UL 142

STANDARD FOR SAFETY

Steel Aboveground Tanks for Flammable and Combustible Liquids

UL Standard for Safety for Steel Aboveground Tanks for Flammable and Combustible Liquids, UL 142

Tenth Edition, Dated May 17, 2019

Summary of Topics

This revision of ANSI/UL 142 dated January 21, 2021 includes the following changes in requirements:

– Revising Section 35 – 38 requirements for revised OSHA references to correct current inaccuracies; 36.1, 36.3 – 36.5, Section 37, Section 38, 52.1.1

– Add requirements for double wall manways for aboveground tanks; 9.6, Figure 9.5, Table 9.5

– Revise Table 23.1 to reverse a change made in error

– Leakage Test revisions to differentiate between requirements for Performance and Production testing; 42.2.1

– Addition of section for Alignment of Structural Members; Section 50A

– Editorial corrections; 1.3, 8.5, 8.6, Table 8.1, 8.9, 12.2, 12.3, 23.4, 52.1.1, 53.4

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated August 7, 2020 and November 13, 2020.

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The most recent designation of ANSI/UL 142 as an American National Standard (ANSI) occurred on January 21, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 142 on August 11, 1989. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover steel primary, secondary and diked type atmospheric storage tanks intended for the storage of noncorrosive, stable flammable and combustible liquids with a specific gravity (spg) not exceeding 1.0 in aboveground applications, except for tanks storing liquids with a specific gravity that exceeds 1.0, covered in Section 12.

1.2 Each tank type may be fabricated in a combination of various shapes (cylindrical, rectangular or obround) and orientations (horizontal, vertical) with or without multiple compartments, as covered in this Standard.

1.3 These tanks are intended for installation and use in accordance with the Flammable and Combustible Liquids Code, NFPA 30; the Standard for Installation of Oil-Burning Equipment, NFPA 31; the Code for Motor Fuel Dispensing Facilities and Repair Garages, NFPA 30A; the Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, NFPA 37; the Uniform Fire Code, NFPA 1; and the International Fire Code published by the International Code Council.

1.4 The tanks covered by these requirements are fabricated, inspected and tested for leakage before shipment from the factory as completely assembled vessels.

1.5 These requirements do not apply to tanks covered by the Specification for Field-Welded Tanks for Storage of Production Liquids, API 12D; and the Specification for Shop-Welded Tanks for Storage of Production Liquids, API 12F.

1.6 These requirements do not cover special evaluations for resistance to hurricanes, tornadoes, earthquakes, floods, or other natural disasters; or resistance to vehicle impact.

1.7 These requirements do not cover portable tanks intended for transporting flammable or combustible liquids (such as shipping containers), or mobile use applications (such as mounted on a trailer). These types of products are covered by separate UN, DOT, or equipment product standards.

2 General

2.1 Units of Measurement

2.1.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Undated References

2.2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

3 Glossary

3.1 For the purpose of this standard the following definitions apply.

3.2 ABOVEGROUND TANK (ABOVEGROUND STORAGE TANK or AST) – A storage tank that is intended for installation above grade, at grade or below grade without backfill.

3.3 ATMOSPHERIC TANK – A storage tank that has been designed to operate at pressures from − 0.5 psig to 1.0 psig (− 3.4 kPa to 6.9 kPa) measured at the top of the tank.

3.4 DIKE – A single wall construction forming a bottom and sides with open or closed top intended to provide secondary containment of aboveground tank(s) but not intended to be pressurized for leak testing. Dike types include combinations of rectangular or cylindrical shapes or horizontal or vertical orientations. Open top dike constructions do not have covers to prevent precipitation or debris from entering the dike area. Closed top dike constructions have covers to resist precipitation or debris from entering the dike area.

3.5 DIKED TANK – A primary or secondary containment tank within a steel open or closed dike intended to provide at least 110 percent containment capacity of the primary tank(s) and spill containment.

3.6 EMERGENCY VENT – A storage tank opening or device that automatically relieves excessive internal pressure due to an external fire exposure or blockage of the normal vent.

3.7 INTERSTITIAL SPACE (ANNULAR SPACE or INTERSTICE) – A space between the walls of a multiple wall tank that is capable of communicating fluid from a leak in an adjacent wall to a collection point for monitoring.

3.8 NORMAL VENT – A storage tank opening or device that automatically relieves internal pressure or vacuum during normal storage (atmospheric pressure equalization) and during normal operations (fill or withdraw). Normal vents are designed so as not to exceed 1.0 psig (6.9 kPa) pressure and minus 0.5 psig (minus 3.4 kPa) in the tank.

