the center of the tank. Alternatively, this test may be run as described in 8.4.5.1 with a superimposed negative internal pressure equal to the (depth of cover in feet − 3 ft) × 0.8826 in. of Hg/ft ([(depth of cover in millimetres − 0.914 m) × 9.78 kPa/m]) added. In this alternative test, maintain both the 36 ± 3 in. (914 ± 76 mm) of water over the top of the tank and the superimposed negative internal pressure for 24 h. Measure the change in vertical diameter at a fitting near the center of the tank.

8.4.5.2.1 For tanks to be installed at depths of cover greater than 36 ± 3 in. (914 ± 76 mm), install the tank as described in 8.4.5.2. After the 24 h have elapsed, superimpose a negative internal pressure of 5.3 in. Hg (18 kPa) on the tank and hold for 1 min. Terminate the test at the end of 1 min.

8.5 *Internal Pressure Tests:*

8.5.1 *Tank Sample*—Test each tank of a specific diameter, wall thickness, or configuration and head thickness, or configuration or combination of these. In the case of tanks with the same diameter but different lengths, testing of the longest tank shall confirm performance of the other lengths, provided the wall thickness is constant.

8.5.2 *Test Procedure*—Test each size of tank to be tested to the required pressure level, holding the pressure for a period of 1 min. Run the test using a pressure gage graduated in increments of 1 psig (6.9 kPa) or less. Failure to hold the required pressure, with a 10 % drop allowed for pressure settlement, is indication of failure. The test may be performed by two different methods, hydrostatic or aerostatic.

8.5.2.1 *Hydrostatic Test (Preferred Method)*—Fill the tank with water and impose an air surcharge to produce the required total pressure. Take care to ensure that the tank is supported in a manner to prevent the development of high bending stresses.

8.5.2.2 *Aerostatic Test*—Place the tank on a horizontal plane surface with no additional support. Take care by performing the test in an isolated area.

8.6 *Fitting Moment Test*—Apply moment loads to tank fittings through a pipe attached to the fitting. The moment arm shall be such that the required loads can be applied in increments of 100 lb (45.4 kg). Apply the loads in at least the tank circumferencial and longitudinal direction.

8.7 *Fitting Torque Test*—Apply torque loads to the tank fittings. Transmit the applied loads to the fittings through a fitting plug attached to the fitting in increments of 50 lb (22.7 kg).

8.8 *Leakage Test*—Subject the tank to an aerostatic test to the required pressure level above ground without special support, using a pressure gage graduated in 0.25-psig (1.75-kPa) increments or less. While holding at the required pressure level, soap the entire tank with a liquid composed of water and leak-test fluid or detergent. After soaping, check the tank visually for leaks, giving special attention to tank openings.

8.8.1 The pressure may drop in this test as the tank makes a temperature adjustment. Do not start the leakage test until the pressure settles and the tank holds the pressure. Make adjustments to the tank pressure to maintain the required pressure during this settling period.

8.9 *Internal Impact Resistance Test*—Bed the tank on a sand bed. Compact the bed well and take care to ensure that the tank bottom is in full contact with the bed. Position an 0.8-lb (0.36-kg) steel ball at a distance equal to the diameter of the tank above the tank bottom. Release the steel ball and allow it to free fall to the tank bottom.

8.10 *Lifting Lug Strength Test*—Test a tank with the lifting lug installed. Place a force to the required level on the lifting lug. Apply this force in a vertical plane, taking care to ensure that no load, other than in the vertical plane, is applied. If the tank has more than one lifting lug, test them in combination with the total load equal to the required load in accordance with the manufacturer's recommendation on spreader bars, etc.

8.11 *Negative Pressure Test*—Perform this test on a tank lying in a horizontal plane without special side support, using a vacuum pump capable of reaching the required negative test pressure and a mercury manometer graduated in increments of 0.1 psig (70 kPa) or less. The test level need only be reached to prove conformance.

8.12 *Material Properties*—Specimens taken from a tank should be used, if possible, to establish material properties. If it is not possible to take the specimens from a tank because of dimensional requirements for testing or the need of flat specimens for strength property tests, the specimens shall be made independently of the tank but, in any case, must be consistent in all respects with the construction of the tank.

8.12.1 *Material Composition*—Determine composition in accordance with Test Method D 2584. For specimens with fillers or additives, or both, separate the residue into its components (glass, sand, etc.) in order to determine the glass content.

