

Specification for Bolted Tanks for Storage of Production Liquids

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Specification for Bolted Tanks for Storage of Production Liquids

1 Scope

1.1 This specification covers material, design, fabrication, and testing requirements for vertical, cylindrical, aboveground, closed and open top, bolted steel storage tanks in various standard sizes and capacities for internal pressures approximately atmospheric, not to exceed those listed in Section 4.1.

1.2 This specification is designed to provide the oil production industry with safe and economical bolted tanks for use in the storage of crude petroleum and other liquids commonly handled and stored by the production segment of the industry. This specification is for the convenience of Purchasers and Manufacturers in ordering and fabricating tanks.

NOTE See Annex C for a list of items that should be specified by the tank Purchaser and conveyed to the tank Manufacturer. See Annex D information related to the API Monogram program for tank Manufacturers.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Recommended Practice 12R1, *Recommended Practice for Setting, Maintenance, Inspection, Operation and Repair of Tanks in Production Service*

API Specification 5L, *Specification for Line Pipe*

API Specification 6A, *Specification for Wellhead and Christmas Tree Equipment*

API Standard 650, *Welded Steel Tanks for Oil Storage*

API Standard 2000, *Venting Atmospheric and Low-pressure Storage Tanks*

ASCE 7 ¹, *Minimum Design Loads for Buildings and Other Structures*

ASME B1.1 ², *Unified Inch Screw Threads, (UN and UNR Thread Form)*

ASME B16.11, *Forged Fittings, Socket-Welding and Threaded*

ASME B18.2.1, *Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)*

ASME B18.2.2, *Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)*

ASTM A6 ³, *Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling*

ASTM A36, *Standard Specification for Carbon Structural Steel*

¹ American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, Virginia 20191, www.asce.org

² ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

³ ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

ASTM A53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*

ASTM A105, *Standard Specification for Carbon Steel Forgings for Piping Applications*

ASTM A106, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*

ASTM A123, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*

ASTM A153, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

ASTM A181, *Standard Specification for Carbon Steel Forgings, for General-Purpose Piping*

ASTM A216, *Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service*

ASTM A307, *Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength*

ASTM A350, *Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components*

ASTM A568, *Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements*

ASTM A572, *Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel*

ASTM A992, *Standard Specification for Structural Steel Shapes*

ASTM A1011, *Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy, High-Strength Low Alloy with improved Formability, and Ultra-High Strength*

ASTM B695, *Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel*

NFPA 30⁴, *Flammable and Combustible Liquids Code*

3 Material

3.1 General

Materials listed in this section have been selected to provide strength and desired service life. Other materials having mechanical properties equal to or greater than these listed may be used by agreement between the Purchaser and the Manufacturer. If higher strength materials are used, the minimum thickness called for in this specification shall not be reduced.

3.2 Plates

Plates shall conform to the latest edition of ASTM A36 or A572. Plates shall have a yield strength of not less than 36 ksi.

3.3 Sheets

Sheets shall conform to the latest edition of ASTM A1011 Grade 36. Sheets with yield strength higher than 36 ksi may be used by agreement between the Purchaser and the Manufacturer. Sheets may be ordered on a weight or thickness basis, at the option of the tank Manufacturer.

⁴ National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.

3.4 Structural Shapes

Structural shapes shall be open-hearth, electric-furnace, or basic oxygen process and shall conform to the latest edition of ASTM A36, A572, or A992.

3.5 Piping

Pipe shall conform to Grade A or B of the latest edition of API 5L, ASTM A53, or ASTM A106.

3.6 Flanges

Flanges shall be steel, conforming to one of the following specifications: ASTM A216 for cast steel (for non-welded use only), or ASTM A181, ASTM A105, or ASTM A350 for forged steel.

3.7 Couplings

Couplings for threaded connections may be supplied with or without recess, complying with the requirements of the latest edition of API 5L, Grade B. Alternatively, couplings may comply with the latest edition of ASME B16.11.

3.8 Finish

Tanks shall be furnished with mill finish, painted, galvanized, or with factory applied coating for corrosion control, as specified by the Purchaser. If galvanizing is specified, the galvanized coating on all tank plates, sheets, and structural shapes shall be applied after shop fabrication and shall conform to ASTM A123, except that, at the option of the Purchaser, written assurance shall be furnished to the Purchaser as to compliance, in lieu of actual test reports.

3.9 Bolting

Tank bolting $\frac{1}{2}$ inches in diameter, to and including $1\frac{1}{2}$ inches in length, shall conform to the requirements as given in Annex A. All other bolting shall conform to the latest revision of ASTM A307 Grade A and shall have dimensions conforming to ANSI regular square or regular hex.

4 Design

4.1 General

Tanks covered by this Specification have been designed using established engineering calculations to determine minimum metal thickness and bolting specifications for each size tank filled with water (62.37 lb/ft³ at 60° F) and at the internal design pressure of:

- a) 3 oz/in.² for tanks with a diameter of 15 ft, $4\frac{5}{8}$ in. and less; *
- b) 2 oz/in.² for tanks with a diameter of 21 ft, $6\frac{1}{2}$ in. and 29 ft, $8\frac{5}{8}$ in.; *
- c) 1 oz/in.² for tanks with a diameter of 38 ft, $7\frac{5}{8}$ in. and greater. *

In order to assure structural stability and integrity, additional metal thickness has been added to that determined by calculation. The minimum metal thickness specified in this Specification shall in no case be decreased.

* All tanks with a shell height of 8 ft (or less) shall be limited to internal design pressure of 1 oz/in.² (due to tank uplift from internal pressure). Although the internal design pressure exceeds the "weight of roof plate" limit of API RP 12R1 (for "atmospheric tanks") and API 650, this is permitted due to the roof plates being attached to the supporting structure.

Design of a tank that requires anchorage for overturning loads is outside the scope of this Specification.

NOTE All tanks included in this Specification are designed for a 3-second gust wind speed of 90 MPH, based on ASCE 7-05 (this was not adjusted for new requirements of ASCE 7-10), with an Occupancy Category of I (Importance factor of 0.87, Exposure C). Wind is not considered combined with internal pressure. If the design wind speed is greater or combined with internal pressure, tank anchorage to prevent overturning shall be considered. Pressure design and/or modification for wind above 90 mph (applied above) is outside the scope of this Specification.

For all tanks included in this Specification, the tank roof is designed for a live load is 20 lb/ft². At the design external pressure (vacuum) of –0.5 oz/in.²:

- a) the tank roof is designed for an external pressure (vacuum) of –0.5 oz/in.²; and
- b) seismic design is outside the scope of this Specification.

4.2 Size

Tanks shall conform to the sizes and dimensions shown in Table 1 as specified on the purchase order.

Table 1—Sizes and General Dimensions

(1)	(2)	(3)	(4)	(5)
Nominal Capacity 42-gal bbl	Number of Rings	Inside Diameter ^a ft, in.	Height of Shell ^b ft, in.	Calculated Capacity ^c 42-gal bbl
100	1	9, 2 ³ / ₄	8, 1 ¹ / ₂	96
200	2	9, 2 ³ / ₄	16, 1	192
250	1	15, 4 ⁵ / ₈	8, 1 ¹ / ₂	266
High 500	2	15, 4 ⁵ / ₈	16, 1	533
750	3	15, 4 ⁵ / ₈	24, 1 ¹ / ₂	799
Low 500	1	21, 6 ¹ / ₂	8, 1 ¹ / ₂	522
High 1000	2	21, 6 ¹ / ₂	16, 1	1044
1500	3	21, 6 ¹ / ₂	24, 1 ¹ / ₂	1566
Low 1000	1	29, 8 ⁵ / ₈	8, 1 ¹ / ₂	994
2000	2	29, 8 ⁵ / ₈	16, 1	1987
3000	3	29, 8 ⁵ / ₈	24, 1 ¹ / ₂	2981
5000	3	38, 7 ⁵ / ₈	24, 1 ¹ / ₂	5037
10,000	3	54, 11 ³ / ₄	24, 2	10,218
^a The inside diameter is an approximate dimension. The values shown are 2 in. less than the bottom bolt-circle diameters. ^b Shell heights shown do not include thickness of gaskets. ^c The calculated capacity is based on the inside diameter (Column 3) and height of shell (Column 4).				

4.3 Tank Bottoms

Tank bottoms shall conform to one of the following requirements as specified by the Purchaser.

- a) *Flat bottoms.* Flat bottoms shall conform to the requirements of Table 2 and Figure 2 and Figure 3 for the particular size tank ordered. Bottom segments shall be supplied with a $\frac{1}{4}$ in. identification hole, as shown in Figure 2 and Figure 3.
- b) *Cone bottoms.* A cone bottom (limited to tank sizes 29 ft, $8\frac{5}{8}$ in. in diameter and smaller) shall conform to the requirements of Figure 1. Cone bottom segments shall have the same dimensions as roof segments for the particular size tank ordered (see Figure 5), except without plate flange and flanged roof dome. If a cone bottom is furnished, the inside center support shall be determined by the Manufacturer and agreed in writing by the Purchaser, as either extended to the sump bottom, or the sump opening shall be bridged with the center support attached to the bridge.
- c) By written agreement between the Purchaser and Manufacturer, a bottom design alternative to those specified in 4.3 a) and 4.3 b) shall be furnished to provide equivalent strength, tightness, and utility.