3.9 PERFORMANCE TESTS – A complete evaluation conducted on a limited quantity of representative tanks. These tests are intended to verify compliance with all applicable performance requirements in a standard.

3.10 PRIMARY CONTAINMENT – The ability of a tank design and construction to contain a liquid while in normal use.

3.11 PRIMARY CONTAINMENT TANK – The wall of a tank construction that provides primary containment.

3.12 PRODUCTION TESTS – A limited evaluation conducted on each tank prior to shipping. These tests are intended to verify compliance with production requirements in a standard, such as leakage.

3.13 SECONDARY CONTAINMENT – The ability of a tank design or construction to contain a liquid only in abnormal use (from primary containment leakage or rupture).

3.14 SECONDARY CONTAINMENT ABOVEGROUND TANK FOR FLAMMABLE LIQUIDS – A primary containment aboveground tank contained within a steel secondary containment shell forming an interstitial (annular) space, which is capable of being monitored for leakage into the space from either the interior or exterior walls. Secondary containment aboveground tank types include: horizontal cylindrical, vertical cylindrical, and rectangular.

3.15 STORAGE TANK (TANK) – A vessel having a liquid capacity that exceeds 60 gal (230 L), is intended for stationary installation, and is not used for processing.

3.16 TANK ACCESSORY – Optional devices or components of an aboveground tank intended to provide a specific function, such as walking or climbing access, load bearing support, spill containment, venting or heating.

CONSTRUCTION – ALL TANKS

4 Capacities and Dimensions

4.1 Capacities, dimensions, and construction details shall comply with the applicable requirements of this standard.

4.2 Capacities per foot of length or height of cylindrical shells are given in Table A1 of Annex A for convenience in checking capacities of tanks of various diameters.

4.3 The total (actual) capacity of a tank shall not be:

a) Less than the rated nominal capacity and

b) More than 105 percent of the rated nominal capacity.

5 Materials

5.1 A tank shall be constructed of commercial or structural grade carbon steel per 5.2 or Type 304 or 316 stainless steel per 5.3. Only new material shall be used.

5.2 Carbon steel shall be in accordance with (a), (b), or both:

a) Comply with the Specification for Carbon Structural Steel, ASTM A36M; or Specification for Steel, Sheet and Strip, Hot Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, ASTM A1011/A1011M; or Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled, ASTM A635/A635M.

b) Have a carbon content of 0.3 percent or less, or a carbon equivalency (CE) of 0.53 percent or less as determined by the formula below, and mechanical strength and welding characteristics at least equivalent to one of the steels specified in 5.2(a).

$$CE = C + \frac{(Mn + Si)}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Ni + Cu)}{15}$$

in which:

(C = Carbon, Mn = Manganese, Si = Silicone, Cr = Chromium, Mo = Molybdenum, V = Vanadium, Ni = Nickel and Cu = Copper)

5.3 Stainless steel shall comply with the Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip, ASTM A167; or Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels, ASTM A240/A240M.

5.4 The thickness of steel is to be determined by five micrometer readings equally spaced along the edge of the full piece as rolled. Thickness is to be determined on the plate or sheet not less than 3/8 inch (9.5 mm) from a cut edge and not less than 3/4 inch (19.1 mm) from a mill edge.

6 Joints

6.1 Joint types for specific tank geometries shall be selected from Table 6.1 and shall comply with the constructions referenced in the appropriate Figures.

Table 6.1
Joint types

Tank type	Joint types				
	Shells Figure 6.1	Heads Figure 6.2	Bottom Figure 6.3	Roof Figure 6.4	Corner Figure 6.5
Horizontal cylindrical					
(primary and secondary)	All[a]	All	–	–	–
Vertical cylindrical					
(primary and secondary)	All[a]	–	All	All	–
Rectangular					
(primary and secondary)	All	–	–	–	All
Diked					
(open and closed top)	All	–	–	–	All

[a] Shell joint #6 shall not be used on tanks with a diameter greater than 65 inches (1.65 m) unless it is used on the shell of the secondary containment tank where the secondary containment shell is in direct contact with the primary tank.

Figure 6.1

Shell joints

NO. 1

Double-welded U, V, bevel, or square groove butt joint.

NO. 2

Full penetration and complete fusion.

