

# Specification for Fiberglass Reinforced Plastic Tanks

API SPECIFICATION 12P  
THIRD EDITION, OCTOBER 2008

EFFECTIVE DATE: APRIL 1, 2009





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## Upstream Segment

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# Specification for Fiberglass Reinforced Plastic Tanks

## 1 Scope

### 1.1 General

This specification covers material, design, fabrication, and testing requirements for fiberglass reinforced plastic (FRP) tanks. Only shop-fabricated, vertical, cylindrical tanks are covered. Tanks covered by this specification are intended for above ground and atmospheric pressure service. Unsupported cone bottom tanks are outside the scope of this specification.

This specification is designed to provide the petroleum industry with various standard sizes of FRP tanks. Because of the versatility of FRP tanks, the user shall be responsible for determining the suitability of FRP tanks for the intended service.

The consequences of exposing the FRP tank to high temperatures created by exposure fires should be considered. This material loses strength as the temperature increases. FRP tanks should be suitably protected against fire exposure or so located that any spills resulting from the failure of these materials could not unduly expose persons, buildings, structures or other equipment to the above.

### 1.2 Compliance

The manufacturer is responsible for complying with all of the provisions of this specification.

## 2 References

ASTM A153 <sup>1</sup>, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

ASTM B454, *Specification for Mechanically Deposited Coatings/Cadmium/Zinc on Ferrous Metals*

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

ASTM D638, *Standard Test Method for Tensile Properties of Plastics*

ASTM D648, *Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position*

ASTM D790, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*

ASTM D2150, *Specification for Woven Roving Glass Fabric for Polyester-Glass Laminates*

ASTM D2583, *Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor*

ASTM D2584, *Standard Test Method for Ignition Loss of Cured Reinforced Resins*

ASTM D2990, *Test Method for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics*

ASTM D3299, *Standard Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks*

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<sup>1</sup> ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, [www.astm.org](http://www.astm.org).

ASTM D4097, *Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermostat Resin Chemical-Resistant Tanks*

SPI<sup>2</sup>, *Recommended Practice for Acoustic Emission Testing of Fiberglass Tanks/Vessels*

### **3 Material**

#### **3.1 General**

Materials listed in this section have been selected to provide adequate strength and reasonable service life.

#### **3.2 Material**

The various materials used in manufacture of tanks furnished to this specification shall be described as composite materials. These composite materials shall consist of thermosetting polymer reinforced with glass fibers. Acceptable polymer resins include polyester resins, epoxy resins, or vinyl ester resins.

#### **3.3 Resin**

The resin used shall be commercial grade thermosetting polymer and shall not contain fillers and pigments, except when required as follows.

A thixotropic agent that will not interfere with visual inspection may be added for viscosity control. The thixotropic agent shall not exceed 5 weight percent. Resin paste used to fill crevices before overlay shall not be subject to these limitations.

Ultraviolet protection shall be provided for the exterior layer for improved resistance to degradation by ultraviolet radiation. After long exposure to ultraviolet radiation, FPR parts will experience surface chalking and discoloration. These effects shall be reduced or eliminated by one of the following:

- a) incorporating UV absorber into the resin—these are incorporated in the external coat at a level of 0.1 to 0.3 weight percent;
- b) pigmenting outer resin layers/pigment to opacity;
- c) painting;
- d) gelcoating (polyester paint).

It must be noted that such additions of any of the above may interfere with visual inspection of laminate quality.

Antimony compounds or other fire retardant agents provide improved fire resistance. Metal powder, carbon, or other types of conductive compounds provide improved conductivity. Additions of such compounds interfere with visual inspection of laminate quality and physical properties of the laminate. The resulting laminate must meet physical properties of this specification.

Resins used for construction of stock tanks which will be used for hydrocarbon or elevated temperature service, must have demonstrated resistance to attack by such hydrocarbons or temperatures. Resistance to attack by hydrocarbons shall be verified by testing in accordance with ASTM C581. Tensile and flexural strength shall be determined at the rated temperature by testing in accordance with ASTM D2990.

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<sup>2</sup> Society of the Plastics Industry, <http://www.plasticsindustry.org/>.

### 3.4 Reinforcing Material

The reinforcing materials shall be a commercial grade of E-type glass fiber having a coupling agent chemically compatible with the resin used. The reinforcing material used to fabricate the tank shall be that used to generate the corrosion resistance and physical property design data required by Section 4.

### 3.5 Surfacing Material

Reinforcing used on the inner surface shall be in compliance with the latest edition of ASTM D3299.

### 3.6 Appurtenances

Woven roving used for reinforcement of knuckles, manways, and other appurtenances shall be tested in compliance with and meet requirements of ASTM D2150.

## 4 Design

### 4.1 General

Standard designs shall have a maximum working pressure equal to the hydrostatic head of the stored fluid plus 6 in. of water column (0.217 psig) and 2 in. of water column vacuum. Design criteria are dependent on method of construction. Filament winding, chop-spray and combinations of these methods (commonly referred to as chop-hoop) are covered in this section. Tanks constructed using hand lay-up (contact molding) shall be designed to the same standard as chop-spray construction. Dimensions shall conform to Figure 3 and Table 1.

### 4.2 Shell Design—Chop-spray

Allowable design tensile stress ( $S_a$ ) shall be 10% of the ultimate stress ( $S_u$ ). Ultimate stress shall be determined in accordance with ASTM D638 for each composite combination used by manufacturer. This test shall be conducted for all standard composite combinations offered by manufacturer. Shell thickness for testing is defined as the structural layer and the exterior layer. Test specimens shall be constructed with resins containing all additives used in the finished product. Minimum shell thickness shall be in accordance with the following design equation but not less than 0.1875 in.

$$t = PD/2S_a \quad (1)$$

where

$t$  is the minimum allowable shell thickness at point where  $P$  is determined, in inches;

$P$  is the pressure exerted by combination of fluid head and gas blanket, psi;

$D$  is the inside diameter of tank, in inches.

### 4.3 Shell Design—Filament Wound and Chop-hoop

Allowable design tensile stress ( $S_a$ ) is that stress which produces 0.001 in./in. tensile strain according to the formula:

$$S_a = 0.001E \quad (2)$$

where

$E$  is the tensile modulus of elasticity, psi, for the particular filament wound laminate in the direction of loading.

Modulus of elasticity and ultimate stress shall be determined in accordance with ASTM D638. This test shall be conducted for each standard composite combination used by manufacturer. Test specimens shall be constructed with resins containing all additives used in the finished product. If  $S_a$  calculated by Equation (2) is greater than 0.10, the ultimate tensile stress, then  $S_a$  becomes  $S_a = 0.10 \times S_u$ . Minimum shell thickness shall be determined using the same Equation (1) as in 4.2 but not less than 0.1875 in.

### 4.4 Shell Design—Laminate Construction

The laminate comprising the structural components (bottom cylindrical shell, deck) shall consist of an inner surface, interior layer, structured layer, and an exterior layer.

#### 4.4.1 Inner Surface Shell

The inner surface shall be between 0.010 in. to 0.020 in. of reinforced resin-rich surface, reinforced with a chemical-resistant glass fiber surface veil or with an organic fiber surface veil as specified in the datasheet. The manufacturer shall provide documentation that material utilized for the inner surface is suitable for the fluid specified in the datasheet. This resin-rich layer shall contain less than 20% by weight of reinforcing material.