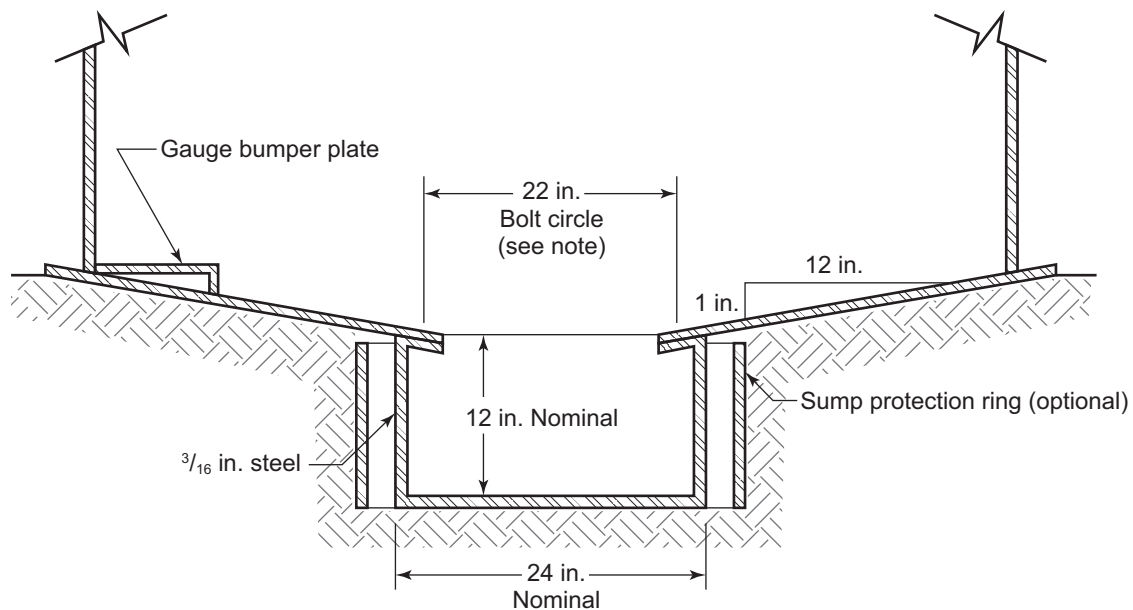
4.4 Staves (Shell Plates/Sheets)

Tank staves shall conform to the requirements of Table 2 and Figure 4 for the particular size of tank ordered.

4.5 Tank Roof

4.5.1 The tank roof shall conform to the requirements of Table 2 and Figure 5 for the size of tank ordered.

4.5.2 With written agreement between the Purchaser and the Manufacturer, an alternative roof design (including supporting members) of equivalent strength, tightness, and utility shall be furnished. For alternatives, see API 650 Annexes C, G and H and API RP 12R1 (both with design caution for stability of small diameter floating roofs).



NOTE 30 holes $\frac{17}{32}$ in. diameter required for all sizes, except 21 ft, $6\frac{1}{2}$ in. diameter tanks, which require 28 holes $\frac{17}{32}$ in. in diameter.

Figure 1—Cone Bottoms [See 4.3 b)]

Table 2—Details of Bottoms, Shells, and Roofs

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bottom		Shell							Roof	
Nominal Capacity 42-gal bbl	No. of Bottom Segments (See Figure 2 and Figure 3)	Thickness of Bottom Elements ^a in.	No. of Staves per Ring	Thickness of Staves ^a in.			No. of Rows of Bolts in Vertical Seams			No. of Roof Segments (See Figure 5)	Thickness of Roof Elements ^a in.
				1st Ring ^b	2nd Ring	3rd Ring	1st Ring ^b	2nd Ring	3rd Ring		
100	2	0.105	6	0.105	—	—	1	—	—	6	0.105
200	2	0.105	6	0.105	0.105	—	1	1	—	6	0.105
250	10	0.105	10	0.105	—	—	1	—	—	10	0.105
High 500	10	0.105	10	0.105	0.105	—	1	1	—	10	0.105
750	10	0.105	10	0.135	0.105	0.105	1	1	1	10	0.105
Low 500	14	0.105	14	0.105	—	—	1	—	—	14	0.105
High 1000	14	0.105	14	0.105	0.105	—	1	1	—	14	0.105
1500	14	0.105	14 ^c	0.105	0.105	0.105	2	1	1	14	0.105
Low 1000	20	0.105	20	0.105	—	—	2	—	—	20	0.105
2000	20	0.105	20	0.105	0.105	—	2	2	—	20	0.105
3000	20	0.105	20	0.135	0.105	0.105	2	2	2	20	0.105
5000	26 ^d	0.135	26	0.135	0.135	0.105	2	2	2	26 ^d	0.105
10,000	37 ^d	0.135	37	³ / ₁₆	0.135	0.135	3	2	2	37 ^d	0.105
^a Thickness of bottoms, staves, and roofs are minimum, and may be increased to 0.135 in., ³ / ₁₆ in., or ¹ / ₄ in. by agreement between the Purchaser and the Manufacturer. Sheet (less than ³ / ₁₆ in.) shall be ordered to decimal thickness. Tolerance shall be per ASTM A6. Corresponding AISC gage numbers and thickness are: — 12-gauge: [0.1045 (0.105) in.]; and — 10-gauge: [0.1345 (0.1345) in.]. Plate (³ / ₁₆ in. and over) shall be ordered to nominal thickness. Tolerance shall be per ASTM A6.											
^b The first ring is the bottom ring.											
^c The first ring of the 1500-bbl tank shall consist of 14 regular staves with 56 in. coverage, and a fill-in stave having 15 bolt-hole spaces with 28 in. coverage on the chimes or, alternately, 14 staves with 58 in. coverage.											
^d Two piece segments.											

4.5.3 Tanks furnished with floating roofs shall be furnished with round-head bolts (see Annex A, Section A.13).

NOTE Floating roof seals will be offset at stave laps and bolt heads, but with attention to details the seals can be made to function as with riveted tanks.

4.5.4 If an open-top tank is supplied under this Specification, a top reinforcing member shall be provided. The minimum section modulus of this member shall conform to the following equation:

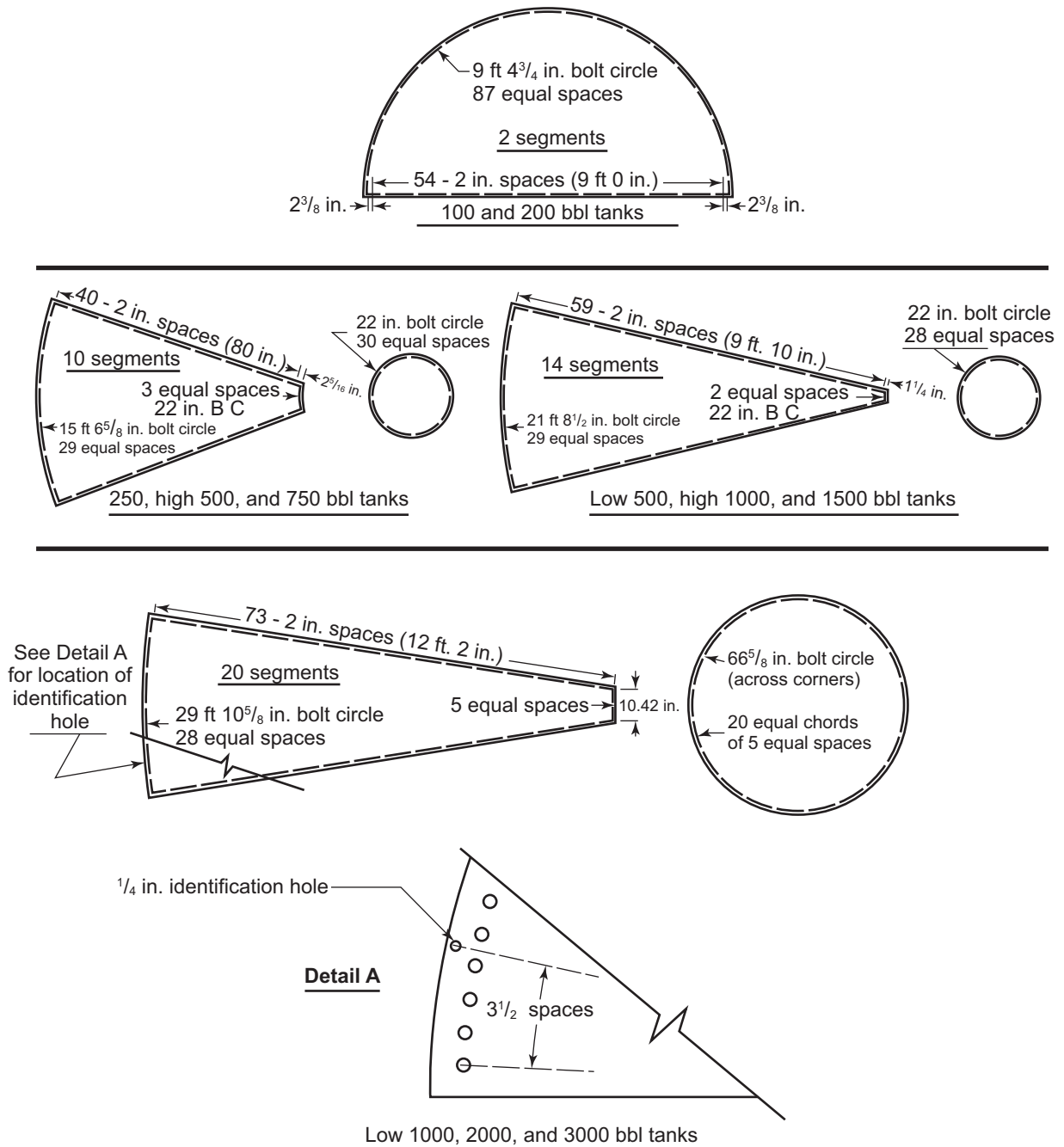
$$S = 0.0001 HD^2 \quad (1)$$

where

S is the section modulus, in inches³;

H is the height of tank, in ft;

D is the diameter of tank, in ft.



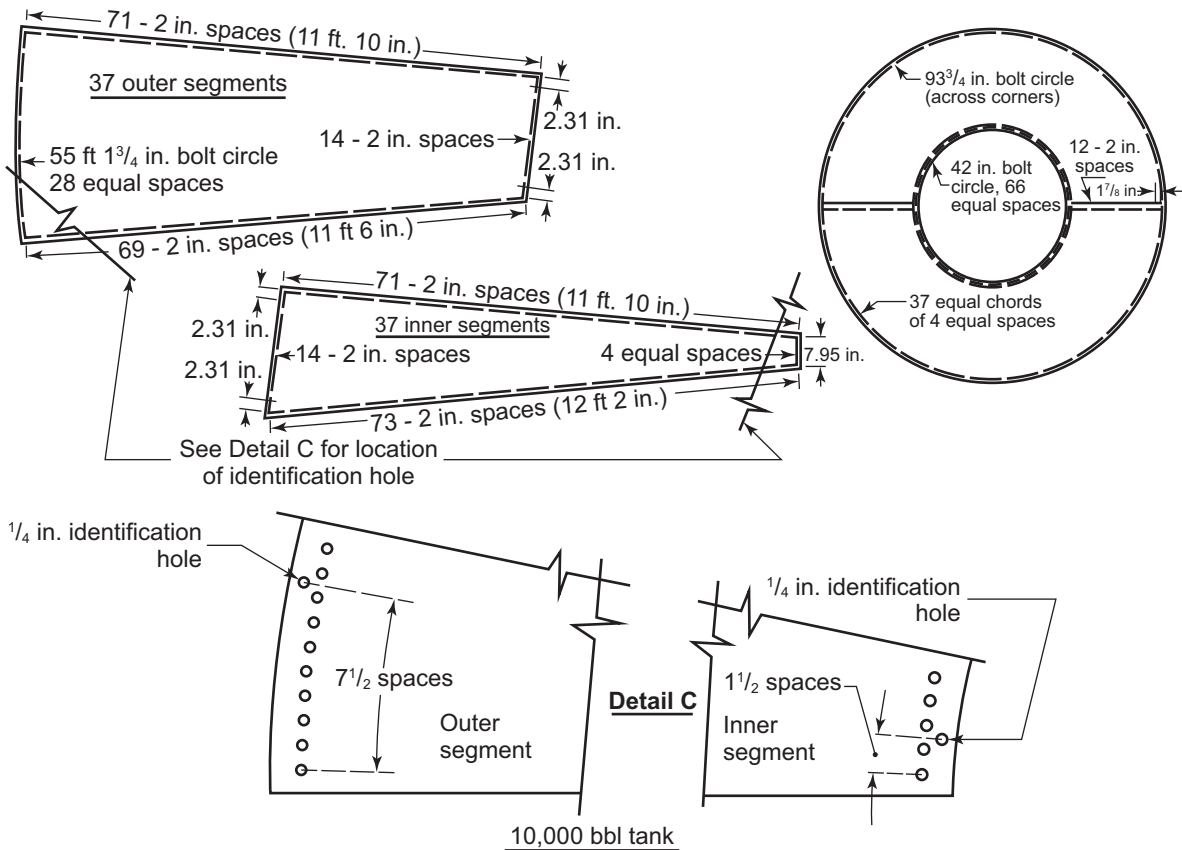
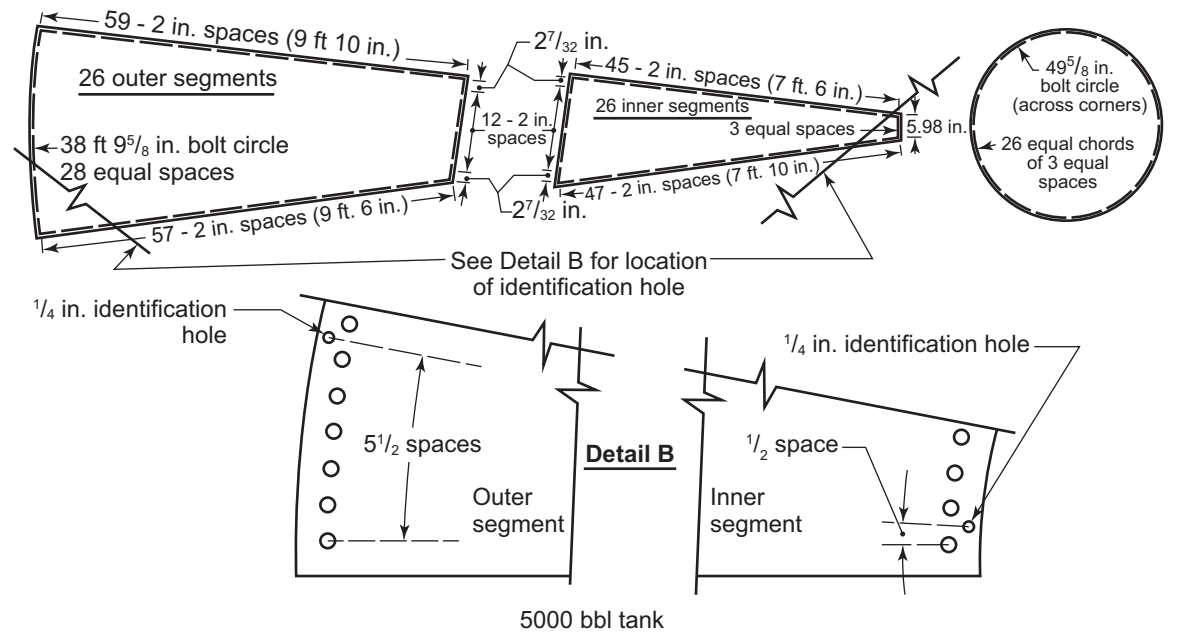
NOTE 1 Edge distance, all seams = ³/₄ in. min.

NOTE 2 Bolt-hole diameter = ¹⁷/₃₂ in.

NOTE 3 Bolt diameter = ¹/₂ in.

NOTE 4 All bolt-circle dimensions are diameter measurements.

Figure 2—Bottom Elements [See 4.3 a]



NOTE 1 Edge distance, all seams = $\frac{3}{4}$ in. min.

NOTE 2 Bolt-hole diameter = $\frac{17}{32}$ in.

NOTE 3 Bolt diameter = $\frac{1}{2}$ in.

NOTE 4 All bolt-circle dimensions are diameter measurements.

Figure 3—Bottom Elements

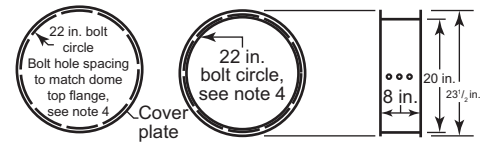
Section through lap

Diagram illustrating the geometry of a 90-degree lap joint. The joint consists of two overlapping plates, each with a thickness of $\frac{1}{16}$ in. The overlap length is $\frac{1}{32}$ in. The distance from the centerline of the overlap to the center of the concentric radius is B . The concentric radius is labeled as $\frac{3}{4}$ in. $\pm \frac{1}{16}$ in. R. The total width of the joint is 1 in. The minimum distance from the centerline of the overlap to the inner edge of the joint is $\frac{3}{4}$ in. min.



