# Specification for Fiberglass Reinforced Plastic Tanks

API SPECIFICATION 12P
SECOND EDITION, JANUARY 1, 1995

**American Petroleum Institute**
1220 L Street, Northwest
Washington, D.C. 20005

# Specification for Fiberglass Reinforced Plastic Tanks

**Exploration and Production Department**

API SPECIFICATION 12P
SECOND EDITION, JANUARY 1, 1995

American
Petroleum
Institute

## SPECIAL NOTES

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations under local, state, or federal laws.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety data sheet.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. Sometimes a one-time extension of up to two years will be added to this review cycle. This publication will no longer be in effect five years after its publication date as an operative API standard or, where an extension has been granted, upon republication. Status of the publication can be ascertained from the API Authoring Department [telephone (214) 953-1101]. A catalog of API publications and materials is published annually and updated quarterly by API, 1220 L Street, N.W., Washington, D.C. 20005.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API *standard*. Questions concerning the interpretation of the content of this standard or comments and questions concerning the procedures under which this standard was developed should be directed in writing to the director of the Exploration and Production Department, American Petroleum Institute, 700 North Pearl, Suite 1840, Dallas, Texas 75201. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any federal, state, or municipal regulation with which this publication may conflict.

API standards are published to facilitate the broad availability of proven, sound engineering and operating practices. These standards are not intended to obviate the need for applying sound engineering judgment regarding when and where these standards should be utilized. The formulation and publication of API standards is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

# CONTENTS

# FOREWORD

This specification is under the jurisdiction of the API Committee on Standardization of Production Equipment.

This specification is based on the accumulated knowledge and experience of users and manufacturers of shop-fabricated fiberglass reinforced plastic (FRP) tanks. If tanks are to be purchased in accordance with this specification, the user/purchaser is expected to specify certain basic requirements.

This standard requires the user/purchaser to specify certain details and features. A bullet (◦) in the margin indicates that a decision by the user/purchaser is required. These decisions should be indicated clearly on the data sheets.

Suggested revisions are invited and should be submitted to the American Petroleum Institute, Production Associate, Production Department, 2535 One Main Place, Dallas, TX 75202-3904.

*This standard shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution.*

# Specification for Fiberglass Reinforced Plastic Tanks

## 1 Scope

### 1.1 GENERAL

a. 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.

o b. 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.

c. 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 REFERENCED ASTM STANDARDS

The following is a list of ASTM standards referenced in the API Specification. Copies of these standards are available from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103. The user of these standards should be certain he is using the latest revision of the standard.

ASTM

- 4097 *Standard Specification for Contact-Molded Glass Fiber Reinforced Thermostat Resin Chemical-Resistant Tanks.*
- A 153 *Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware*
- B 454 *Specification for Mechanically Deposited Coatings of Cadmium and Zinc on Ferrous Metals.*
- C 581 *Test for Chemical Resistance of Thermosetting Resins used in Glass Fiber Reinforced Structures.*
- D 638 *Test for Tensile Properties of Plastics.*
- D 648 *Test for Deflection Temperature of Plastics Under Flexural Load.*
- D 790 *Tests for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.*
- D 2150 *Specification for Woven Roving Glass Fabric for Polyester-Glass Laminates.*
- D 2583 *Test for Indentation Hardness of Rigid Plastics by means of a Barcol Impressor.*
- D 2584 *Test for Ignition Loss of Cured Reinforced Resins*
- D 2990 *Test for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics.*
- D 3299 *Standard Specification for Filament-Wound Glass Fiber-Reinforced Thermoset Resin Chemical-Resistant Tanks.*

## 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 vinylester 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:

**3.3.1** A thixotropic agent that will not interfere with visual inspection may be added for viscosity control. The thixotropic agent shall not exceed 5 weight %.

**3.3.2** Resin paste used to fill crevices before overlay shall not be subject to the limitations of 3.3.1.

o **3.3.3** Ultraviolet protection shall be provided for the exterior layer for improved resistance to degradation by ultraviolet radiation. After long exposure to ultraviolet radiation, FRP parts will experience surface chalking and discol-

oration. These effects shall be reduced or eliminated by one of the following:

- Incorporating UV absorber into the resin.