NO. 3

Double-welded full fillet lap joint, or single-welded full fillet lap joint on outside with 1-inch (25.4-mm) intermittent weld spaced not over 12 inches (0.3 m) on inside; minimum overlap, "A" – 1/2 inch (12.7 mm) for tank diameters 48 inches (1.2 m) or less, 3/4 inch (19.1 mm) for tank diameters over 48 inches (1.2 m).

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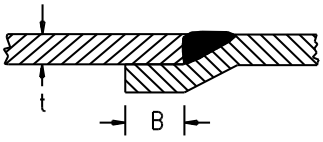
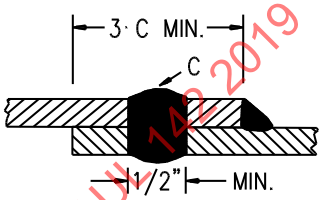


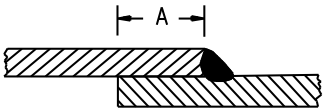
NO. 4

Groove weld equivalent in thickness to "t"; full penetration and complete fusion; minimum overlap, "B" – 1/2 inch (12.7 mm).



NO. 5

Full fillet weld on outside; "C" is 1/2 inch (12.7 mm) minimum diameter lock weld spaced not over 12 inches.



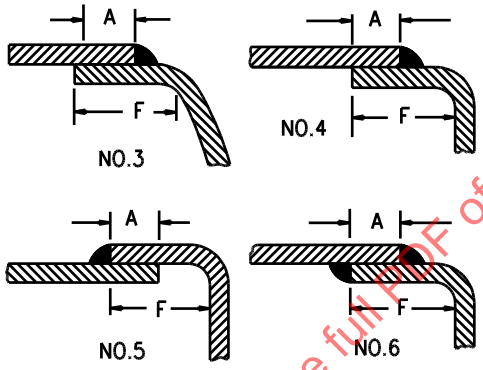
NO. 6

Single-welded full fillet lap joint; minimum overlap, "A" – 1/2 inch (12.7 mm) for tank diameters 48 inches (1.2 m) or less, 3/4 inch (19.1 mm) for tank diameters over 48 inches (1.2 m). This joint shall not be used on tanks with a diameter greater than 65 inches (1.65 m) unless it is used on the shell of the secondary containment tank where the secondary containment shell is in direct contact with the primary tank.

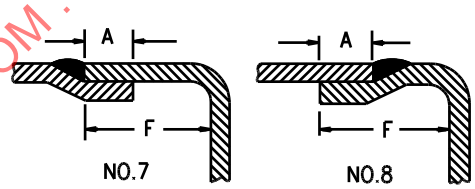
Figure 6.2

Head joints for horizontal cylindrical tanks

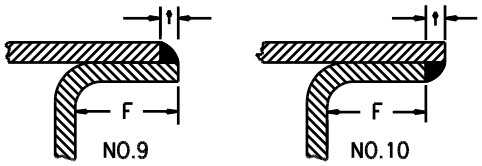
Double-welded U, V, bevel or square groove butt joint; full penetration and complete fusion.



Single-welded full fillet lap joint, single-welded full fillet lap joint on outside with 1-inch (25.4 mm) intermittent weld spaced not over 12 inches (0.3 m) on inside, or double-welded full fillet lap joint; minimum overlap, "A" – 1/2 inch (12.7 mm); "F" is five times head thickness or greater, but not less than 1/2 inch (12.7 mm).



Groove weld equivalent in thickness to that of head or shell; minimum overlap, "A" – 1/2 inch (12.7 mm); "F" is five times head thickness or greater, but not less than 1/2 inch (12.7 mm).

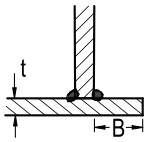


Full fillet weld; "t" – not less than thickness of shell; "F" is five times head thickness or greater, but not less than 1/2 inch (12.7 mm).

S2055B

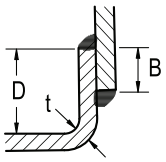
Figure 6.3

Bottom joints for vertical cylindrical tanks

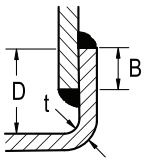


NO. 1

Double-welded full fillet joint; minimum overlap, "B" - 1/2 inch (12.7 mm) or 1-1/2 t, whichever is greater.

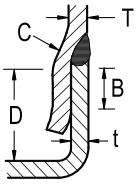


NO. 2



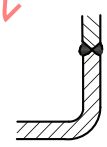
NO. 3

Double-welded full fillet lap joint; minimum overlap,. "B" - 1/2 inch (12.7 mm) or 1-1/2t, whichever is greater; "D" is 5 t or greater, but not less than 1 inch (25.4 mm).