General requirements:

1. Edge distance, all seams = $\frac{3}{4}$ in. minimum
2. Bolt-hole diameter = $\frac{17}{32}$ in., bolt diameter = $\frac{1}{2}$ in.
3. Dome shall have 30 equally spaced bolt holes in one flange, 28 in the other flange, and shall be installed so that the lower flange matches the bolt-hole spaces of the deck segments or deck center pieces.
4. Dimensions of deck segments are on nominal slope (1 in 12), dimensions of deck center pieces are in the flat.



Detail of deck dome

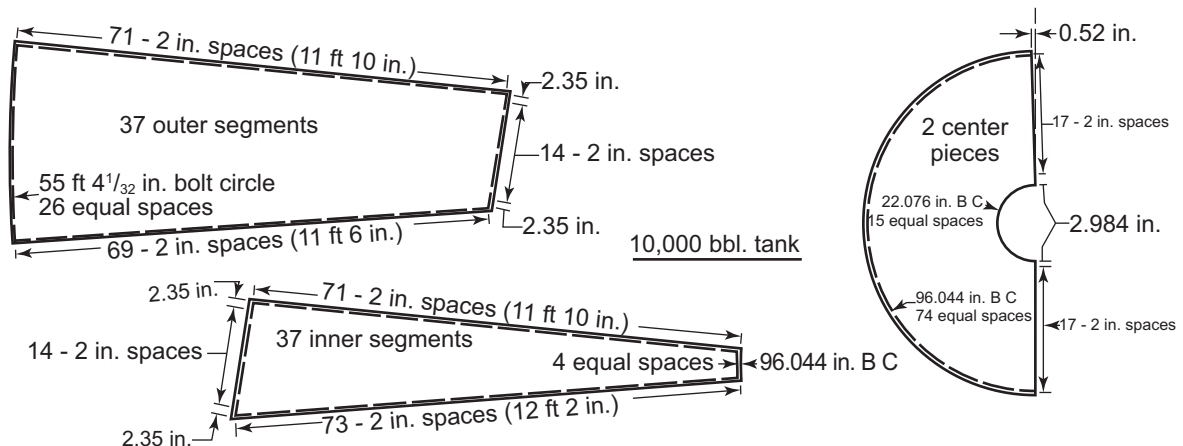
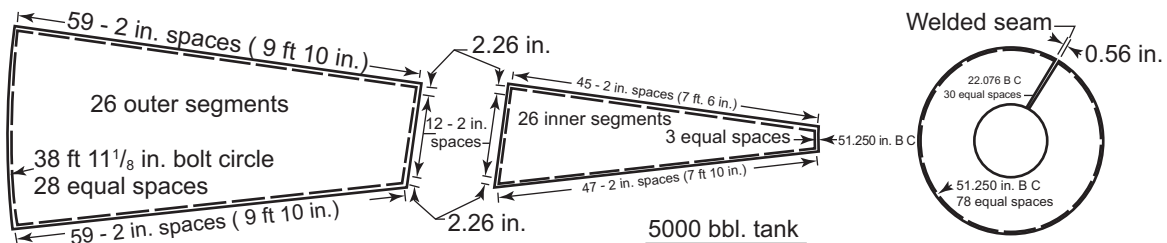
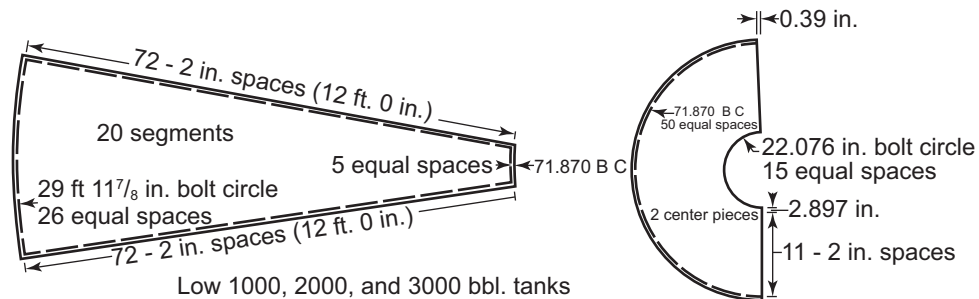
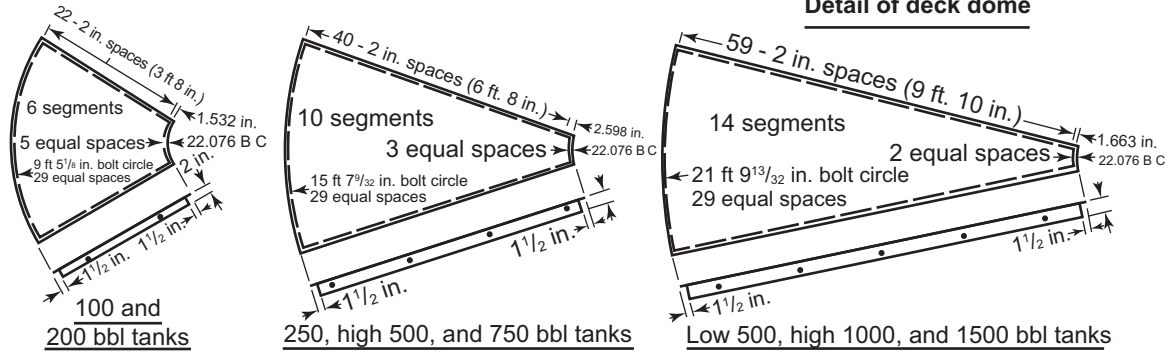


Figure 5—Roof Elements (See 4.5)

4.6 Roof Supports

4.6.1 General

Unless otherwise specified by the Purchaser, tanks with a roof diameter less than 29 ft, 8⁵/₈ in. shall have self-supporting roofs and tanks with a roof diameter 29 ft, 8⁵/₈ in. or greater shall have a support column. If provided, a center support column shall comply with 4.6.2, 4.6.3, and 4.6.4.

All elements of roof supports not specifically dimensioned herein shall be designed to support a live load of not less than 20 psf, in addition to the dead load. Allowable design stresses shall be as follows:

— Rolled structural shapes:

tension, psi, max	20,000
bending, psi, max	20,000
compression, psi, max	$\frac{20,000}{1 + L^2 / (20,000r^2)}$
L/r ratio, max	200

— For formed sections:

basic design stress, psi, max	18,000
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— Column footings:

soil-bearing load, psf, max*	1500 or 4000 with supporting geotechnical/foundation analysis by the Purchaser
------------------------------	--

4.6.2 Low Capacity Tanks

Tanks with a roof diameter under 29 ft, 8⁵/₈ in. (100-bbl, 200-bbl, 250-bbl, high 500-bbl, 750-bbl, low 500-bbl, high 1000-bbl, and 1500-bbl capacity) are self-supporting, unless otherwise specified by the Purchaser. If columns are specified, they shall be a structural or pole-type center support, with the upper end fastened to a support ring with three bolts in each leg and the lower end fastened to a bottom attachment base designed to permit height adjustment.

4.6.3 Medium Capacity Tanks

Unless otherwise specified by the Purchaser, tanks with a roof diameter of 29 ft, 8⁵/₈ in. (low 1000-bbl, 2000-bbl, and 3000-bbl capacity) shall be furnished with a structural- or pole-type center support, including a rafter support ring.

4.6.4 High Capacity Tanks

Unless otherwise specified by the Purchaser, tanks with a roof diameter greater than 29 ft, 8⁵/₈ in. (5000-bbl and 10,000-bbl capacity) shall be furnished with pole-type center support.

4.6.5 Rafters

Tanks with a roof diameter greater than 21 ft, 6¹/₂ in. (low 1000-bbl, 2000-bbl, 3000-bbl, 5000-bbl, and 10,000-bbl capacity) shall be furnished with rafters attached to each radial roof joint. The allowable design stresses for rafters is given in Section 4.6. Each rafter shall be attached to the center support ring and by brackets to the top chime area. The depth of rafters, measured from the underside of the roof at each end, shall be 5¹/₂ in. for low 1000-bbl, 2000-bbl,

* Based on included maximum water load plus superimposed roof load.

3000-bbl, and 5000-bbl tanks, and 6³/₄ in. for 10,000-bbl tanks. Rafters shall be punched or drilled to accommodate supporting clips for bolt retainers.

Except as specified above, rafter design details are subject to agreement between the Purchaser and Manufacturer.

4.7 Bolted Joints

Bolt holes shall be ¹⁷/₃₂ in. diameter. The tolerance on bolt-hole spacing shall be $\pm 1/32$ in. between any two holes, measured in the flat before forming.

If using square head or hex head bolts, bolt retainers in the form of channels or other shapes shall be provided outside of all bottom joints, and inside of all staves, cleanouts, and roofs to prevent inaccessible bolt heads from turning.

4.8 Joint Gaskets

Joint gaskets shall be dimensioned on the assumption that the final net thickness in place will be ¹/₁₆ in.

4.9 Bolting

All tank bolts and nuts, except flange bolting, shall be ¹/₂ in. diameter and shall comply with Annex A.