#### 4.4.2 Interior Layer

To eliminate weeping, the inner surface exposed to the corrosive environment shall be followed with a layer composed of resin, reinforced only with non-continuous glass-fiber strands applied in a minimum of two piles of chopped-strand mat equivalent to a total of 3 oz/ft<sup>2</sup>. As an alternative, a minimum of two passes of chopped roving of minimum length 0.5 in. to a maximum length of 2.0 in., shall be applied uniformly to an equivalent weight of 3 oz/ft<sup>2</sup>. Each ply of mat or pass of chopped roving shall be rolled prior to the application of additional reinforcement. The combined thickness of the inner surface and interior layer shall not be less than 0.080 in. To prevent weeping, glass content of the inner surface and the interior layer combined shall be 27 ± 5% by weight when tested in accordance with ASTM D2584.

#### 4.4.3 Structural Layer (Chop-hoop, Filament Wound)

Subsequent reinforcement shall be continuous strand roving. The thickness of the structural layer shall be sufficient to provide minimum strength requirements at various tank heights as specified by 4.3. The use of other reinforcement, such as woven fabric, unidirectional fabric, chopped-strand mat, or chopped strands interspersed in the winding provides additional strength. Glass content of this structural layer shall range from 45% to 55% for chop-hoop wound laminates and 50% to 80% for filament wound laminates, when tested in accordance with ASTM D2584.

#### 4.4.4 Structural Layer (Chop-spray)

Subsequent reinforcement shall consist of 1.5 oz/ft<sup>2</sup> chopped strand mat or equivalent weight of chopped roving and such additional number of alternating piles of 24 oz/yd<sup>2</sup> woven roving and 1.5 oz/ft<sup>2</sup> chopped-strand mat or equivalent chopped roving as required to achieve the thickness as calculated according to 4.2. Each successive ply or pass of reinforcement shall be rolled prior to the application of additional reinforcement. Glass content of this structure layer

shall be a minimum of 35% when tested in accordance with ASTM D2584. Alternating layers of directional reinforcement shall be lapped a minimum of 1.5 in. with laps staggered at least 2.25 in. from one layer to the next.

#### 4.4.5 Exterior Layer

Tank shell and deck shall have an exterior layer consisting of chopped strand, chopped-strand mat, or surfacing mat. No glass fibers shall be exposed. Resin used in the exterior layer shall be resistant to ultraviolet degradation. Ultraviolet resistance shall be accomplished as outlined by 3.3.3.

**Table 1—Tank Dimensions (See Figure 3)**

(1) Nominal Capacity bbl	(2) Approximate Working Capacity bbl (See Note)	(3) Inside Diameter ft, in. $\pm$ 1/2 in. A	(4) Height ft, in. $\pm$ 1/2 in. B	(5) Height of Walkways Lugs ft, in. $\pm$ 1/8 in. C	(6) Height of Walkways Lugs ft, in. $\pm$ 1/8 in. D	(7) Location of Fill-line Connection in. $\pm$ 1/8 in. E	(8) Size of Connections in.		(9)
							C-1, C-4	C-3, C-2, C-5, C-6	
90	74	8, 0	10, 0	9, 6	7, 7	14	3	3	
110	96	8, 0	12, 6	12, 0	10, 1	14	3	3	
150	92	8, 0	16, 6	16, 0	14, 1	14	3	3	
150	122	10, 0	10, 6	10, 0	8, 1	14	3	3	
210	185	10, 0	15, 0	14, 6	12, 7	14	3	4	
210	176	12, 0	10, 6	10, 0	8, 1	14	3	4	
250	217	12, 0	12, 6	12, 0	10, 1	14	4	4	
300	267	12, 0	15, 0	14, 6	12, 7	14	4	4	
400	368	12, 0	20, 0	19, 6	17, 7	14	4	4	
500	459	14, 0	18, 6	18, 0	16, 1	14	4	4	
500	445	15, 6	16, 0	15, 6	13, 7	14	4	4	
500	466	12, 0	25, 0	24, 6	22, 7	14	4	4	
750	705	15, 6	24, 0	23, 6	21, 7	14	4	4	
1000	955	15, 6	30, 0	29, 6	27, 7	14	4	4	
1000	935	21, 6	16, 0	15, 6	13, 7	14	4	4	
1500	1438	21, 6	24, 0	23, 6	21, 7	14	4	4	

NOTE The approximate working capacities shown in Column 2 apply to flat-bottom tanks.

#### 4.5 Bottom Knuckle Radius Design

The bottom knuckle shall be reinforced with overlay of glass fiber and resin extending from the flat bottom tangent line upward a minimum of 12 in. with an additional 4 in. of thickness transition. Reinforcement of the knuckle radius shall taper so that it is tangent with the flat bottom and shall not extend beyond the tangent line onto the tank bottom. The reinforced perimeter shall not prevent the bottom from uniformly contacting a flat support surface when liquid covers the bottom inside of the tank. The minimum thickness of this radius section shall be equal to the combined thicknesses of the bottom shell wall and the bottom. The minimum acceptable knuckle radius shall be 2 in. as shown in Figure 1.

#### 4.6 Bottom to Shell Joint (Chop-spray) Design

Where tank bottoms and shells are fabricated separately and joined by use of a laminate bond, the joint shall be of alternating layers of mat (or chopped strand) and 24 oz/yd<sup>2</sup> woven roving. The minimum thickness of this overlay shall be equal to the thickness of the tank shell at the joint. The reinforcement shall meet requirements specified in

Section 6.5 of ASTM D4097. The interior layer of the joint shall be reinforced with at least two layers of 1.5 oz/ft<sup>2</sup> material. The minimum width of this seal joint is 6 in. The inner surface of the joint shall be sealed according to 4.5 of this specification.

#### 4.7 Bottom Strength

Minimum acceptable bottom thickness shall be 0.25 in. for fully supported flat or cone bottoms for tanks of 12 ft diameter or less. For tanks greater than 12 ft in diameter minimum acceptable bottom thickness shall be 0.375 in. Bottom laminate construction shall conform to 4.4, 4.4.1, 4.4.2, and 4.4.4.

#### 4.8 Geometry

The deck shall be ellipsoidal, flanged and dished, or 1.12 pitch conical dome configuration.

Regardless of shape, the deck shall be able to support a concentrated 250 lb load on any single 4 in. × 4 in. area without damage, with a maximum deflection of  $\frac{1}{2}\%$  of the inside tank diameter. The use of stiffener ribs or sandwich construction stiffening systems is acceptable.

#### 4.9 Deck Laminate Construction

Deck laminate construction shall conform to 4.4, 4.4.1, 4.4.2, and 4.4.4. Minimum deck thickness shall be 0.1875 in.

If the tank has a gas blanket installed, the purchaser should consider the option of laminating the interior of the top deck sea (see datasheet).

#### 4.10 Cleanout

Cleanout dimensions and bolting shall conform to dimensions shown in Table 2. Cleanout construction shall conform to ASTM D3299, Table 4. The bottom of the cleanout shall not extend lower than 12 in. from the bottom of the tank.