These are incorporated in the external coat at a level of 0.1 to 0.3 weight %.

- Pigmenting outer resin layers. Pigment to opacity.
- Painting
- Gelcoating (polyester paint)

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

o **3.3.4** 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.

**3.3.5** 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 C 581. Tensile and flexural strength shall be determined at the rated temperature by testing in accordance with ASTM D 2990.

### 3.4 REINFORCING MATERIAL

The reinforcing material 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 D 3299.

**3.6** Woven roving used for reinforcement of knuckles, manways and other appurtenances shall be tested in compliance with and meet requirements of ASTM D 2150.

## 4 Design

### 4.1 GENERAL

o 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.

### SHELL DESIGN

### 4.2 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 D 638 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:*

$t$ = minimum allowable shell thickness at point where $P$ is determined, in inches
$P$ = pressure exerted by combination of fluid head and gas blanket, psi
$D$ = inside diameter of tank, in inches

### 4.3 FILAMENT WOUND AND CHOP-HOOP

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

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

*Where:*

$E$ = 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 D 638. 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 x $S_u$. Minimum shell thickness shall be determined using the same equation (1) as in 4.2 but not less than 0.1875 in.

### 4.4 LAMINATE CONSTRUCTION

The laminate comprising the structural components (bot-

Table 1—Tank Dimensions (See Figure 3)

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|
| Nominal Capacity bbl. | Approximate Working Capacity, bbl. (See Note) | Inside Diameter Ft. In. ±1/2" A | Height Ft. In. ±1/2" B | Height of Overflow Connection Ft. In. ±1/8" C | Height of Walkway Lugs Ft. In. ±1/8" D | Location of Fill-Line Connection In. ±1/8" E | Size of Connections In. 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 Col. 2 apply to flat-bottom tanks.

tom, cylindrical shell, deck) shall consist of an inner surface, interior layer, structured layer and an exterior layer.

**4.4.1** The inner surface shall be between 0.010 to 0.020 inches 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 data sheet. The manufacturer shall provide documentation that material utilized for the inner surface is suitable for the fluid specified in the data sheet. 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 plies of chopped-strand mat equivalent to a total of 3 oz./sq. ft. 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./sq. ft. 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 inches. 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 D 2584.

### 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 D 2584.

### 4.4.4 Structural Layer (Chop-Spray)

Subsequent reinforcement shall consist of 1.5 oz./sq. ft. chopped strand mat or equivalent weight of chopped roving and such additional number of alternating plies of 24 oz./sq. yd. woven roving and 1.5 oz./sq. ft. 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 structural layer shall be a minimum of 35% when tested in accordance with

ASTM D 2584. 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.

## BOTTOM DESIGN

### 4.5 KNUCKLE RADIUS

The bottom knuckle shall be reinforced with overlay of glass fiber and resin extending from the flat bottom tangent line upward a minimum 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 Fig. 1.

### 4.6 BOTTOM TO SHELL JOINT (CHOP-SPRAY)

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./sq. yd. 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 D 4097. The interior layer of the joint shall be reinforced with at least two layers of 1.5 oz./sq. ft. mat. 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 feet diameter or less. For tanks greater than 12 feet 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 either ellipsoidal, flanged and dished, or 1.12 pitch conical dome configuration.

o **4.9** Regardless of shape, the deck shall be able to support a concentrated 250 lb. load on any single 4 inches x 4 inches area without damage, with a maximum deflection of ½% of the inside tank diameter. The use of stiffener ribs or sandwich construction stiffening systems is acceptable.

### 4.10 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 inches.

o **4.11** If the tank has a gas blanket installed, the purchaser should consider the option of laminating the interior of the top deck seam. (See data sheet)

### o 4.12 CLEANOUT

Cleanout dimensions and bolting shall conform to dimensions shown in Table 2. Cleanout construction shall conform to ASTM 3299, Table 4. The bottom of the cleanout shall not extend lower than 12 in. from the bottom of the tank.