4.10 Cleanouts

4.10.1 General

Cleanouts shall be furnished, unless otherwise specified by the Purchaser. The location of the cleanout shall be as specified by the Purchaser.

4.10.2 Type of Cleanouts

Cleanouts shall be of the flush-type, the extended-neck type, or other type, if specified by the Purchaser, using the material type and strength equivalent to sheet or plate stave material used.

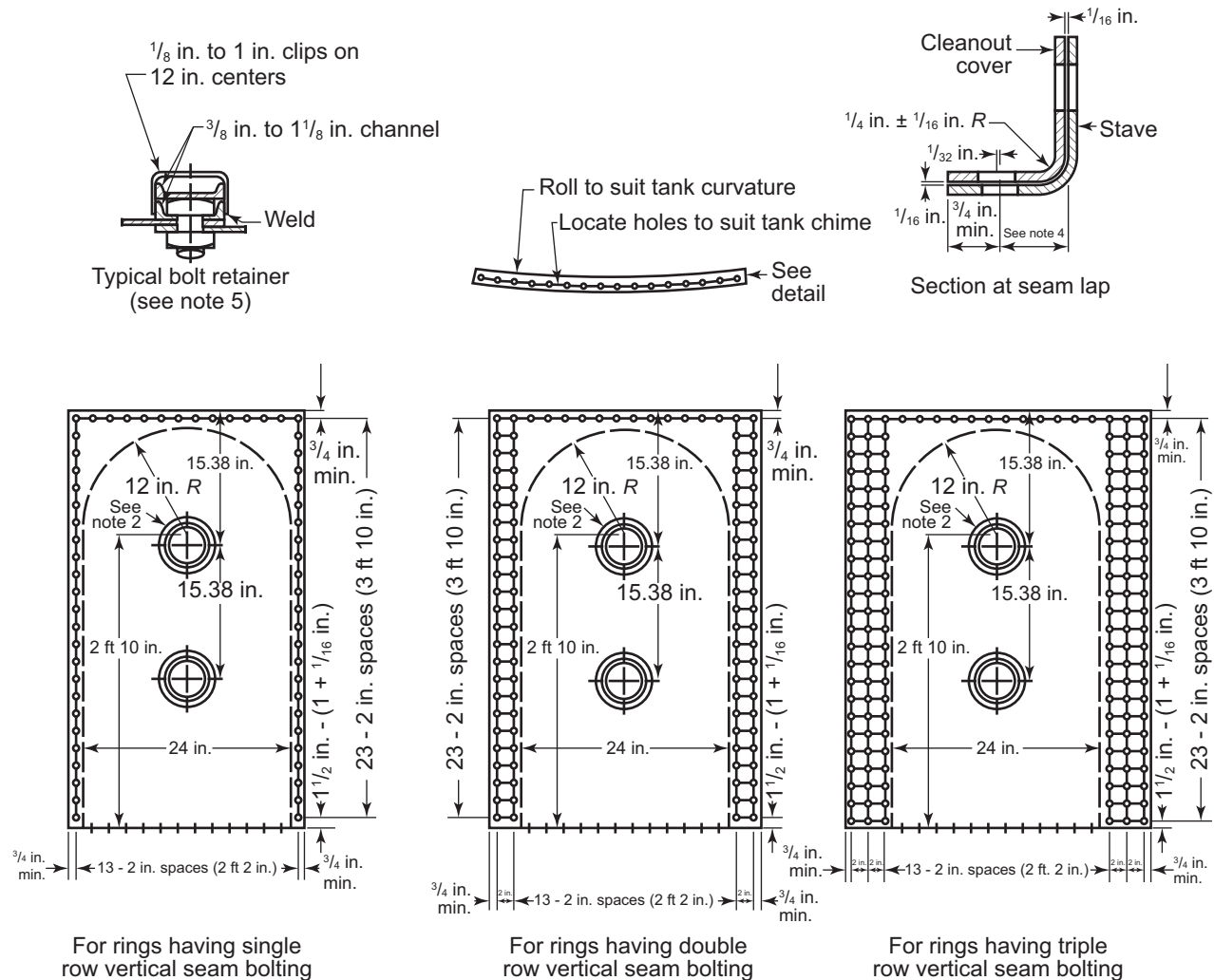
4.10.3 Flush-type Cleanouts

Flush-type cleanouts shall conform to Figure 6, except that alternative widths and heights of the cleanout opening in the tank stave shall be supplied, if so agreed in writing between the Purchaser and the Manufacturer.

4.10.4 Extended-neck or Other Type Cleanouts

Cleanouts of the extended neck or alternative type shall conform to the following requirements.

- a) The height of cleanout opening in the stave shall be 3 ft, 10 in., unless agreed in writing by the Purchaser and Manufacturer to be 3 ft.
- b) The bolting details for attachment of the cleanout neck to the stave shall conform to Figure 7, regardless of type of cleanout.
- c) The design shall provide a minimum factor of safety of 2.5 (based on yielding) as installed and as determined by Manufacturer proof test and/or calculation. The Manufacturer shall submit evidence acceptable to the Purchaser, indicating compliance with this requirement.
- d) The design of extended-neck cleanout shown in Figure 7 has been determined to be adequate for tanks of high 1000-bbl and smaller capacity, in the sizes shown in Table 1. If used on such tanks, the requirements of 4.10.4(c) shall be considered to have been satisfied.



NOTE 1 The nominal thickness of the cleanout cover shall be not less than that of the stave to which attached.

NOTE 2 Cleanouts shall be furnished with bolt retainers, handles, or both, if so specified on the purchase order. If not otherwise specified, retainers only shall be supplied. Alternative types of retainers may be substituted if demonstrated adequate.

NOTE 3 See 4.10.3 for alternative designs.

NOTE 4 See Figure 4.

NOTE 5 Bolt retainers are not required when round-head bolts are used.

Figure 6—Flush-type Cleanout

4.11.3 Bolted Pipe Flanges

Except as provided in 4.11.2, bolted pipe flanges shall be attached using bolts or bolt-studs, and shall conform to the following requirements.

- a) Flanges shall be furnished as specified by the Purchaser, per Table 3 and Figure 8.
- b) The inner flange shall be provided with bolt-head or bolt-stud nut retainers.
- c) The length of thread shall conform to the requirements of Table 3. In all other respects the threads shall conform to the requirements of API 6A.

Table 3—Bolted Pipe Flanges (See Figure 8)

(1)	(2)	(3)	(4)	(5)	(6)
Size, in.	2	3	4	6	8
Diameter of bolt circle, in.	4	5 ³ / ₈	6 ³ / ₈	9	11 ¹ / ₄
Number of bolts	4	4	5	6	8
Diameter of bolts, in.	1/2	5/8	5/8	5/8	5/8
Diameter of bolt holes, in.	5/8	3/4	3/4	3/4	3/4
Minimum thread length, <i>Y</i> , in.	7/8	1 ³ / ₁₆	1 ⁵ / ₁₆	1 ⁹ / ₁₆	1 ³ / ₄
Depth of counterbore	Optional with Manufacturer	Optional with Manufacturer	Optional with Manufacturer	Optional with Manufacturer	Optional with Manufacturer
Outside diameter of flange, <i>O</i> , in.	5 ¹ / ₈	6 ⁵ / ₈	7 ³ / ₄	10 ¹ / ₂	12 ³ / ₄

4.11.4 Flange Attachment

If specified by the Purchaser, bolted pipe flanges conforming to Table 3 and Figure 8 shall be furnished and the tank members shall be drilled for flange attachment as follows.

- a) The bolt-circle diameter and the number of bolt holes shall be as shown in Table 3 and Figure 8.
- b) Bolt-hole size shall be optional with the Manufacturer, but shall accommodate the sizes of bolts given in Table 3.
- c) Flange bolt holes shall straddle the radial centerlines on roofs and bottoms and vertical centerlines on staves, except that for the 4-in., 5-hole flange, the odd hole shall be located on the centerline toward the center of the roof or the top of the stave.

4.11.5 Downcomer Pipe

If specified by the Purchaser, a downcomer pipe shall be installed with design agreed in writing by the Purchaser and Manufacturer.

4.12 Bolting Patterns for the Gauge Hatches and Relief Valve

If specified by the Purchaser, the tank roof shall be cut and drilled for the direct attachment of bolted gauge hatches and pressure-relief valves or vacuum-relief valves, with bolting patterns as shown in Figure 9, Figure 10, and Figure 11.