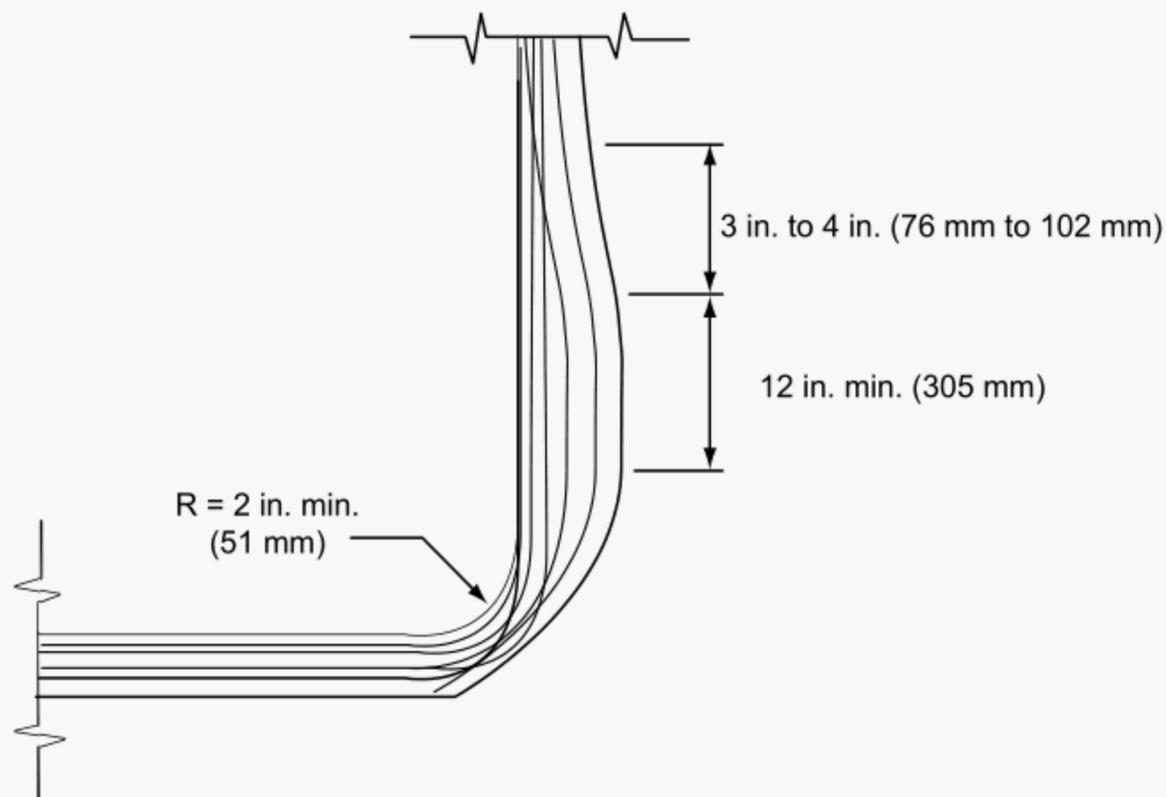


Figure 1—Bottom Knuckle of Flat-bottom Tank

#### 4.11 Nozzles

Standard tanks shall be furnished with nozzles as shown in Figure 3. The size and location of nozzles on “standard” tanks shall conform to Table 1 and Figure 3.

The purchaser may modify the orientation, size, and quantity of nozzles. If the nozzles are changed, the tank shall become a “modified” API tank, and shall be marked as such on the tank label.

Standard nozzles shall be female NPT. The purchaser may specify on the datasheet other types of nozzles see Datasheet 1 and Figure 2 (flanged, grooved, male NPT). Fittings C-1 and C-4 shall be a full coupling design to allow for internal connection (drain and inlet downcomer). All nozzles shall be of the glassed-in type.

**Table 2—Typical Dimensions of Manways**

Side-shell Manway—Up to 15 psig Hydrostatic Head										
Size <sup>a</sup>		Diameter of Flange and Cover		Thickness of Flange and Cover		Diameter of Bolt Circle		No. of Bolts	Bolt Hole Diameter	
in.	(mm)	in. ± 3/32	(mm)	in. ± 1/32	(mm)	in. ± 3/32	(mm)		in. ± 1/32	(mm)
18	(457)	25	(635)	1	(25)	22 3/4	(578)	16	3/4	(19)
20	(508)	27 1/2	(699)	1	(25)	25	(635)	20	7/16	(22)
22	(559)	30	(762)	1	(25)	27	(686)	20	1	(25)
24	(610)	32	(813)	1 1/2	(29)	29 1/2	(749)	20	1	(25)
Side-shell Manway—Up to 15 psig Hydrostatic Head										
Size <sup>a</sup>		Diameter of Flange and Cover		Thickness of Flange and Cover		Diameter of Bolt Circle		No. of Bolts	Bolt Hole Diameter	
in.	(mm)	in. ± 3/32	(mm)	in. ± 1/32	(mm)	in. ± 3/32	(mm)		in. ± 1/32	(mm)
18	(457)	25	(635)	3/8	(10)	22 3/4	(578)	16	1/2	(13)
20	(508)	27 1/2	(699)	3/8	(10)	25	(635)	20	1/2	(13)
22	(559)	30	(762)	3/8	(10)	27	(686)	20	1/2	(13)
24	(610)	32	(813)	3/8	(10)	29 1/2	(749)	20	1/2	(13)

<sup>a</sup> Bolt size = bolt hole diameter minus 1/8 in. (3 mm).

#### 4.12 Cutout Reinforcements

Cutout for nozzles and cleanouts which will bear hydrostatic pressure shall be reinforced on a circular area concentric with the cutout. The thickness of the reinforcement ( $T_r$ ) in inches shall be determined as follows:

$$T_r = PDK/2S_a \quad (3)$$

where

$K$  is 1.0 for nozzles 6 in. in diameter and larger or  $d/(d_r - d)$  for nozzles less than 6 in. diameter;

$d$  is the nozzle outside diameter, inches;

$d_r$  is the reinforcement diameter, inches =  $2 \times d$  for nozzles 6 in. or larger or  $d + 6$  for nozzles less than 6 in.;

$P$  is the hydrostatic pressure at the point of nozzle installation in psi;

$D$  is the inside diameter of the tank in inches;

$S_a$  is the allowable tensile stress in psi (see 4.3).

For  $T_r < 1/8$  in., no additional reinforcement shall be required other than the overlay for glassed-in nozzles.