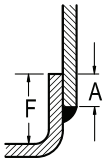
NO. 4

Groove weld at least equivalent in thickness to that of thinner member joined; minimum overlap, "B" - 1/2 inch (12.7 mm) or 1-1/2 t, whichever is greater; depth of offset, "C" - equals T; "D" is 5t or greater, but not less than 1/2 inch (12.7 mm).

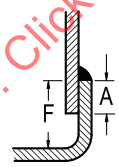


NO. 5

Double-welded U, V, bevel, or square groove butt joint; full penetration and complete fusion.

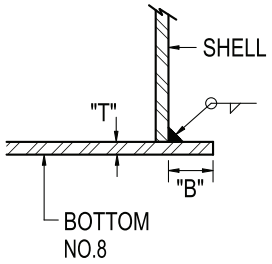


NO.6



NO.7

Single-welded full fillet lap joint, single-welded full fillet lap joint on outside with 1-inch (25.4 mm) intermittent weld spaced not over 12 inches (0.3 m) on inside; minimum overlap, "A" - 1/2 inch (12.7 mm); "F" is five times head thickness or greater, but not less than 1/2 inch (12.7 mm).



NO.8

Welded full fillet joint
"B" = 1/2 inch (12.7mm) or 1 1/2 T, whichever is greater.

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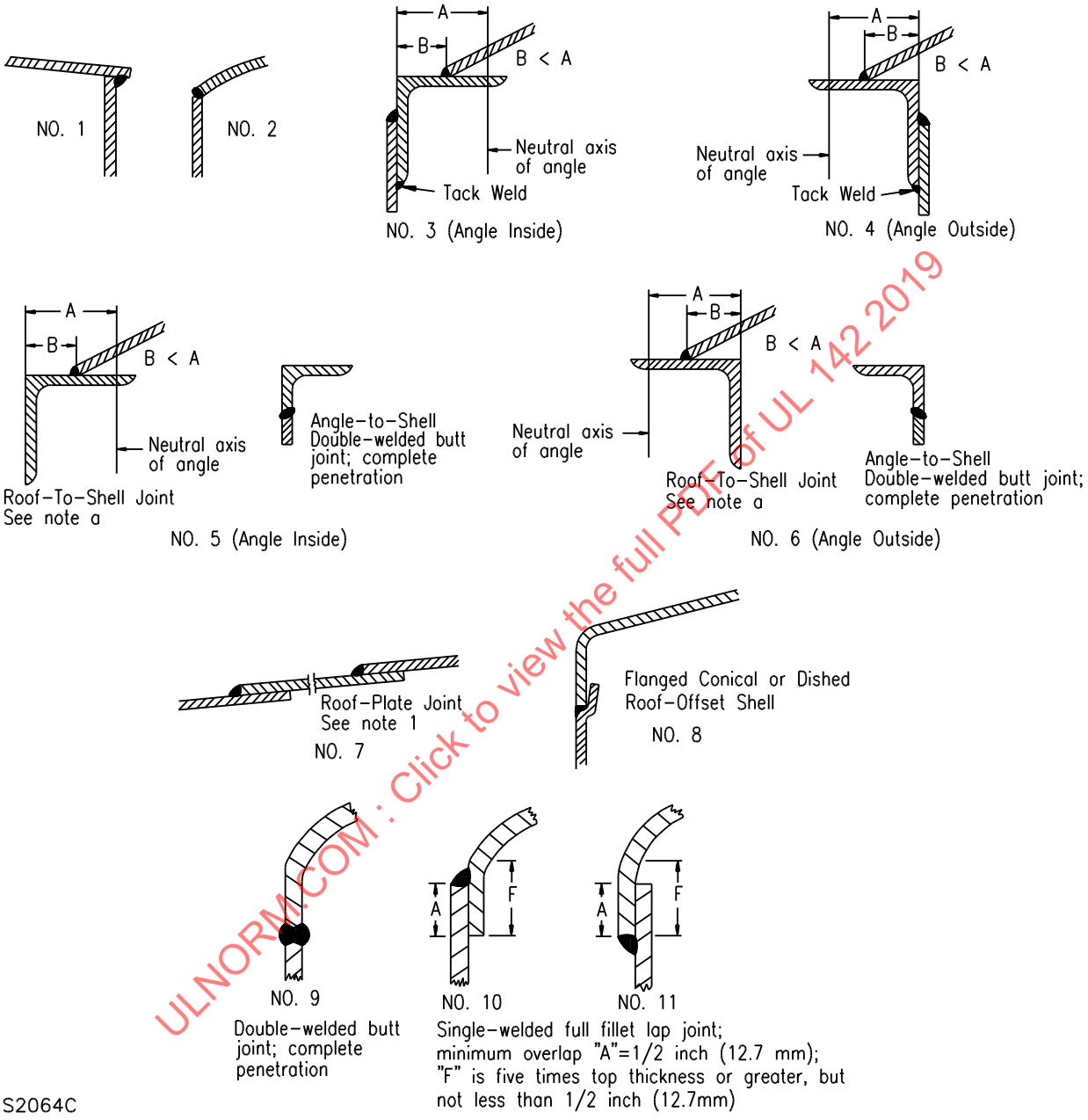
NOTE – Joint No. 8 also permissible for primary tanks up to 24 feet high