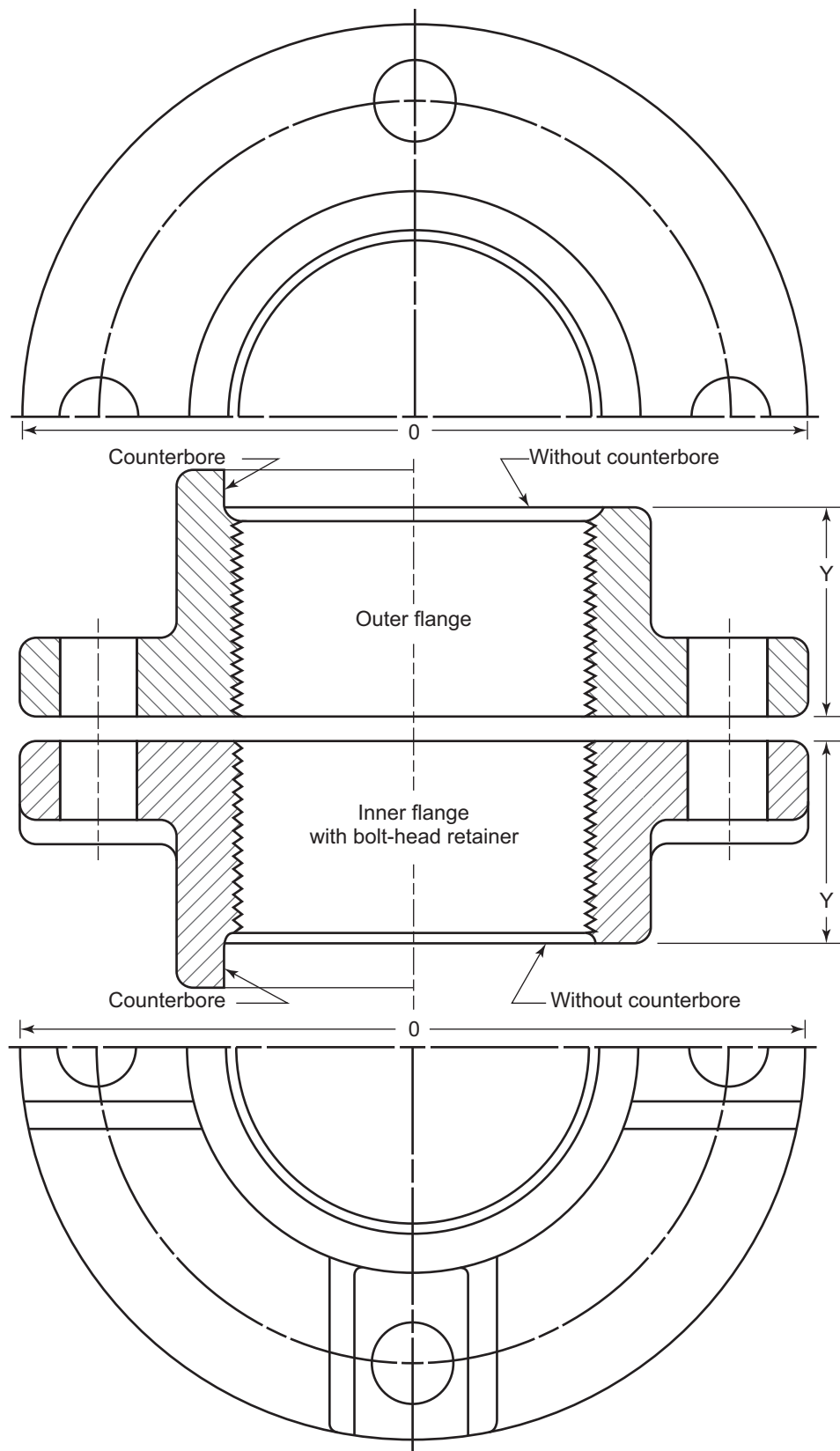
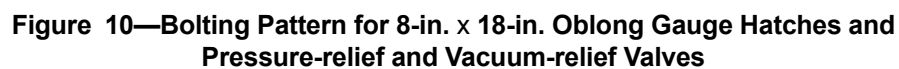
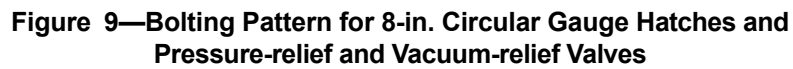


Figure 8—Bolted Piping Flanges (See Table 3 for Dimensions)



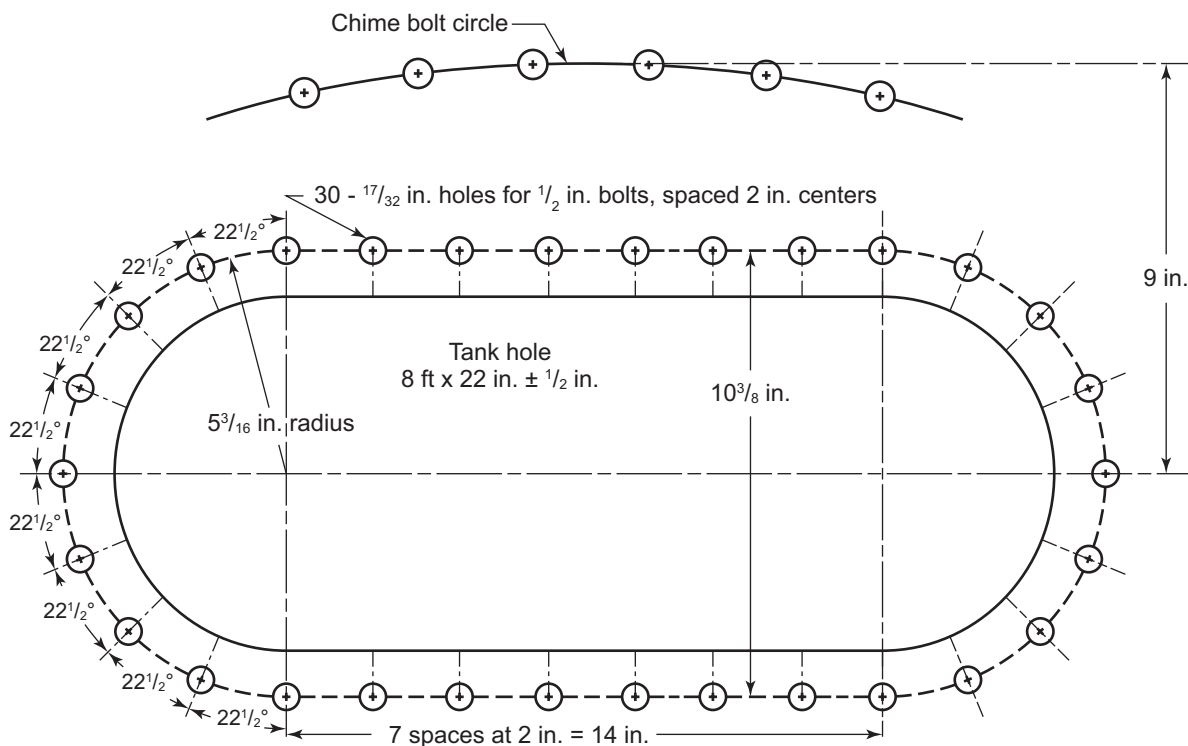


Figure 11—Bolting Pattern for 8-in. x 22-in. Oblong Gauge Hatches and Pressure-relief and Vacuum-relief Valves

5 Venting Requirements

5.1 Normal Venting

The Purchaser shall specify the number, size and location of connections to be installed in the roof of each tank to provide for normal inbreathing and outbreathing due to temperature changes and to liquid movement into and out of the tank. These connections shall be an opening for vent piping provided by the Purchaser, or to be fitted with a PV vent valve and/or flame arrestor provided by the Purchaser and properly sized in accordance with API 2000. The pressure setting shall be at least $\frac{1}{2}$ oz/in.² less than the opening pressure of devices used for emergency venting.

5.2 Emergency Venting

The Purchaser shall specify the number, size and location of connections to be provided in the roof of each tank for emergency venting to supplement the capacity of normal venting. These connections are to be fitted with pressure relieving devices provided by the Purchaser and properly sized in accordance with API 2000. The full flow pressure of emergency pressure relieving devices shall not exceed the design pressure of the tank on which they are installed. These Purchaser-specified pressure relieving devices shall take the form of:

- a) larger or additional normal vents (open vents or PV vent valves);
- b) larger or additional gauge hatches; or
- c) roof dome covers (see Figure 5) installed with loose fitting long bolts and suitable gaskets so that the dome covers will lift at the specified pressure.

6 Walkways, Stairways, Ladders, and Platforms

The Purchaser shall specify any walkways, stairways, ladders, and/or platforms to be provided with the tank. If specified, see Annex B for requirements.

7 Erection and Clean Up

7.1 This Specification establishes the minimum requirements for the purchase of material, design, fabrication, shop inspection and accessories. This Specification does not address preparation of the tank site, foundation and/or tank construction, connections, access, testing, and inspection. The Purchaser shall make additional consideration to achieve a complete installation and to specify additional scope requirements.

NOTE Refer to API RP 12R1 for additional field construction requirements.

7.2 The following are general and field construction requirements specific to bolted tank installation, or are not addressed in API RP 12R1.

7.2.1 Tank staves shall be erected with the male side on the left when facing the outside surface of the stave (see Figure 4).