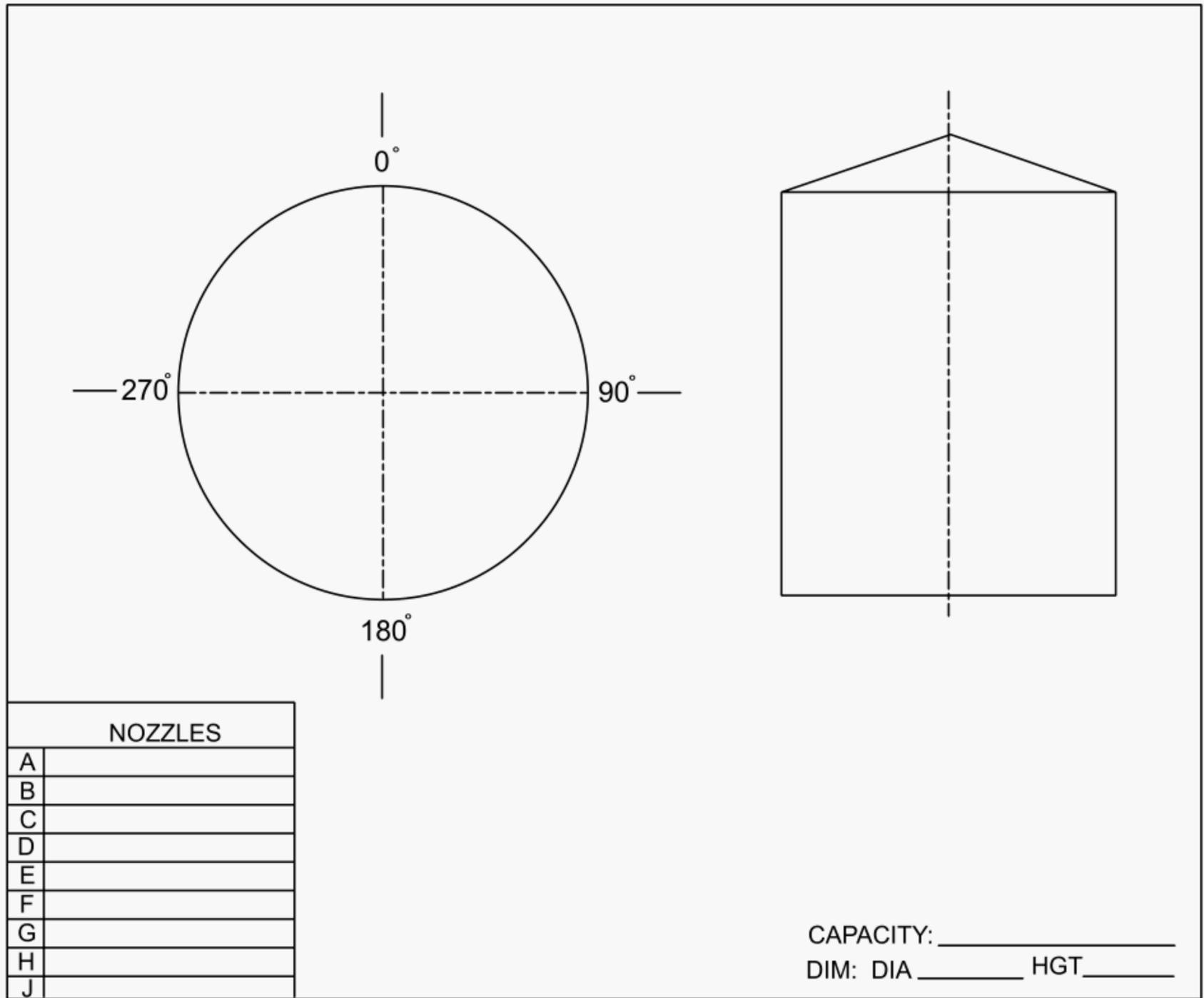


Figure 2—FRP Tank Nozzle Location Guide (Used with Datasheet)

**Datasheet 1**  
**General Information**

Company \_\_\_\_\_  
 Lease \_\_\_\_\_  
 Field \_\_\_\_\_ Approx. Location \_\_\_\_\_  
 Estimate No \_\_\_\_\_ Inquiry No \_\_\_\_\_  
 Requisition No \_\_\_\_\_  
 Contact \_\_\_\_\_ Phone No \_\_\_\_\_  
 Cost Estimate Only \_\_\_\_\_ [ ] For Purchase \_\_\_\_\_ [ ]  
 Inquiry Date \_\_\_\_\_ Required Date \_\_\_\_\_

**Specifications**

API 12P with API Monogram [ ] Yes [ ] No  
 [ ] Standard API [ ] Modified API

Number of Units Required \_\_\_\_\_  
 Capacity \_\_\_\_\_  
 Diameter \_\_\_\_\_ Height \_\_\_\_\_  
 Style of Top [ ] Cone [ ] Dome [ ] Flat [ ] Other  
 Style of Bottom [ ] Flat [ ] Cone [ ] Other  
 Type of Fluid \_\_\_\_\_  
 Specific Gravity \_\_\_\_\_ Design Vacuum \_\_\_\_\_  
 Maximum Operating Pressure \_\_\_\_\_  
 Maximum Operating Temperature \_\_\_\_\_  
 Testing Requirements: Standard [ ] Other \_\_\_\_\_

Wind Load [ ] Yes [ ] No \_\_\_\_\_ MPH  
 Snow Load [ ] Yes [ ] No \_\_\_\_\_ PSF  
 Resin Temperature Rating [ ] 150°F [ ] 170°F [ ] 190°F Plus  
 Liner [ ] \_\_\_\_\_ Mil. C-Veil [ ] \_\_\_\_\_ Mil. Nexus [ ] Other \_\_\_\_\_  
 UV Protection [ ] UV Inhibitor [ ] Pigmenting [ ] Gelcoating  
 [ ] Painting [ ] Other \_\_\_\_\_  
 Tank Color [ ] Natural [ ] Other \_\_\_\_\_  
 Fire Retardants [ ] Yes [ ] No  
 Grounding Ground Rod [ ] Yes [ ] No Type \_\_\_\_\_  
 Carbon C-Veil [ ] Yes [ ] No  
 Other \_\_\_\_\_

Downcomer Pipe [ ] Yes [ ] No Type \_\_\_\_\_  
 Nozzle Location [ ] Per Figure 3 of API 12P or [ ] "Modified"  
 Nozzles [ ] Threaded [ ] Grooved [ ] Flanged [ ] Gusseted Flanges  
 Manway [ ] 18 in. [ ] 20 in. [ ] 22 in. [ ] 24 in. Quantity \_\_\_\_\_  
 Walkway Brackets [ ] Painted Steel [ ] Galvanized Steel  
 Lifting Lugs [ ] Painted Steel [ ] Galvanized Steel  
 [ ] Fiberglass [ ] Stainless Steel

Thief Hatch Model \_\_\_\_\_  
 Pressure \_\_\_\_\_ Vacuum \_\_\_\_\_  
 Plastic Trim [ ] Yes [ ] No Type \_\_\_\_\_

Pipe Support Brackets [ ] Yes [ ] No Quantity \_\_\_\_\_  
 Insulation [ ] Yes [ ] No Type \_\_\_\_\_  
 Heat Tracing [ ] Yes [ ] No  
 Ladder [ ] Yes [ ] No  
 [ ] Fiberglass [ ] Painted Steel [ ] Galvanized Steel  
 Caged Ladder (OSHA) [ ] Yes [ ] No  
 [ ] Fiberglass [ ] Painted Steel [ ] Galvanized Steel  
 Tie Down Lugs [ ] Yes [ ] No  
 [ ] Painted Steel [ ] Galvanized Steel  
 [ ] Fiberglass [ ] Stainless Steel

Interior Top Seam Laminated [ ] Yes \* [ ] No  
 Striker Plate [ ] Yes [ ] No  
 Stairway Required [ ] Yes [ ] No  
 [ ] Galvanized [ ] Painted  
 Length \_\_\_\_\_ ft \_\_\_\_\_ in. Width \_\_\_\_\_ ft \_\_\_\_\_ in.

Walkway Required [ ] Yes [ ] No  
 [ ] Galvanized [ ] Painted  
 Length \_\_\_\_\_ ft \_\_\_\_\_ in. Width \_\_\_\_\_ ft \_\_\_\_\_ in.