Figure 6.4

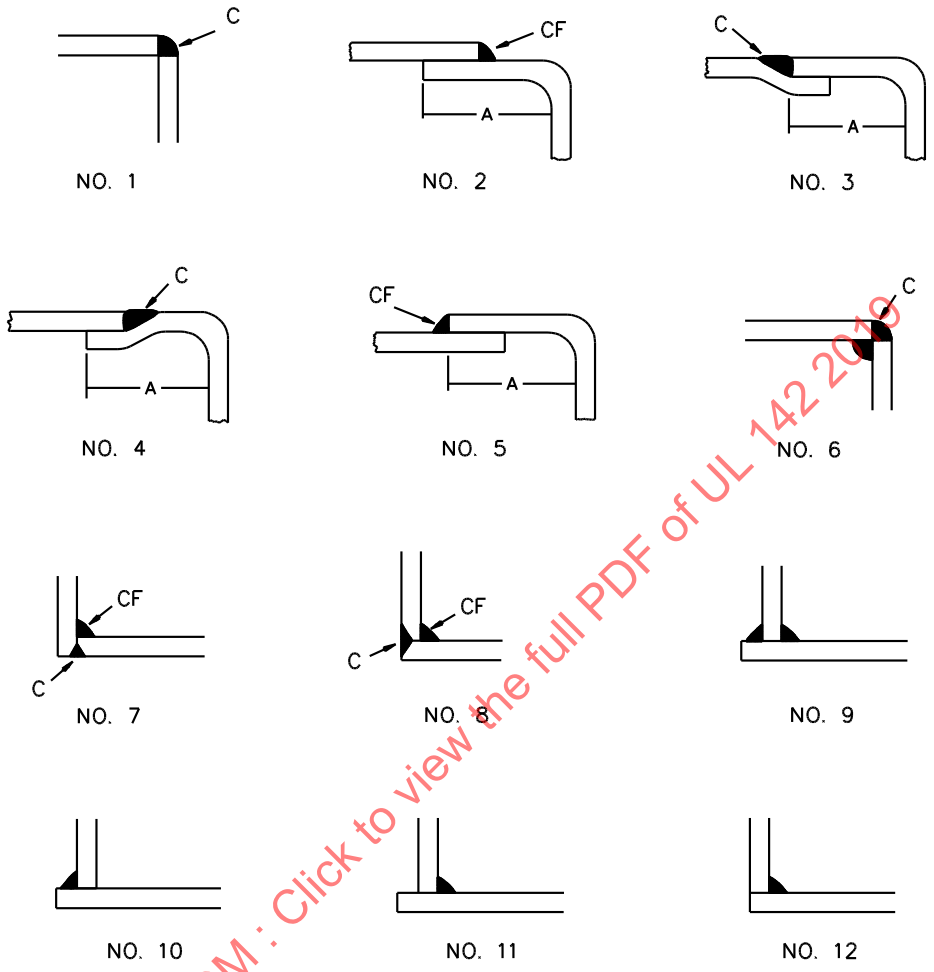
Roof joints for vertical cylindrical tanks



NOTE – Unless otherwise indicated, all welds are to be full fillet welds, at least the thickest of the thinnest material.

Figure 6.5

Corner joints



C – Continuous weld.

CF – Shall be continuous full fillet welds.

A – Not less than 1/2 inch (12.7 mm).