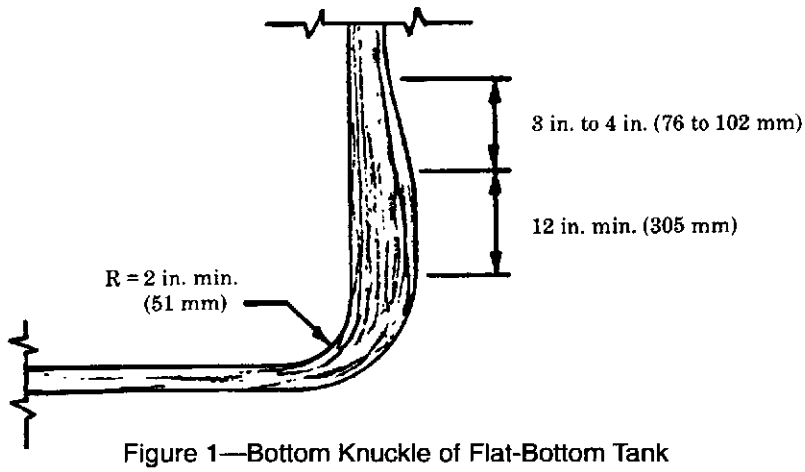


Figure 1—Bottom Knuckle of Flat-Bottom Tank

Table 2—Typical Dimensions of Manways

| Side-Shell Manway—up to 15 psig hydrostatic head | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Size* | | 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) |
| Top Manway—atmospheric pressure | | | | | | | | | | |
| Size* | | 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) |

*Bolt size = bolt hole diameter minus 1/8 in. (3 mm).

## ○ 4.13 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 data sheet other types of nozzles see Data Sheet 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.

## 4.14 CUTOUT REINFORCEMENTS

Cutouts 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:*

$K$ = 1.0 for nozzles 6 inches in diameter and larger
$K$ = d/(dr-d) for nozzles less than 6 inches diameter
$d$ = nozzle outside diameter, inches
$d_r$ = reinforcement diameter, inches: = 2 × d for nozzles 6 inches or larger
$d_r$ = d + 6 for nozzles less than 6 inches
$P$ = hydrostatic pressure at the point of nozzle installation in psi
$D$ = inside diameter of the tank in inches
$S_a$ = allowable tensile stress in psi (Ref. 4.3)

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

## 4.15 APPURTENANCES

Nozzles, cleanouts, and other appurtenances shall be installed in accordance with 4.14. Installation laminates shall meet minimum standards shown in Figures 5 and 6 of ASTM 3299.

FRP flanged nozzle construction and design shall conform to ASTM 3299, Table 4. Flange drilling and bolting shall conform to ANSI B 16.5 for Class 150 flat faced flanges.

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

## ○ 4.16 WALKWAY, LADDER, LIFTING AND HOLD DOWN LUGS

The manufacturer shall demonstrate by physical test that all lugs are capable of withstanding 2 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 Appendix B.

If hold down (wind anchorage) lugs are specified by purchaser, manufacturer shall use ANSI Standard 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.

## ○ 4.17 DOWNCOMER PIPE

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

## Data Sheet 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 Fig. 3.2 of API 12P or [ ] "Modified"
Nozzles: [ ] Threaded [ ] Grooved [ ] Flanged [ ] Gusseted Flanges
Manway: [ ] 18" [ ] 20" [ ] 22" [ ] 24" Quantity _____
Walkway Brackets: [ ] Painted Steel [ ] Galvanized Steel
Lifting Lugs: [ ] Painted Steel [ ] Galvanized Steel
[ ] Fiberglass [ ] Stainless Steel

Thief Hatch: Model _____
Pressure _____ Vaccum _____
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 |

Remarks:
*Suggested if tank is to have a gas blanket.