7.2.2 The dimensions as specified herein are based on the assumption that most of the slack, due to the difference in bolt and bolt-hole diameters, will be taken up in all stave joints by slippage when the tank is initially filled. The bottom and deck roof bolt-circle diameters provide for such slippage. At the time of erection, some pinning of the vertical stave joints will be required to bring the bolt holes into alignment.

7.2.3 Upon completion of erection, the erector shall remove or dispose of all rubbish and other unsightly material caused by erecting operations and shall leave the premises in an as good condition as found.

8 Marking

8.1 Tanks manufactured in conformance with this Specification shall be identified by nameplates bearing, as a minimum, the information shown in Figure 12.

8.2 A tank that is not manufactured in full conformance with this Specification shall not be identified by a nameplate bearing the compliance statement “Manufactured in Accordance with API Specification 12B”, as shown in Figure 12. Additional requirements apply for use of the API Monogram (see Annex D).

Manufactured in Accordance with API Specification 12B	
Manufacturer	_____
Serial Number	_____
Year Built	_____
Nominal Diameter	_____
Nominal Height	_____
Design Pressure	_____ oz
Nominal Capacity	_____ bbl

NOTE May be completed after field erection

Figure 12—Nameplate Format

8.3 Nameplates shall be made of a corrosion-resistant material and installed on the cleanout stave at approximately 8 in. above the top of the cleanout cover or frame. The nameplate shall be attached to a boss seal welded to the stave (prior to galvanizing, if applicable) or supported by another means.

8.4 Nameplates may be attached at the point of manufacture or, if the tank is erected by the Manufacturer, at the time of field erection.

9 Inspection and Rejection

9.1 Inspection Notice

If the inspector representing the Purchaser desires to inspect the tank materials, reasonable notice shall be given as to the time that the production run will be made.

9.2 Inspection by Purchaser

The inspector representing the Purchaser shall have access, at all times, and to all parts of the Manufacturer's works, which concern the Manufacturer of the material ordered, while work on the contract is being performed. The Manufacturer shall afford the inspector reasonable access to facilities to satisfy him/her that the material is being manufactured in accordance with this Specification. All inspections shall be made at the place of manufacture prior to shipment, unless otherwise specified on the purchase order; and shall be so conducted as not to interfere unnecessarily with manufacturing operations.

9.3 Rejection

Material which shows injurious defects on mill inspection or subsequent to acceptance at Manufacturer's works, or which proves defective when properly applied in service, may be rejected and the Manufacturer so notified.

9.4 Compliance

The Manufacturer shall be responsible for complying with all provisions of this Specification. The Purchaser may make any investigation necessary to be assured of Manufacturer compliance and may reject all material that does not comply with this Specification.

Annex A **(normative)**

Specification for Tank Bolting

A.1 Scope

This annex covers tank bolting $\frac{1}{2}$ inches in diameter that is not longer than $1\frac{1}{2}$ in. Bolts and nuts shall be either black-finish or galvanized, as specified by the Purchaser.

A.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/in.², based on the stress area (mean thread area), or approximately 91,000 lb/in.², based on the root thread area.

A.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.

A.4 Stripping Test

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

A.5 Head Test

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

A.6 Number of Tests

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

A.7 Retests

If the sample from the test lot fails to meet the requirements of a specified test, two additional samples shall be tested; in which case, both samples shall meet the test requirement.

A.8 Thread Requirements

Threads of unplated product shall be coarse-thread series as specified for screw threads (ASME 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 in.

A.9 Bolt Requirements

Bolts shall be regular square, unless otherwise agreed upon between the Purchaser and the Manufacturer, in which case they may be regular hex. All bolts shall comply with the applicable section of the latest edition of ASME B18.2.1.

A.10 Nut Requirements

Nuts shall be regular square, unless otherwise agreed upon between the Purchaser and the Manufacturer, in which case they may be regular hex. All nuts shall comply with the applicable section of the latest edition of ASME B18.2.2.

A.11 Galvanizing

Unless otherwise specified, galvanized bolts and nuts shall be hot-dip galvanized in accordance with the requirements of ASTM A153. The weight of coating shall be that specified for Class C materials in ASTM A153 and the nuts shall be tapped after galvanizing. If specified by the Purchaser 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 B695 or to the coating thickness, adherence, and quality requirements for Class C of ASTM A153. Mechanically zinc-coated nuts for assembly with mechanically zinc-coated bolts shall be tapped oversize prior to coating and need not be re-tapped afterwards.

A.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 internal use.

A.13 Specification for Tank Bolting Using Round-head Bolts

A.13.1 Scope

This annex covers tank bolting using 1/2 in. diameter SAE Grade 5 round-head bolts. Bolts and nuts shall be mechanically galvanized, hot-dip galvanized, or electro-zinc plated.

A.13.2 Physical Properties

The breaking load of the bolts, tested in full size, shall not be less than 17,000 lb.

NOTE The breaking load of 17,000 lb is equivalent to a tensile strength of 120,000 lb/in.², based on the stress area (mean thread area), or approximately 135,000 lb/in.², based on the root thread area.

A.13.3 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.

A.13.4 Stripping Test

The nuts for bolts shall be capable of developing the load specified on A.13.2 without stripping.

A.13.5 Head Test

During the tension test specified in A.13.3, failure shall occur in the threaded section and not at the junction of the head and shank.

A.13.6 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 ensure 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 contemplated. If specified on order, one tension test shall be made using material from each lot. A lot shall consist of 5,000 pieces or fraction thereof.

A.13.7 Retests

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

A.13.8 Thread Requirements

Threads of unplated product shall be coarse-thread series as specified for screw threads (ASME 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 in.

A.13.9 Bolt Requirements

Round-head bolts shall have a fin neck or ribbed neck to prevent turning upon tightening. The height of the head shall be 0.25 in. to 0.27 in., with a diameter of 1 in. to 1.06 in.

On ribbed neck bolts, the longitudinal ribs shall have a length of 0.186 in. to 0.206 in. with an outside diameter of 0.540 in. to 0.550 in. There shall be at least 16 ribs.

On fin neck bolts, there shall be four radial fins equally spaced under the bottom side of the head. The longitudinal length of the fins shall be 0.156 in. to 0.187 in., with an outside diameter of 0.675 in. to 0.695 in.

For corrosion protection, the head of the bolt may be encapsulated with polyvinylidene fluoride (PVDF), ABS, or polyester. A sealing ring shall be molded under the head of the bolt.

A.13.10 Nut Requirements

Nuts shall be regular square or regular hex. All nuts shall comply with the applicable section of the latest edition of ASME B18.2.2.

For corrosion protection, nuts in contact with the stored liquid may be protected with threaded PVDF nut caps, or the nuts may be encapsulated with polyester.

A.13.11 Galvanizing

Galvanized bolts and nuts shall be hot-dip galvanized in accordance with the requirements of ASTM A153. The weight of coating shall be that specified for Class C materials in ASTM A153 and the nuts shall be tapped after galvanizing. Mechanically galvanized bolts and nuts shall be mechanically zinc-coated, and the coating shall conform to the requirements for Class 50 of ASTM B695 or to the coating thickness, adherence, and quality requirements for Class C of ASTM A153. Mechanically zinc-coated nuts for assembly with mechanically zinc-coated bolts shall be tapped oversize prior to coating and need not be re-tapped afterwards.

Electro-zinc plated bolts and nuts shall have a minimum zinc coating of 0.0005 in. with a yellow dichromate dip. Electro-zinc plated nuts do not require oversize tapping prior to plating.

A.13.12 Marking

Bolt heads or shank ends shall be marked to identify the bolt Manufacturer, including three radial marks indicating SAE Grade 5. Encapsulated bolts are to be marked prior to be encapsulated. Markings may be either raised or depressed.

Annex B (normative)

Walkways, Stairways, and Ladders

B.1 General

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

B.2 Access

The Purchaser shall specify if individuals are required to have access to devices on the roof, where suitable guard railings shall be installed to provide fall protection.

NOTE Walkways, platforms, and stairways or ladders are intended to provide access to devices on or near the roof, and not for personnel access onto the roof.

B.3 Walkways

Walkways shall consist of tread sections, railing assemblies, and toe-boards designed and assembled so that the completed structure will support a uniform load of 50 lb/ft², or a concentrated load of 1000 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. If intermediate supports are required, the vertical members shall terminate at the top rail. The base for ground shall be of concrete or other suitable permanent foundation.

Walkways shall be a minimum of 26 in. wide. Walkway tread shall be uniformly perforated from the bottom with shaped punches to form a non-skid surface. Optionally, if specified by the Purchaser, the surface of walkway sections may be fabricated from structural expanded metal or grating to avoid the buildup of snow or ice.

B.4 Railings

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

B.5 Toe Plates

Toe plates 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 walkway.

B.6 Midrail

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

B.7 Brackets

The tank shall be equipped with two bracket assemblies, supported from the top and bottom chimes of the top ring. The brackets shall be installed to provide a 26-in. wide access to the tank at the point of attachment.