Enclosed Nozzle Orientation Drawing [ ] Yes [ ] No  
 Walkway/Stairway/Ladder Drawing [ ] Yes [ ] No

\* Suggested if tank is to have a gas blanket.

### 4.13 Appurtenances

Nozzles, cleanouts, and other appurtenances shall be installed in accordance with 4.14. Installation laminates shall meet minimum standards shown in Figure 5 and Figure 6 of ASTM D3299.

FRP flanged nozzle construction and design shall conform to ASTM D3299, Table 4. Flange drilling and bolting shall conform to ANSI B16.5 for Class 150 flat faced flanges.

All fittings below liquid level shall be reinforced internally with at least two layers of 1.5 oz/ft<sup>2</sup> mat. The inner surface shall be sealed according to 4.4.1 of this specification.

### 4.14 Walkway, Ladder, Lifting and Hold Down Lugs

The manufacturer shall demonstrate by physical test that all lugs are capable of withstanding two times the allowable service load. The service load for each lifting lug equals the empty weight of the tank. Lugs shall not be installed by the use of fasteners that penetrate the shell. Walkway and ladder loads are specified in Annex B.

If hold-down (wind anchorage) lugs are specified by purchaser, the manufacturer shall use ANSI A58.1 to calculate wind loads. Hold-down lugs shall be placed on the tank so they do not protrude below the bottom surface of the tank.

### 4.15 Downcomer Pipe

A conductive downcomer pipe shall be installed when specified in the datasheet.

### 4.16 Thief Hatches

Thief hatch pressure and vacuum ratings shall be in accordance with the design conditions (see 4.1). Bolt patterns shall conform to one of those shown in Figure 4. A grounding lug shall be installed on the thief hatch for grounding purposes. The lug size shall accommodate the attachment of a No. 4 wire. A striker plate consisting of a minimum of 0.1875 in. × 16 in. × 16 in. steel material shall be laminated to the tank bottom directly below the thief hatch.

### 4.17 Design Considerations for Potential Electrostatic Hazards

The electrostatic hazards which might arise when filling or emptying FRP tanks may be divided into two parts:

- 1) that due to the accumulation of charge on the outside of the tank;
- 2) that due to the build-up of electric field inside the tank.

To minimize the risk in the first type of hazard, it is recommended that the thief hatch be connected to electrical ground. It is also recommended that any metallic walkway, stairway, or ladder attached to an FRP tank be connected to electrical ground.

To minimize risk of the second type of hazard there are several different options to consider. As in metal tanks, the primary method utilized to minimize charge accumulation inside the tanks is to limit flow rates until the filling pipe is covered. The use of conductive metallic downcomers shall also be considered. Conductive tank materials used in tank construction and properly grounded can also be utilized as specified in datasheet. In severe cases the use of a suspended conductor within the tank can be used (see Figure 5).

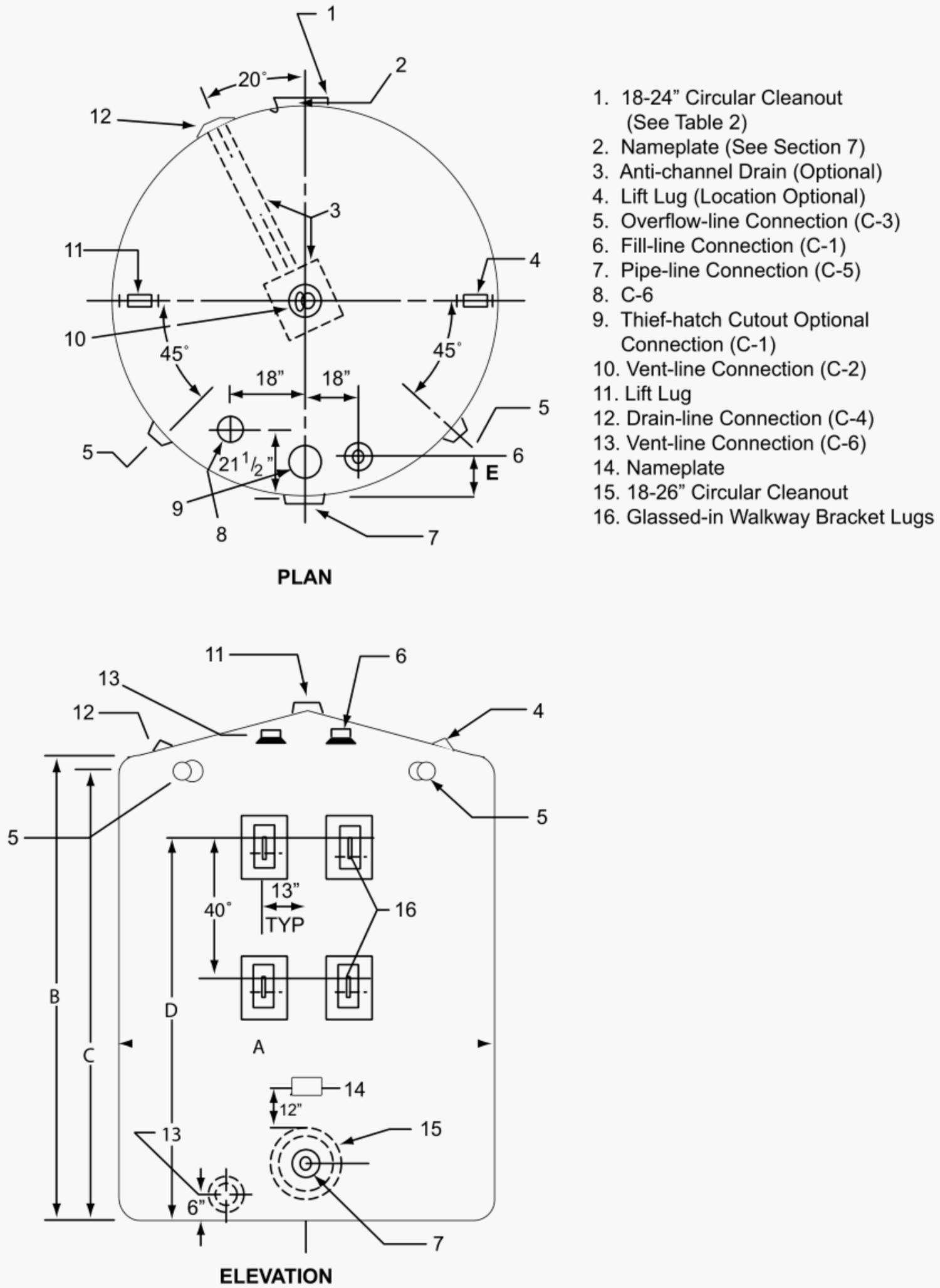
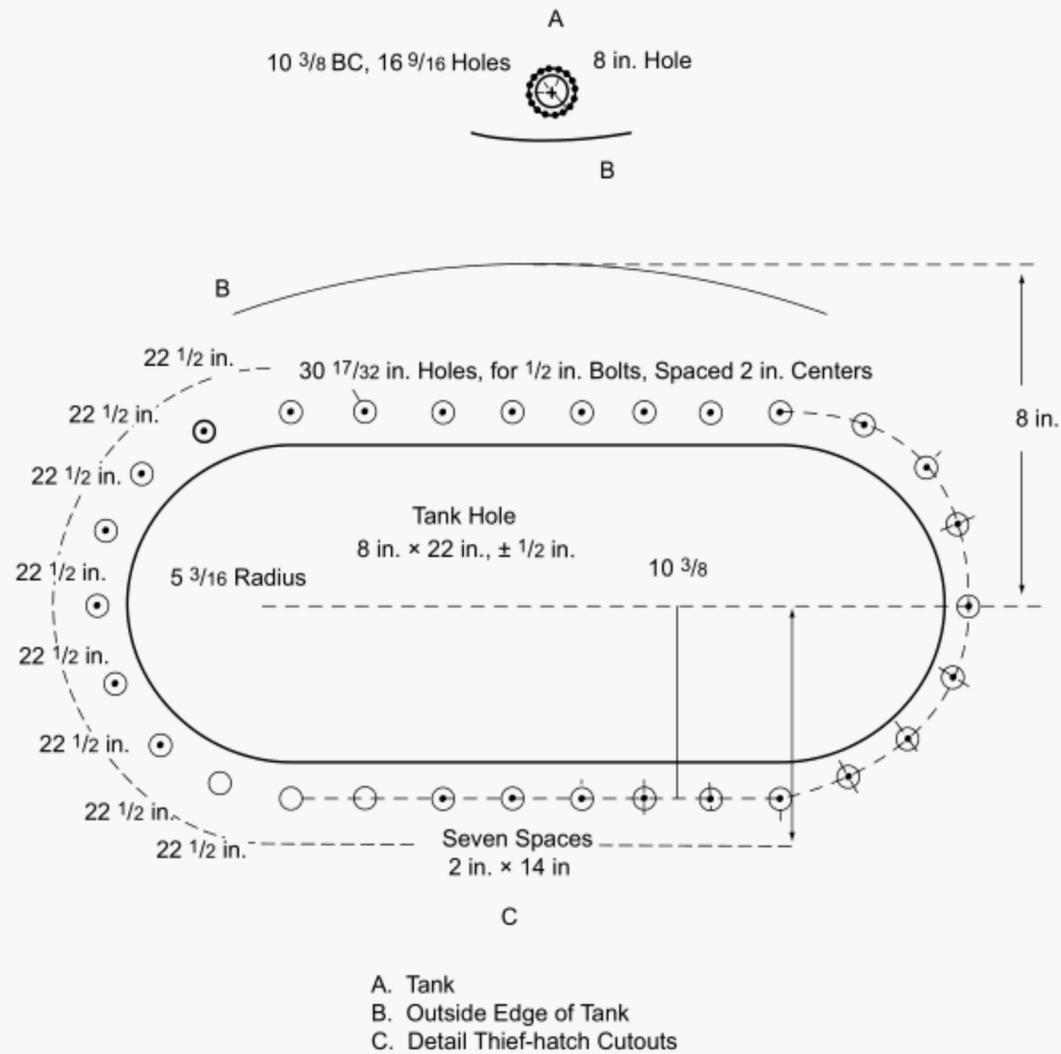