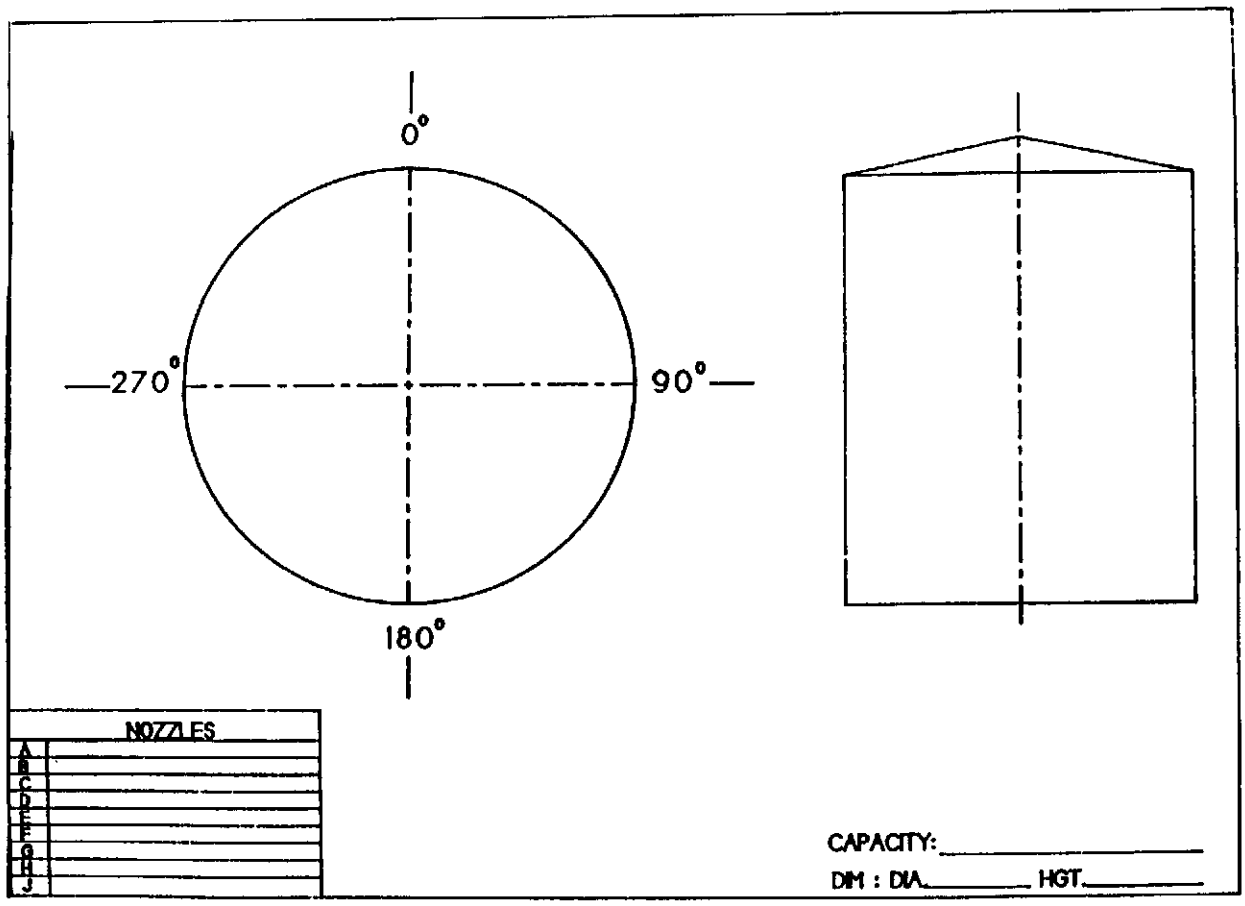


Figure 2

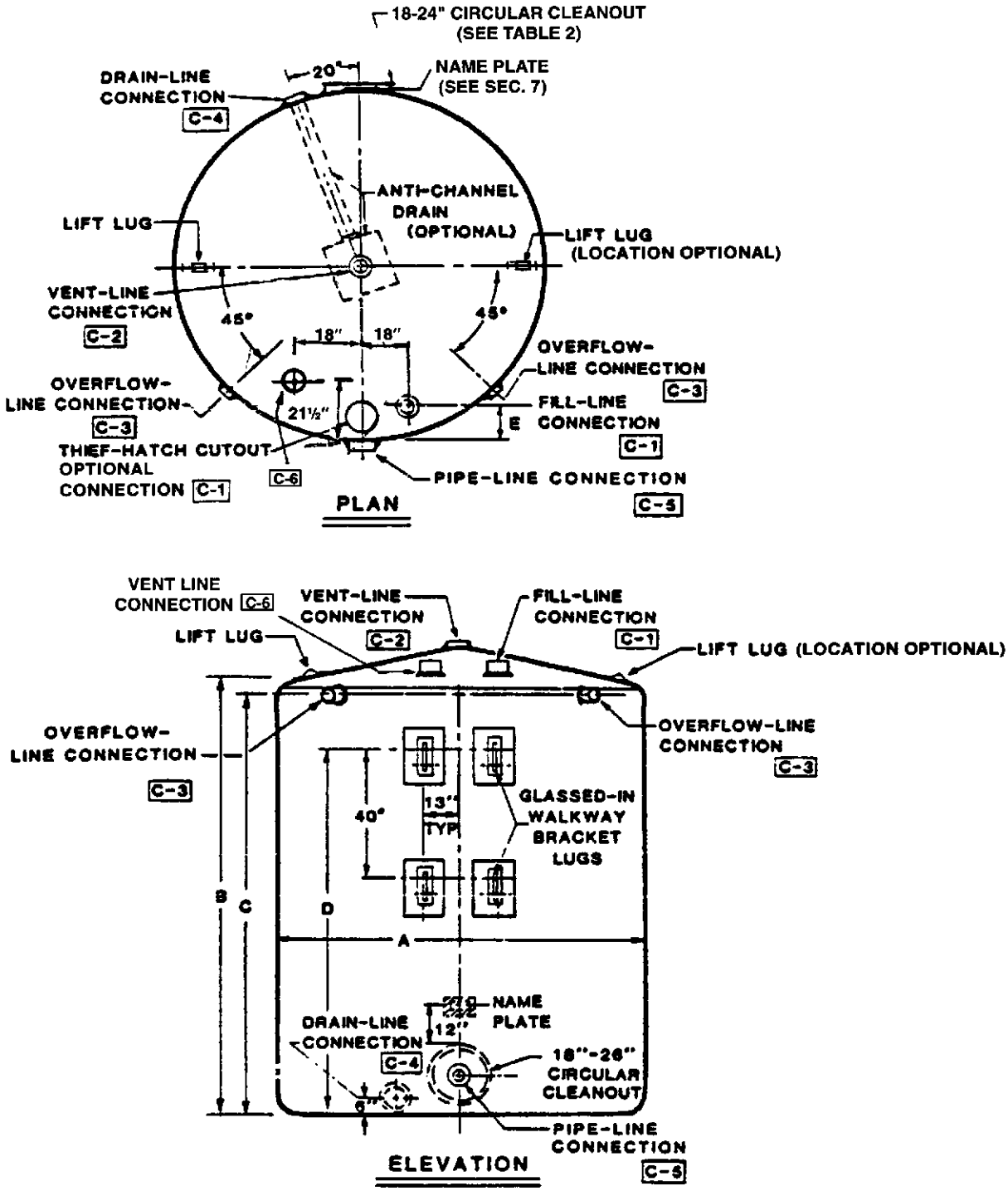


Figure 3—Closed Top FRP Tank Dimensions (See Table 1)

### ○ 4.18 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. x 16 in. x 16 in. steel material shall be laminated to the tank bottom directly below the thief hatch.

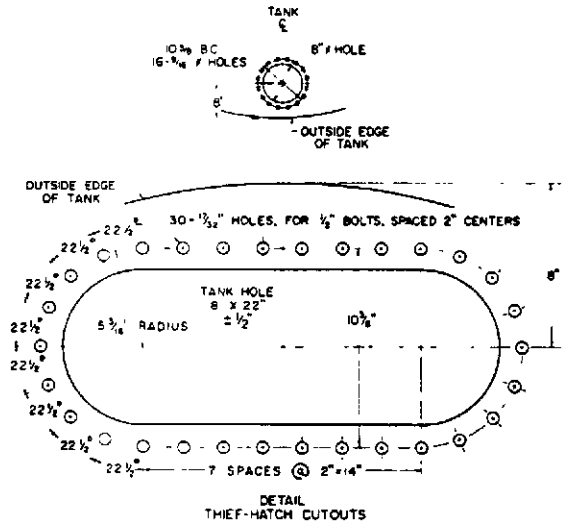


Figure 4—Thief-Hatch Cutouts

### ○ 4.19 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 data sheet. In severe cases the use of a suspended conductor within the tank can be used. Reference Fig. 5.