7 Tank Connections

7.1 A tank connection shall be provided for each opening as illustrated in Figure 7.1 or Figure 7.2 by:

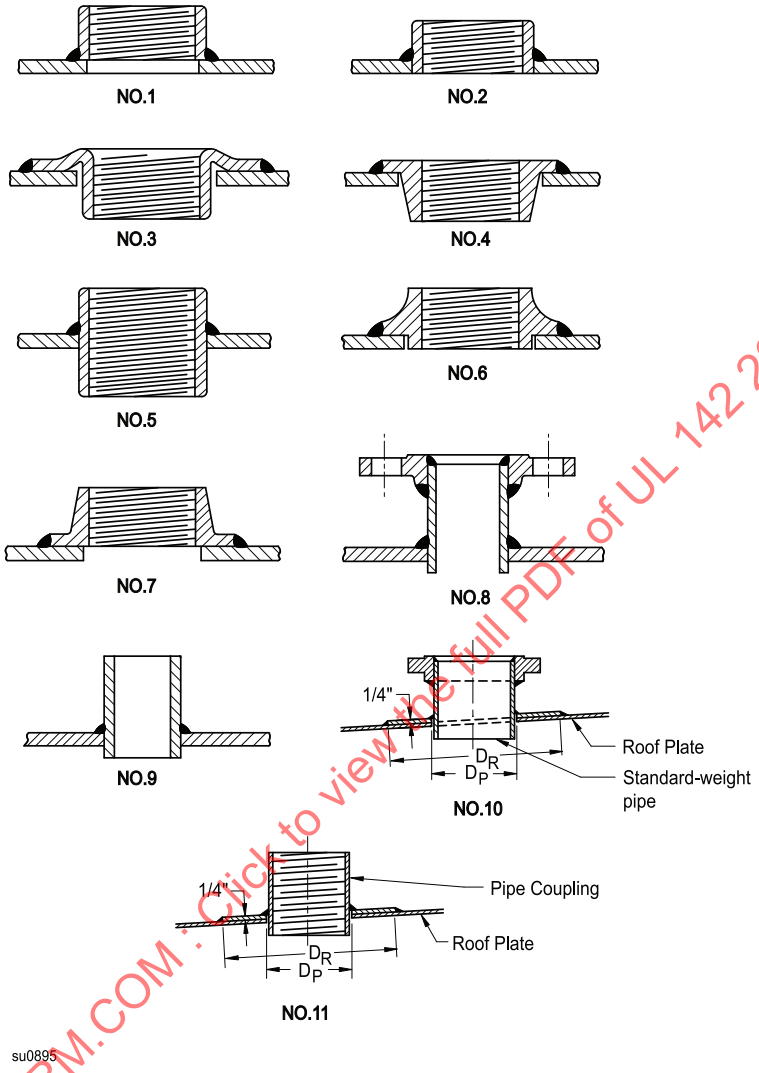
a) Welding a steel pipe coupling, threaded steel flange, or standard pipe nipple to the tank or

b) A steel flange welded to a length of pipe that, in turn, is welded to the tank.

The reinforcing plates illustrated in Figure 7.2 are optional.

Figure 7.1

Pipe connections



No. 1 – Half pipe coupling.

No. 2 – Half pipe coupling.

No. 3 – Pressed steel, hub inside tank only.

No. 4 – Forged steel, hub inside tank.

No. 5 – Full pipe coupling.

No. 6 – Forged steel, with pilot.

No. 7 – Forged steel, without pilot.

No. 8 – Standard pipe nipple and welding flange.

No. 9 – Standard pipe nipple – may be unthreaded.