Figure 3—Closed Top FRP Tank Dimensions (See Table 1)



**Figure 4—Thief-hatch Cutouts**

## 4.18 Grounding

The manufacturer shall, as specified in datasheet, provide a means to ground the interior fluid. The following are some methods currently used:

- a) conductive downcomers;
- b) conductive ground rods (vertical or horizontal);
- c) carbon c-veil (internally).

## 5 Venting Requirements

### 5.1 Normal Venting

Closed top tanks shall be positively vented to atmosphere. Connection C-2 is provided for normal inbreathing and outbreathing due to temperature changes and to liquid movement into and out of the tank. This connection shall be equal to or greater than the largest outlet or inlet connection. Thief hatches and other pressure/vacuum valves shall be in accordance with the design conditions (see 4.1).

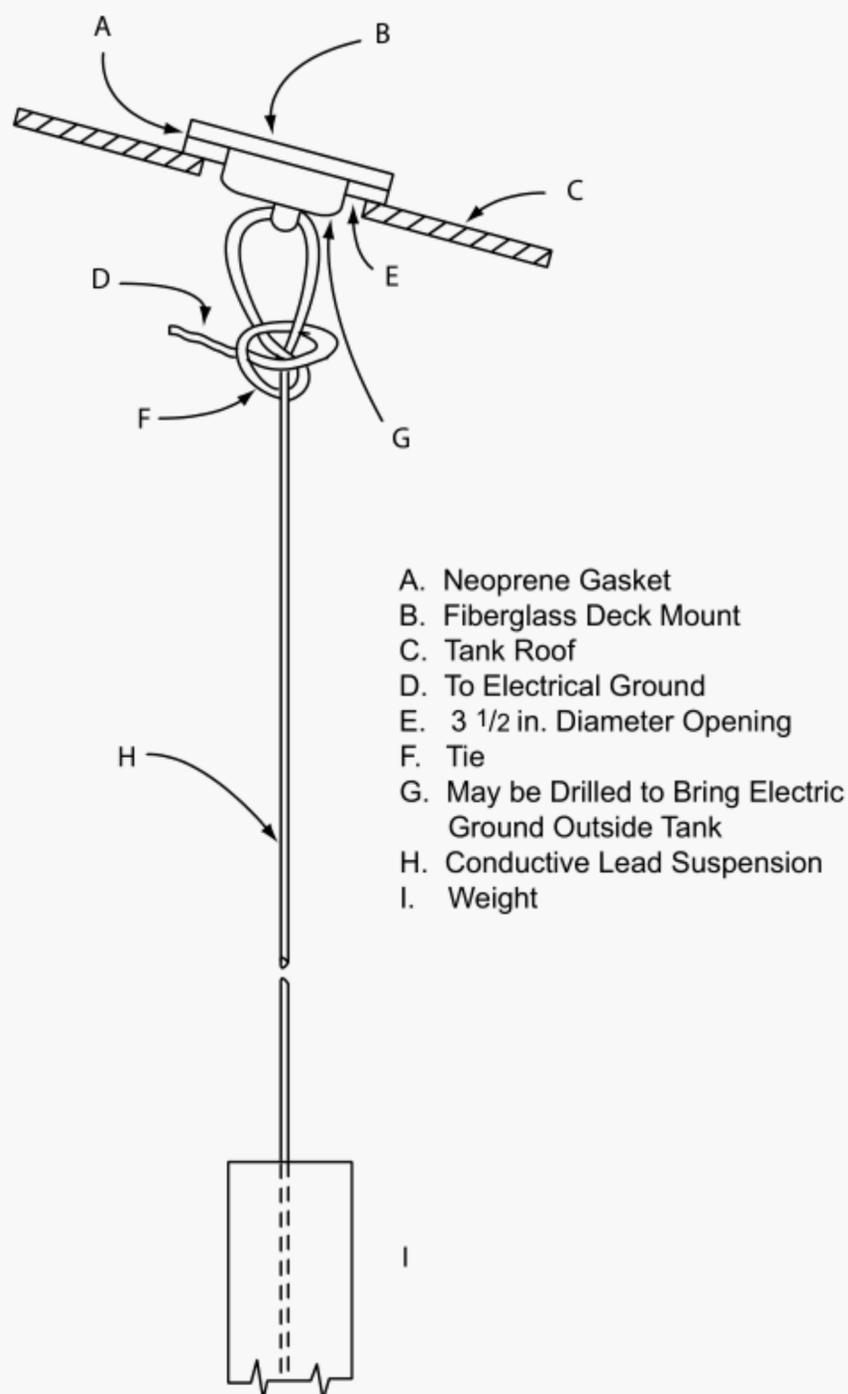


Figure 5—Suspended Conductor Example Installation

## 5.2 Emergency Venting

Emergency venting capacity is not normally required for FRP tanks as they will fail at temperatures in the neighborhood of 200°F. This temperature would be before vaporizing sufficient amount of the liquid in the tanks to create a venting problem.