### ○ 4.20 GROUNDING

The manufacturer shall, as specified in data sheet, 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 out breathing 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).

**5.2** 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 Fig. 4.

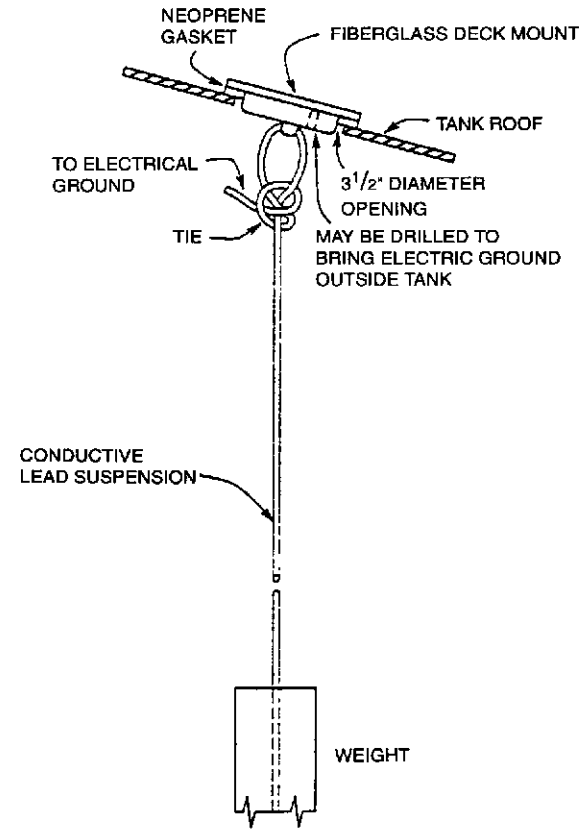


Figure 5—Suspended Conductor Example Installation

# 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 standard D 4097-88, and filament-wound tanks shall meet the requirements of ASTM standard D 3299-88. 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 hoop section of tanks formed separately shall be formed by overlay to at least the minimum widths of Table 2, ASTM D 4097, 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 4.1 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 one foot 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 permissable 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 data sheet.

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

**6.2.2** Tests shall be held for a minimum of four (4) hours.

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

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

**6.2.5** Any leaks or defects found shall be repaired by the manufacturer and the tank retested for a minimum of two (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.

**6.3.1** 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.

**6.3.2** Degree of cure of the laminate shall be determined to meet resin manufacturer's standards by measuring Barcol hardness in accordance with ASTM D 2583.

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

### 6.3.4 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.

**6.3.5** Other tests may be specified at the Purchaser's option. These optional tests may include any or all of the following: Tensile strength (ASTM D 638); Flexural strength (ASTM D 790); Glass content (ASTM D 2584); Temperture resistance of resin (ASTM D 790); Acoustic emission (API *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

## 7.1 MARKING

The following information 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.

a. Name of manufacturer;
b. Serial Number of Tank;
c. Date of Manufacturer;
d. Tank Nominal Diameter;
e. Tank Nominal Height;
f. Tank Nominal Capacity in BBL;
g. Type of Resin used in Manufacturer: Isophthallic, Vinylester, etc.;
h. Maximum Operating Temperature, Degrees °F;
i Design Pressure (oz);
j. Design Fluid Specific Gravity;
k. Design Vacuum (Inches of WC);
l. A second label shall be attached to the tank with the wall thickness taken every 90° around the tank and every two feet up the tank, starting 45° of the manway, if required by the purchaser.
m. "Standard API" or "Modified API" depending on the tank nozzles configuration.

**7.2** This section shall be superseded by Appendix D when applicable.

# APPENDIX A—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 1/8" 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 webb 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 tends 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.

# APPENDIX B—WALKWAYS, STAIRWAYS AND LADDERS

## General

### B.1

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 2.

### B.2

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 employees 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.