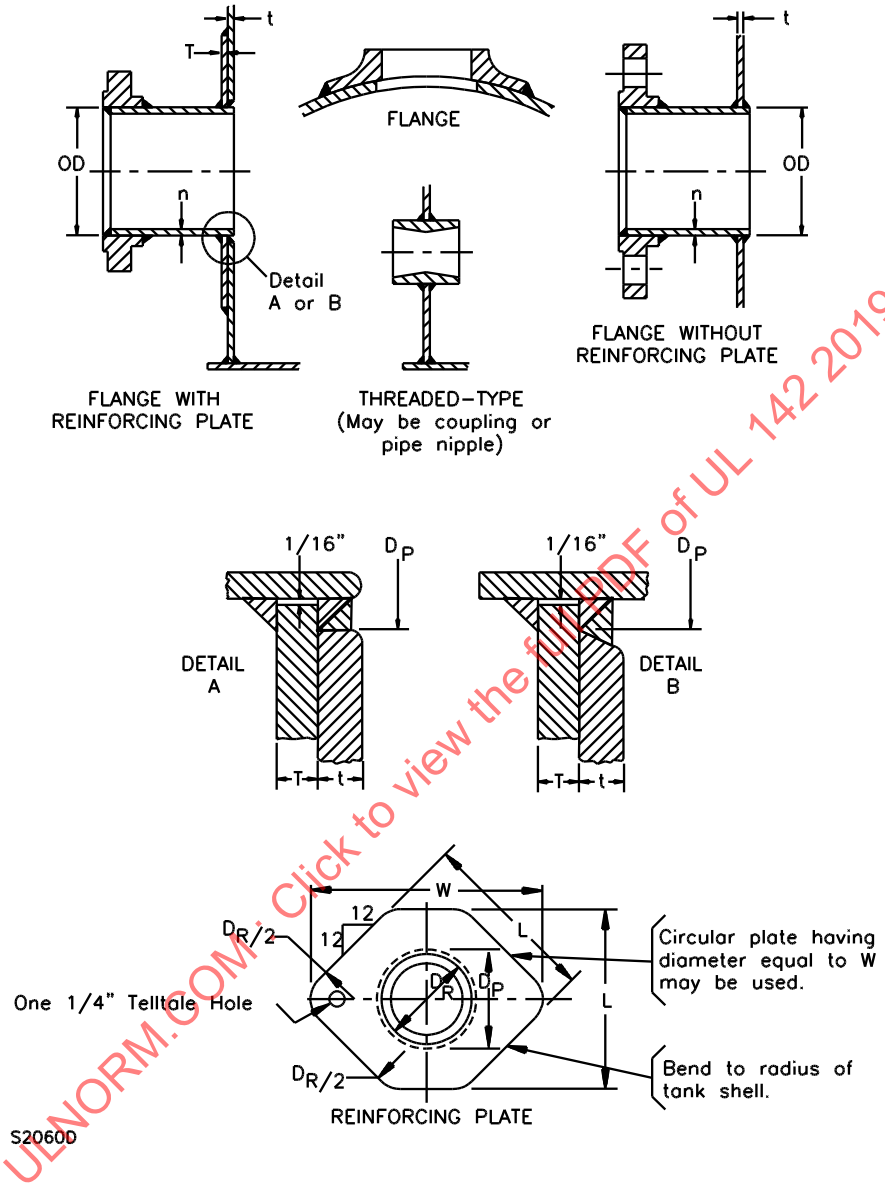
No. 10 – Flanged connection with reinforcing plate.

No. 11 – Threaded connection with reinforcing plate.

NOTES –
1 All welds are to be full fillet welds.
2 Pipe connections Nos. 8, 9, 10, and 11 may be trimmed flush, or installed set-on (as shown in No. 1).
3 Pipe connections Nos. 3, 4, 5, 8, and 9 may be seal welded on the opposite side of the weld shown.
4 When roof nozzle is used for venting purposes, it shall be trimmed flush with reinforcing plate or roof line. Axis of connections is to be vertical. All welds shall be full fillet welds.
5 If reinforcing plates are used, they shall be of a thickness equal to or greater than the roof or shell thickness, as applicable.
6 For Detail 10 above, refer to Table 7.2
7 For Detail 11 above, refer to Table 7.3

Figure 7.2

Top or shell connections (See Table 7.1)



NOTES –
1 All welds are to be full fillet welds.
2 D_P is the outside diameter of the pipe plus 5/8 inch (0.63 mm).
3 For SI units, 1 inch = 25.4 mm.

Table 7.1
Top or shell connections (See Figure 7.2)
All dimensions in inches

Size of connection	Outside diameter of pipe	Minimum thickness of flanged connection, pipe wall[a] (n)	Diameter of hole in reinforcing plate (D_R)	Length of side of reinforcing plate (L)	Width of reinforcing plate (W)
24	24	0.375	24-1/2	49-1/2	60
22	22	0.375	22-1/8	45-1/2	55-1/4
20	20	0.375	20-1/8	41-1/2	50-1/2
18	18	0.375	18-1/8	37-1/2	45-3/4
16	16	0.375	16-1/8	33-1/2	40-3/4
14	14	0.375	14-1/8	29-1/2	36
12	12-3/4	0.375	12-7/8	27	33
10	10-3/4	0.365	10-7/8	23	28-1/4
8	8-5/8	0.322	8-3/4	19	23-1/4
6	6-5/8	0.280	6-3/4	15-3/4	19-1/2
4	4-1/2	0.237	4-5/8	12	15-1/4
3	3-1/2	0.216	3-5/8	10-1/2	13-1/2
2	2-3/8	0.154	2-1/2	–	–
1-1/2	1.90	0.145	2	–	–

NOTE – For SI units, 1 inch = 25.4 mm.