The bolting pattern of the thief hatch base shall conform to one of those shown in Figure 4.

## 6 Fabrication and Testing

### 6.1 Fabrication

Tanks shall be fabricated by the contact-molded or filament-wound process. Contact-molded tanks shall meet the requirements of ASTM D4097-88, and filament-wound tanks shall meet the requirements of ASTM D3299-88. It is common practice to use both of these methods to construct a tank. Tanks fabricated using a combination of the two aforementioned methods shall meet the standard applicable to the method used for the respective part fabricated.

### 6.1.1 Joints

Joints between the hoop section of tanks formed separately shall be formed by overlay to at least the minimum widths of Table 2, ASTM D4097, with an overlay thickness equal to the required design shell thickness. The overlay shall be tapered back from this minimum thickness to become flush with the adjoining section over a minimum width of 3 in. The inner surface of the joint shall be sealed in accord with 4.4.1.5 of this specification.

### 6.1.2 Dimensional Tolerances

Tanks shall be fabricated to the dimensions of Table 1 within the tolerances listed. The shell, including bottom and deck, thickness tolerance is  $-0 + 15\%$  as designed per Section 4.

### 6.1.3 Defects

Tanks shall be free of obvious defects such as foreign inclusions, dry spots, air bubbles, pin holes, and delaminations.

- a) The internal surface shall be smooth, free of cracks and crazing and shall contain no more than 2 pits per 1 ft square area. Acceptable pits shall be less than  $1/8$  (3.2 mm) in diameter and less than  $1/32$  (0.8 mm) deep. Acceptable pits shall be covered with sufficient resin to assure coverage of the inner surface reinforcement. Pits of larger dimensions are not acceptable and shall be repaired. Some waviness is permissible as long as the surface is smooth and free of pits.
- b) The exterior surface shall be smooth and free of exposed fibers.

## 6.2 Hydrostatic Testing

Tanks shall be hydrostatically tested in the manufacturer's shop or conducted in the field after installation as specified on the datasheet.

Tests shall be conducted with clean fresh water to which a surfactant has been added.

Tests shall be held for a minimum of 4 hours.

Tanks shall be tested by filling 12 in. above the top crown of the tank through use of a temporary standpipe.

All connections shall be plugged or blinded during the test with the type and size fittings intended for use after installation, to conform thread or flange sealing integrity.

Any leaks or defects found shall be repaired by the manufacturer and the tank retested for a minimum of 2 hours.

## 6.3 Quality Control Tests

Tests shall be conducted on the completed tank to confirm that this standard is met. At a minimum, these include thickness, degree of cure, dimensional tolerances, and surface cure.

Vessel thickness shall be measured and recorded at all cutouts to verify specified minimum thickness is met or exceeded. Readings shall be taken utilizing a micrometer or calipers at four positions, 90 degrees apart at each cutout.

Degree of cure of the laminate shall be determined to meet resin manufacturer's standards by measuring Barcol hardness in accordance with ASTM D2583.

Tank dimensions and standard nozzle locations shall be verified on the finished tank to meet the tolerances of Table 1 and locations on Figure 3.

### 6.3.1 Surface Cure Test

An acetone test shall be used to detect surface inhibition on external surfaces and secondary bond surfaces exposed to air during cure (non-mold surfaces). The following procedure shall be used: wipe surface with clean acetone, wait at least 30 seconds for drying, and check for tackiness. Tackiness is an indication of incomplete cure. When, as a result of the above described procedure, tackiness is present, the Barcol hardness test shall be performed to verify incomplete cure. Incomplete cure is cause for rejection of the tank.

### 6.3.2 Optional Tests

Other tests may be specified at the purchaser's option. These optional tests may include any or all of the following: tensile strength (ASTM D638); flexural strength (ASTM D790); glass content (ASTM D2584); temperature resistance of resin (ASTM D790); acoustic emission (SPI *Recommended Practice for Acoustic Emission Testing of Fiberglass Tanks/Vessels*). When the purchaser has specified destructive testing requirements, destructive tests will be conducted on nozzle and manway cutouts. The manufacturer is responsible for retaining cutouts of sufficient size for testing.

## 7 Marking

The following information, shown by example in Figure 6, shall be incorporated on a raised metal label and shall be securely attached with bolts and nuts or, with a comparable method, to the tank in the location shown in Figure 3:

- 1) name of manufacturer;
- 2) serial number of tank;
- 3) date of manufacture;
- 4) tank nominal diameter;
- 5) tank nominal height;
- 6) tank nominal capacity, in barrels;
- 7) type of resin used in manufacturer; isophthallic, vinylester, etc.;
- 8) maximum operating temperature, in degrees Fahrenheit;
- 9) design pressure, in ounces;
- 10) design fluid specific gravity;
- 11) design vacuum (inches of WC);
- 12) "Standard API" or "Modified API" depending on the tank nozzles configuration.

NOTE This section shall be superseded by Annex D if applicable.

A second label shall be attached to the tank with the wall thickness taken every 90° around the tank and every 2 ft up the tank, starting at 45° of the manway, if required by the purchaser.

Manufactured in Accordance with API Specification 12P	
Manufacturer	_____
Serial Number	_____
Date of Manufacture	_____
Nominal Diameter	_____
Nominal Height	_____
Nominal Capacity	_____ bbl
Type of Resin Used in Manufacture	_____
Maximum Operating Temperature	_____ °F
Design Pressure	_____ oz
Design Fluid Specific Gravity	_____
Design Vacuum	_____ in. of WC
Standard API or Modified API (Depending on Nozzle Configuration)	

**Figure 6—Metal Label Format**

## **Annex A** (informative)

### **Recommended Installation and Handling**

#### **A.1 Installation**

Vertical flat bottom tanks should be installed on a base providing continuous support for both the tank bottom and knuckle radius, and having sufficient strength to support the weight of the tank full of liquid with negligible deflection. The following materials are recommended when possible for tank grades: sand or material of less than  $\frac{1}{8}$  in. diameter, smooth surfaced concrete, or a concrete grout. Retaining rings are highly recommended for tank pads to help prevent wind and water erosion around the base of the tank, also the use of rock riprap, large diameter gravel, or other coarse material around the base of the tank after installation will prevent tank grade erosion.

#### **A.2 Handling**

During installation of the tank, several methods of handling are recommended. Tanks may be handled with a crane utilizing the lifting lugs laminated to the tank.

**Caution—Do not attempt to lift by attaching to fitting.**

When using cranes for handling, care must be taken to prevent damage to the knuckle radius or to connections by dragging the tank. A tank skid should only be used with a bottom plate to protect the knuckle radius, insuring the base of the tank is setting solidly on the base of the tank skid and is securely fastened to the tank skid by chains or web belting. Care must also be taken when tail boarding with a tank skid that there is sufficient ground clearance for maneuvering the tank on to the grade and that the tank is not severely dropped when set into place. Once the tank is installed on the grade, a final inspection is recommended to ensure that there are no fractures in the base, knuckle, side wall or connections, either in the interior or exterior of the tank. Since the majority of problems with fiberglass tanks tend to occur during handling and shipping, it is strongly recommended that the manufacturer's special instructions be followed in all cases.