## Walkways

### B.3

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. per sq. ft., or a concentrated load of 1,000 lb. at any place on the span without deflecting more than $^1/_{360}$ of the unsupported span length. The maximum span between tank brackets or ground supports shall be 25 feet. 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 inches wide. Tread shall be uniformly perforated from the bottom with shaped punches to form a non-skid surface. Optionally, as specified in the data sheet, 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 inches 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 inches 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 3.2.1. The brackets shall be installed to provide a 26-inch wide access to the tank at the point of attachment.

## Stairways

### B.9

Stairways, when required for access to walkway sections, shall be designed for field erection, and shall be capable of supporting a minimum of 100 lb. per linear foot of tread width, or a concentrated load of 1,000 lb. at any point on the stairway without deflecting more than $^1/_{360}$ of the unsupported stairway length. Stairway width shall be a minimum of 26 inches. Stairways shall be designed and installed to have an angle of 45 degrees with the horizontal, unless otherwise specified by the purchaser. When installed at 45 degrees, the stairway shall have a run and rise of $8^1/_2$ inches with a nominal tread width of not less than 8 inches. Other uniform rise and tread combinations which will produce a stairway within angles to the horizontal between 30 and 50 degrees shall be acceptable, so long as all other requirements of this specification are met. The rise height and tread width shall be uniform throughout any stairway, including any foundation used as one or more steps.

### B.10

Railings shall be installed on both sides of stairways, and shall be designed so that the completed assembly will withstand a minimum of 200 lb. force in any direction applied at any point on the top rail. Top rails shall be installed so that the top rail is not less than 30 inches nor more than 34 inches measured vertically from the upper surface of the nose of a tread. Protection against falling shall be provided between the stairway runners and the top rail.

The juncture of the top rail of the stair railing shall make a smooth transition with the top rail of the walkway railing, preferably through the use of a structural gusset member.

### B.11

Spiral stairways, attached to brackets on the circumference of the tank, may be used in lieu of straight stairways,

provided all of the above requirements are met, with the exception that railings are required only on the outside of the stairway. The run of the stair tread will depend on the radius of the exterior arc, and the minimum effective tread shall be 7 inches, measured 13 inches from the exterior arc. Spiral stairways are not recommended for installation on tanks less than 15 feet, 6 inches in diameter.

## Ladders

### B.12

Fixed industrial ladders may be used in lieu of stairways. The use of a platform is optional per data sheet, but when used, the platform shall have minimum dimensions of 26 inches x 30 inches with standard railings except at the entrance from the ladder.

### B.13

Ladders, when used, shall be anchored with the center of the rung at least 7 inches from the surface of the tank or other obstruction.

### B.14

Rungs shall be a minimum of 3/4 inch diameter, spaced a maximum of 12 inches center to center with a minimum clear length of 16 inches, and designed to support a minimum load of 200 lb.

### B.15

Open ladders may be used to climb a maximum of 20 feet, and caged ladders or acceptable safety slide devices should be used when the climbing height is between 20 feet and 30 feet.

# APPENDIX C—SPECIFICATION FOR WALKWAY, STAIRWAY & LADDER BOLTING

## C.1 Scope

The Appendix covers tank bolting 1/2 inch in diameter to and including 1 1/2 inch in length. Bolts and nuts shall be either black-finish or galvanized, as specified on the purchase order.

## C.2 Physical Properties

The breaking load of the bolts, tested in full size, shall not be less than 11,350 lb.

Note: The breaking load of 11,350 lb. is equivalent to a tensile strength of 80,000 lb. per sq in based on the stress area (mean thread area) or approximately 91,000 lb per sq. in. based on the root thread area.

## C.3 Tension Test

Tension tests of bolts shall be taken on the finished bolt with the load applied between the head and a nut or suitable fixture, either of which will have sufficient thread engagement to develop the full strength of the bolt. The nut or fixture shall be assembled on the bolt leaving at least three full bolt threads exposed within the grip. If failure occurs by threads stripping before reaching the minimum required tensile load, the individual test shall be discarded.

## C.4 Stripping Test

The nuts for bolts shall be capable of developing the load specified in A.2 without stripping.