8.12.2 *Flexural Strength and Modulus*—Determine the flexural strength and modulus in accordance with Test Method D 790.

8.12.3 *Surface Hardness*—Determine the hardness in accordance with Test Method D 2583. The frequency of checks shall be no less than four random points per component part.

8.13 *Chemical Resistance*—The testing procedure for measuring chemical resistance shall conform to Practice C 581 with the exceptions noted below.

8.13.1 *Test Specimen Construction*—The basic test specimen shall be fabricated in a manner consistent in every way with the tank construction. Factors to be considered include percent glass, type of glass, resin, catalyst system, post-cure, fillers and additives, and whether or not air is excluded from the specimen surfaces during cure.

8.13.1.1 If the specimen is to be tested in an environment simulating a contained substance, a resin-rich layer may be added to the exterior portion of the specimen. This second resin-rich surface, not present in the tank itself, shall be of the same construction and thickness and made with the same considerations, (that is, exclusion of air) as the resin-rich interior surface on the opposite side of the specimen. Where

a dual-resin construction is used, this second resin-rich layer should employ the same resin as the first. Cut edges shall be sealed with the resin used in the resin-rich surfaces.

8.13.1.2 If the specimen is to be tested in an environment simulating soil conditions, it shall be that described in 8.13.1. Cut edges of the specimen shall be sealed with that resin used in the outer surface of the tank.

8.13.2 Test intervals for the specimens shall be determined by test temperature selected. When testing at 37.8°C (100°F) specimens shall be drawn and tested after 1 month, 3 months, and 6 months of immersion in each test medium. When testing at 23°C (73.4 °F) specimens shall be drawn and tested after 1 month, 3 months, 6 months, and 12 months of immersion in each test medium. It may be advisable to include an extra specimen in the test at the time of the initial immersion in the event it becomes necessary to extend the test interval because of inconclusive results. For applications that will require heated fuel or oils, the test interval shall be 1 month, 3 months, and 6 months.

8.13.3 *Test Media*—Test media shall be those specified in Table 4. For application that will require heated fuel or oils, an additional test media shall be the materials stored in the tank.

8.13.4 The temperature for the test media in Table 4 shall be 23 ± 2°C (73.4 ± 3.6°F) or 37.8 ± 2°C (100 ± 3.6°F) and is dependent upon the testing interval selected from 8.13.2. For fuel or oils that require elevated temperatures, testing shall be at least at the maximum service temperature.

8.13.5 *Interpretation of Results:*

8.13.5.1 Properties to be determined initially and after each test period are flexural strength and flexural modulus (both in accordance with Test Method D 790, Method I, Procedure A), and Barcol hardness (in accordance with Test Method D 2583) of both the interior and exterior of the laminate. In the case of soil conditions testing, no exterior Barcol hardness is required. The specimen should be fully cured before initial properties are obtained.

8.13.5.2 Note any effect upon the immersion medium or specimen observed during visual inspection and use to augment physical data determining the suitability of the tank in any given medium.

8.13.5.3 Plot the log of percent retention of each property (see 8.13.5.1) after immersion testing against the log of immersion time in hours (see Fig. 8).

9. Inspection

9.1 Inspection of the material shall be made as agreed upon between the purchaser and the supplier as part of the purchase contract.

10. Rejection and Rehearing

10.1 Tanks that fail to conform to the requirements of this specification may be rejected. Rejection should be reported to the manufacturer or supplier promptly and in writing. In case of dissatisfaction with the results of any test, the manufacturer or supplier may make a claim for a rehearing.

11. Certification

11.1 When requested by the purchaser on his order, a certification shall be made the basis of acceptance. This shall consist of a copy of the manufacturer's test report, or a statement by the supplier, accompanied by a copy of the test results, that the tank has been sampled, tested, and inspected in accordance with the provisions of this specification and meets all requirements. Each certification so furnished shall be signed by an authorized agent of the supplier or manufacturer.

12. Marking

12.1 The tanks shall be marked with the following information:

12.1.1 This ASTM designation.

12.1.2 Manufacturer's name or trademark.

12.1.3 Manufacturing serial number.

12.1.4 Installation instructions (to be printed and adhered, at the manufacturer's option, to the tank. Printing shall be typewritten size or larger).

12.1.5 Warning and caution statements:

12.1.5.1 Keep tank vented,

12.1.5.2 Maximum test pressure, 5 psig or 3 psig,

12.1.5.3 Do not drop tank, and

12.1.5.4 **Caution:** Do not fill before backfilling.