B.8 Stairways

If required for access to a walkway section, the stairway shall be designed for field erection, and shall be capable of supporting a minimum of 100 lb per linear ft of tread width, or a concentrated load of 1000 lb at any point on the stairway without deflecting more than $\frac{1}{360}$ of the unsupported stairway length. Stairway width shall be a minimum of 26 in. The stairway shall be designed and installed to have an angle of 45 degrees with the horizontal, unless otherwise specified by the Purchaser. If installed at 45 degrees, the stairway shall have a run and rise of 8 $\frac{1}{2}$ in. with a nominal tread width of not less than 8 in. 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 area met. The rise height and tread width shall be uniform throughout any stairway, including any foundation used as one or more steps.

B.9 Railings

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 in. nor more than 34 in., 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 with the top rail of the walkway railing shall have a smooth transition, through the use of a structural gusset member.

B.10 Spiral Stairways

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 in., measured 13 in. from the exterior arc.

Spiral stairways are not recommended for installation on tanks less than 15 ft, 6 in. in diameter.

B.11 Ladders

B.11.1 Fixed ladders may be used in lieu of stairways. The use of a platform is required unless specified otherwise by the Purchaser. The platform shall have minimum dimensions of 26 in. × 30 in. with standard railings, except at the entrance from the ladder.

B.11.2 Ladders, if used, shall be anchored with the center of the rung at least 7 in. from the surface of the tank or other obstruction.

B.11.3 Rungs shall be a minimum of $\frac{3}{4}$ in. diameter, spaced a maximum of 12 in., center to center, with a minimum clear length of 16 in., and designed to support a minimum load of 200 lb.

B.11.4 Open ladders may be used to climb a maximum of 20 ft., and caged ladders or safety slide devices shall be used if the climbing height is above 20 ft.

Annex C

(informative)

Suggestions for Ordering Bolted Tanks

In placing orders for tanks to be manufactured in accordance with API 12B, Purchasers should specify the following on their purchase order:

Specification	API 12B
Number of tanks	_____
Nominal capacity	Table 1, Column 1
Size	_____
Inside diameter	Table 1, Column 3
Height of shell	Table 1, Column 4
Type of cleanout	4.10
Design of flush-type cleanout	4.10.3 and Figure 6, Note 2
Design of extended neck cleanout	4.10.4
Cut-outs for gauge hatch and PV relief valve	4.12
Delivery date and shipping instructions	_____
Inspection by Purchaser	Section 9

The Purchaser shall state requirements on the purchase order for the following options:

Finish	3.8
Bolting	3.9
Bottom, stave, and roof thickness	Table 2, Footnote a
Open-top tanks	4.5.4
Two-piece cleanout cover plates	4.10.5
Cleanout location	4.10
Inlet and outlet connections	4.11
Piping flanges	4.11
Walkways, stairways, and ladders	Annex B

Venting connections	4.12 and Section 5
Downcomer pipe and design	4.11.5
Alternative designs of tank bottoms	4.3
Alternative design of roofs	4.5
Rafter design	4.6.5
Alternative widths and heights of cleanout	4.10.4
Alternative designs of piping flanges	4.11.2

Annex D (informative)

Use of the API Monogram by Licensees

D.1 Scope

The API Monogram® is a registered certification mark owned by the American Petroleum Institute (API) and authorized for licensing by the API Board of Directors. Through the API Monogram Program, API licenses product manufacturers to apply the API Monogram to new products which comply with product specifications and have been manufactured under a quality management system that meets the requirements of API Q1. API maintains a complete, searchable list of all Monogram licensees on the API Composite List website (www.api.org/compositelist).

The application of the API Monogram and license number on products constitutes a representation and warranty by the licensee to API and to purchasers of the products that, as of the date indicated, the products were manufactured under a quality management system conforming to the requirements of API Q1 and that the product conforms in every detail with the applicable standard(s) or product specification(s). API Monogram program licenses are issued only after an on-site audit has verified that an organization has implemented and continually maintained a quality management system that meets the requirements of API Q1 and that the resulting products satisfy the requirements of the applicable API product specification(s) and/or standard(s). Although any manufacturer may claim that its products meet API product requirements without monogramming them, only manufacturers with a license from API can apply the API Monogram to their products.

Together with the requirements of the API Monogram license agreement, this annex establishes the requirements for those organizations who wish to voluntarily obtain an API license to provide API monogrammed products that satisfy the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program requirements.

For information on becoming an API Monogram Licensee, please contact API, Certification Programs, 1220 L Street, N. W., Washington, DC 20005 or call 202-682-8145 or by email at certification@api.org.

D.2 Normative References

API Specification Q1, *Specification for Quality Management System Requirements for Product Manufacturing for the Petroleum and Natural Gas Industry*

D.3 Terms and Definitions

For purposes of this annex, the following terms and definitions apply.

D.3.1

API monogrammable product

Product that has been newly manufactured by an API licensee utilizing a fully implemented API Q1 compliant quality management system and that meets all the API specified requirements of the applicable API product specification(s) and/or standard(s).

D.3.2

API specified requirements

Requirements, including performance and licensee-specified requirements, set forth in API Q1 and the applicable API product specification(s) and or standard(s).

NOTE Licensee-specified requirements include those activities necessary to satisfy API specified requirements.

D.3.3**API product specification**

Prescribed set of rules, conditions, or requirements attributed to a specified product which address the definition of terms; classification of components; delineation of procedures; specified dimensions; manufacturing criteria; material requirements, performance testing, design of activities; and the measurement of quality and quantity with respect to materials; products, processes, services, and/or practices.

D.3.4**licensee**

Organization that has successfully completed the application and audit process and has been issued a license by API.

D.3.5**design package**

Records and documents required to provide evidence that the applicable product has been designed in accordance with API Q1 and the requirements of the applicable product specification(s) and/or standard(s).

D.4 Quality Management System Requirements

An organization applying the API Monogram to products shall develop, maintain, and operate at all times a quality management system conforming to API Q1.

D.5 Control of the Application and Removal of the API Monogram

Each licensee shall control the application and removal of the API Monogram in accordance with the following:

- a) Products that do not conform to API specified requirements shall not bear the API Monogram.
- b) Each licensee shall develop and maintain an API Monogram marking procedure that documents the marking/monogramming requirements specified by this annex and any applicable API product specification(s) and/or standard(s). The marking procedure shall:
 - 1) define the authority responsible for application and removal of the API Monogram;
 - 2) define the method(s) used to apply the Monogram;
 - 3) identify the location on the product where the API Monogram is to be applied;
 - 4) require the application of the licensee's license number and date of manufacture of the product in conjunction with the use of the API Monogram;
 - 5) require that the date of manufacture, at a minimum, be two digits representing the month and two digits representing the year (e.g. 05-12 for May 2012) unless otherwise stipulated in the applicable API product specification(s) or standard(s); and
 - 6) require application of the additional API product specification(s) and/or standard(s) marking requirements.
- c) Only an API licensee may apply the API Monogram and its designated license number to API monogramable products.
- d) The API Monogram license, when issued, is site-specific and subsequently the API Monogram shall only be applied at that site specific licensed facility location.

- e) The API Monogram may be applied at any time appropriate during the production process but shall be removed in accordance with the licensee's API Monogram marking procedure if the product is subsequently found to be out of conformance with any of the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program.

For certain manufacturing processes or types of products, alternative API Monogram marking procedures may be acceptable. Requirements for alternative API Monogram marking are detailed in the API Policy, *API Monogram Program Alternative Marking of Products License Agreement*, available on the API Monogram Program website at <http://www.api.org/alternative-marking>.

D.6 Design Package Requirements

Each licensee and/or applicant for licensing must maintain a current design package for all of the applicable products that fall under the scope of each Monogram license. The design package information must provide objective evidence that the product design meets the requirements of the applicable and most current API product specification(s). The design package(s) must be made available during API audits of the facility.

In specific instances, the exclusion of design activities is allowed under the Monogram Program, as detailed in *Advisory # 6*, available on API Monogram Program website at <http://www.api.org/advisories>.

D.7 Manufacturing Capability

The API Monogram Program is designed to identify facilities that have demonstrated the ability to manufacture equipment that conforms to API specifications and/or standards. API may refuse initial licensing or suspend current licensing based on a facility's level of manufacturing capability. If API determines that additional review is warranted, API may perform additional audits (at the organization's expense) of any subcontractors to ensure their compliance with the requirements of the applicable API product specification(s) and/or standard(s).

D.8 API Monogram Program: Nonconformance Reporting

API solicits information on products that are found to be nonconforming with API specified requirements, as well as field failures (or malfunctions), which are judged to be caused by either specification deficiencies or nonconformities with API specified requirements. Customers are requested to report to API all problems with API monogrammed products. A nonconformance may be reported using the API Nonconformance Reporting System available at <http://compositelist.api.org/ncr.asp>.

EXPLORE SOME MORE

Check out more of API's certification and training programs, standards, statistics and publications.

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