## C.5 Head Test

During the tension test specified in C.3, failure shall occur in the threaded section and not at the junction of the head and shank.

## C.6 Number of Tests

The requirements of these specifications are those met in continuous production for stock during which the manufacturer has made such sample inspections as to insure normally that the material is controlled within the specified limits. For this reason, additional tests by the manufacturer of the individual shipments of material are not required. If specified on data sheet, one tension test shall be made from each lot. A lot shall consist of 5000 pieces or fraction thereof.

## C.7 Retests

Should the sample from the lot fail to meet the requirements of the specified tests two additional samples shall be tested; in which case, both samples shall meet the test requirements.

## C.8

Threads of unplated product shall be coarse-thread series as specified for screw threads (ANSI B1.1 of latest issue) having a class 2A tolerance for bolts and class 2B tolerance for nuts. Bolts to be galvanized shall have Class 2A threads before hot dip or mechanical galvanizing. After galvanizing, the maximum limit of pitch and major diameter may exceed the Class 2A limit by 0.021 inches.

## C.9

Bolts shall be regular square, unless as shown on data sheet, in which case they may be regular hex. All bolts shall comply with the applicable section of the latest edition of ANSI B18.2.1, Square and Hex Bolts and Screws.

## C.10

Nuts shall be regular square, unless as shown on data sheet, in which case they may be regular hex. All nuts shall comply with the applicable section of the latest edition of ANSI B18.2.2, Square and Hex Nuts.

## C.11 Galvanizing

Unless otherwise specified in data sheet, galvanized bolts and nuts shall be hot-dip galvanized in accordance with the requirements of ASTM A 153. The weight of coating shall be that specified for Class C materials in ASTM A 153 and the nuts shall be tapped after galvanizing. When specified in data sheet to be mechanically galvanized, bolts and nuts shall be mechanically zinc-coated, and the coating shall conform to the requirements for Class 50 of ASTM B 454 or to the coating thickness, adherence, and quality requirements for Class C of ASTM A 153. Mechanically zinc-coated nuts for assembly with mechanically zinc-coated bolts shall be tapped oversize prior to coating and need not be retapped afterwards.

## C.12 Marking

Bolt heads shall be marked (by raised or depressed mark at the option of the manufacturer) to identify the manufacturer. The manufacturer may use additional marking for his own use.

# APPENDIX D—MARKING REQUIREMENTS FOR API MONOGRAM LICENSEES

## D.1 Requirements

This Appendix is a requirement only for manufacturers licensed to use the API monogram. This Appendix supersedes the marking requirements of Section 7 of this specification for Licensees.

## D.2 Use of Monogram

The API monogram shall be applied only by licensed manufacturers. See API Bulletin S1. Policy and Procedures for Standardization of Oilfield Equipment and Materials, for requirements governing the use of the API monogram. API Specification Q1, Specification for Quality Programs, 2.2.3 gives the requirements for marking Products using the API monogram.

## D.3 Marking

The following marking requirements apply to licensed manufacturers using the API monogram on products covered by this specification.

## D.4

The following information shall be incorporated on a raised metal label, and shall be securely attached to the tank in the location shown in Figure 3.

a. Name of Manufacturer;
b. Serial Number of Tank;
c. Date of Manufacture;
d. Tank Nominal Diameter;
e. Tank Nominal Height;
f. Tank Nominal Capacity in BBL;
g. Type Resin Used in Manufacture: Isophthallic, Vinylester, etc.;
h. Maximum Operating Temperature Degrees °F;
i. Design Pressure (ozs);
j. Design Fluid Specific Gravity;
k. Design Vacuum (Inches of WC);
l. The API Monogram;
m. A second label shall be attached to the tank with the wall thickness taken every 90° around the tank and every two feet up the tank, starting 45° off of the manway, if required by the purchaser;
n. "Modified" or "Standard";
o. API License Number.

10/94—2M (Johnston)

ADDITIONAL COPIES AVAILABLE FROM
PUBLICATIONS AND DISTRIBUTION
(202) 682-8375

**American Petroleum Institute**
1220 L Street, Northwest
Washington, D.C. 20005

Order No. 811-12P02