#### **A.3 Fire Protection**

FRP tanks should be remotely located from any obvious ignition source and or so located that any spill resulting from the failure of these materials could not unduly expose persons, buildings, or structures.



## **Annex B (normative)**

### **Walkways, Stairways, and Ladders**

#### **B.1 General**

Walkways and stairways furnished to this specification shall be constructed from prefabricated components designed to be field erected alongside of tanks or similar structures. All material shall comply with the applicable parts of Section 3.

#### **B.2 Access**

It should be noted that walkways, platforms, and stairways or ladders are intended to provide access to devices on or near the deck within easy reach from the ladder or platform, and not for employee egress onto the deck itself. Where individuals are required to have access to the deck, suitable guard railings should be installed to prevent their falling.

#### **B.3 Walkways**

Walkway shall consist of tread (decking) sections, railing assemblies, and toeboards designed and assembled so that the completed structure will support a uniform load of 50 lb/ft<sup>2</sup>, or a concentrated load of 1,000 lb at any place on the span without deflecting more than  $\frac{1}{360}$  of the unsupported span length. The maximum span between tank brackets or ground supports shall be 25 ft. Where intermediate supports are required, the vertical members shall terminate at the top rail. The base for ground supports shall be of concrete or other suitable permanent foundation.

#### **B.4 Treadway**

Treadway shall be a minimum of 26 in. wide. Tread shall be uniformly perforated from the bottom with shaped punches to form a non-skid surface. Optionally, as specified in the datasheet, the deck of treadway sections may be fabricated from structural expanded metal or grating to avoid the build-up of snow or ice.

#### **B.5 Railings**

Railings shall consist of posts, horizontal braces, sway (truss) braces, gusset plates, toeboards, midrail, and top rail. Railings shall be assembled so that the top rail is 42 in. above the treadway. The completed structure, when assembled, shall be capable of withstanding a concentrated force of 200 lb applied in any direction at any point on the top rail.

#### **B.6 Toeboards**

Toeboards shall be installed on all open sides (except at the entrance of stairways or ladders) to provide an installed height of 4 in. above the treadway.

#### **B.7 Midrail**

Midrail shall be installed approximately halfway between treadway and top rail. Where the midrail projects into a walkway area, the ends shall be formed to a smooth contour.

#### **B.8 Brackets**

Each tank shall be equipped with two bracket assemblies, securely bolted to the lugs specified in Figure 3. The brackets shall be installed to provide a 26-in. wide access to the tank at the point of attachment.

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Toeboards shall be installed on all open sides (except at the entrance of stairways or ladders) to provide an installed height of 4 in. above the treadway.

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Midrail shall be installed approximately halfway between treadway and top rail. Where the midrail projects into a walkway area, the ends shall be formed to a smooth contour.

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Midrail shall be installed approximately halfway between treadway and top rail. Where the midrail projects into a walkway area, the ends shall be formed to a smooth contour.

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It should be noted that walkways, platforms, and stairways or ladders are intended to provide access to devices on or near the deck within easy reach from the ladder or platform, and not for employee egress onto the deck itself. Where individuals are required to have access to the deck, suitable guard railings should be installed to prevent their falling.

#### **B.3 Walkways**

Walkway shall consist of tread (decking) sections, railing assemblies, and toeboards designed and assembled so that the completed structure will support a uniform load of 50 lb/ft<sup>2</sup>, or a concentrated load of 1,000 lb at any place on the span without deflecting more than  $\frac{1}{360}$  of the unsupported span length. The maximum span between tank brackets or ground supports shall be 25 ft. Where intermediate supports are required, the vertical members shall terminate at the top rail. The base for ground supports shall be of concrete or other suitable permanent foundation.

#### **B.4 Treadway**

Treadway shall be a minimum of 26 in. wide. Tread shall be uniformly perforated from the bottom with shaped punches to form a non-skid surface. Optionally, as specified in the datasheet, the deck of treadway sections may be fabricated from structural expanded metal or grating to avoid the build-up of snow or ice.

#### **B.5 Railings**

Railings shall consist of posts, horizontal braces, sway (truss) braces, gusset plates, toeboards, midrail, and top rail. Railings shall be assembled so that the top rail is 42 in. above the treadway. The completed structure, when assembled, shall be capable of withstanding a concentrated force of 200 lb applied in any direction at any point on the top rail.

#### **B.6 Toeboards**

Toeboards shall be installed on all open sides (except at the entrance of stairways or ladders) to provide an installed height of 4 in. above the treadway.

#### **B.7 Midrail**

Midrail shall be installed approximately halfway between treadway and top rail. Where the midrail projects into a walkway area, the ends shall be formed to a smooth contour.

#### **B.8 Brackets**

Each tank shall be equipped with two bracket assemblies, securely bolted to the lugs specified in Figure 3. The brackets shall be installed to provide a 26-in. wide access to the tank at the point of attachment.

## **Annex B (normative)**

### **Walkways, Stairways, and Ladders**

#### **B.1 General**

Walkways and stairways furnished to this specification shall be constructed from prefabricated components designed to be field erected alongside of tanks or similar structures. All material shall comply with the applicable parts of Section 3.

#### **B.2 Access**

It should be noted that walkways, platforms, and stairways or ladders are intended to provide access to devices on or near the deck within easy reach from the ladder or platform, and not for employee egress onto the deck itself. Where individuals are required to have access to the deck, suitable guard railings should be installed to prevent their falling.

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#### **B.5 Railings**

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#### **B.6 Toeboards**

Toeboards shall be installed on all open sides (except at the entrance of stairways or ladders) to provide an installed height of 4 in. above the treadway.

#### **B.7 Midrail**

Midrail shall be installed approximately halfway between treadway and top rail. Where the midrail projects into a walkway area, the ends shall be formed to a smooth contour.

#### **B.8 Brackets**

Each tank shall be equipped with two bracket assemblies, securely bolted to the lugs specified in Figure 3. The brackets shall be installed to provide a 26-in. wide access to the tank at the point of attachment.

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#### **B.6 Toeboards**

Toeboards shall be installed on all open sides (except at the entrance of stairways or ladders) to provide an installed height of 4 in. above the treadway.

#### **B.7 Midrail**

Midrail shall be installed approximately halfway between treadway and top rail. Where the midrail projects into a walkway area, the ends shall be formed to a smooth contour.

#### **B.8 Brackets**

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## **Annex B (normative)**

### **Walkways, Stairways, and Ladders**

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#### **B.6 Toeboards**

Toeboards shall be installed on all open sides (except at the entrance of stairways or ladders) to provide an installed height of 4 in. above the treadway.

#### **B.7 Midrail**

Midrail shall be installed approximately halfway between treadway and top rail. Where the midrail projects into a walkway area, the ends shall be formed to a smooth contour.

#### **B.8 Brackets**

Each tank shall be equipped with two bracket assemblies, securely bolted to the lugs specified in Figure 3. The brackets shall be installed to provide a 26-in. wide access to the tank at the point of attachment.

## **Annex B (normative)**

### **Walkways, Stairways, and Ladders**

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