[a] Schedule 40 (standard) fittings, for sizes up to 12-inch, inclusive; for over 12- to 24-inch, inclusive, refer to the latest edition of ASTM A53/A53M, A134, A135, or A139. Pipe made from formed plate electrically butt-welded may be substituted for any of the above-mentioned pipe sections.

7.2 Connections in the roof of vertical tanks shall be as illustrated in Figure 7.1, or Figure 7.2. Connections in the shell of a vertical tank shall be in accordance with specifications in Figure 7.2. The reinforcing plates illustrated in Figure 7.1 and Figure 7.2 are optional.

7.3 Hub slip-on welding and a welding-neck flange shall comply with the dimensional and material requirements for forged carbon steel flanges as specified in the Standard for Pipe Flanges and Flanged Fittings, ASME B16.5.

7.4 If a welding coupling is used, it shall comply with the Standard for Forged Steel Fittings, Socket Welding and Threaded, ASME B16.11, or the Standard Specification for Threaded Couplings, Steel, Black or Zinc-Coated (Galvanized) Welded or Seamless, for Use in Steel Pipe Joints, ASTM A865.

7.5 A threaded connection shall provide a minimum length of thread as specified in Table 7.4.

7.6 A pressed-steel-pipe-connecting fitting shall be installed with the hub section on the inside of the tank as illustrated in Detail 3 of Figure 7.1. The thickness of the flange shall not be less than specified in Table 7.1.

7.7 All pipe connection openings in a tank shall be protected with wooden or plastic plugs, metal covers, or their equivalent, to protect threads and exclude foreign matter while in storage or in transit.

Table 7.2
Flanged roof connections (See Figure 7.1 Detail No. 10)

Nominal size of nozzle, inches	Maximum diameter of hole in roof plate or reinforcing plate (D_P), inches	Outside diameter of reinforcing plate (D_R), inches
1-1/2	DO[a] + 0.100	5
2	DO + 0.125	7
3	DO + 0.125	9
4	DO + 0.125	11
6	DO + 0.125	15
8	DO + 0.250	18
10	DO + 0.250	22
12	DO + 0.250	24

NOTE – For SI units, 1 inch = 25.4 mm.

[a] DO is the outside diameter of the pipe neck in inches.

Table 7.3
Threaded roof connections (See Figure 7.1 Detail No. 11)

Nominal size of nozzle, inches	Maximum diameter of hole in roof plate or reinforcing plate (D_P), inches	Outside diameter of reinforcing plate (D_R), inches
3/4	DO[a] + 0.100	4
1	DO + 0.100	4-1/2
1-1/2	DO + 0.100	5
2	DO + 0.125	7
3	DO + 0.125	9
4	DO + 0.125	11
6	DO + 0.125	15
8	DO + 0.250	18
10	DO + 0.250	22
12	DO + 0.250	24

NOTE – For SI units, 1 inch = 25.4 mm.

[a] DO is the outside diameter of the coupling in inches.

Table 7.4
Minimum length of thread for threaded pipe connections

Nominal pipe size, inches[a]	Minimum length of thread[b]		Minimum thickness of flanged section of pressed-steel fittings	
	inches	(mm)	inches	(mm)
1/8	1/4	(6.4)		
1/4	3/8	(9.5)		
3/8	3/8	(9.5)		
1/2	1/2	(12.7)		
3/4	5/8	(15.9)	0.135	(3.4)
1	5/8	(15.9)	0.150	(3.8)
1-1/4	11/16	(17.5)	0.150	(3.8)

Table 7.4 Continued on Next Page

Table 7.4 Continued

Nominal pipe size, inches[a]	Minimum length of thread[b]		Minimum thickness of flanged section of pressed-steel fittings	
	inches	(mm)	inches	(mm)
1-1/2	3/4	(19.1)	0.150	(3.8)
2	3/4	(19.1)	0.150	(3.8)
2-1/2	1	(25.4)	0.179	(4.6)
3	1	(25.4)	0.179	(4.6)
3-1/2	1	(25.4)	0.179	(4.6)
4	1-1/8	(28.6)	0.179	(4.6)
5	1-3/16	(30.2)		
6	1-1/4	(31.7)		
8	1-3/8	(34.9)		

[a] Standard for Welded and Seamless Wrought Steel Pipe, ASME B36.10.

[b] The threaded connection shall comply with the Standard for Pipe Threads, General Purpose (Inch), ASME B1.20.1.

8 Venting

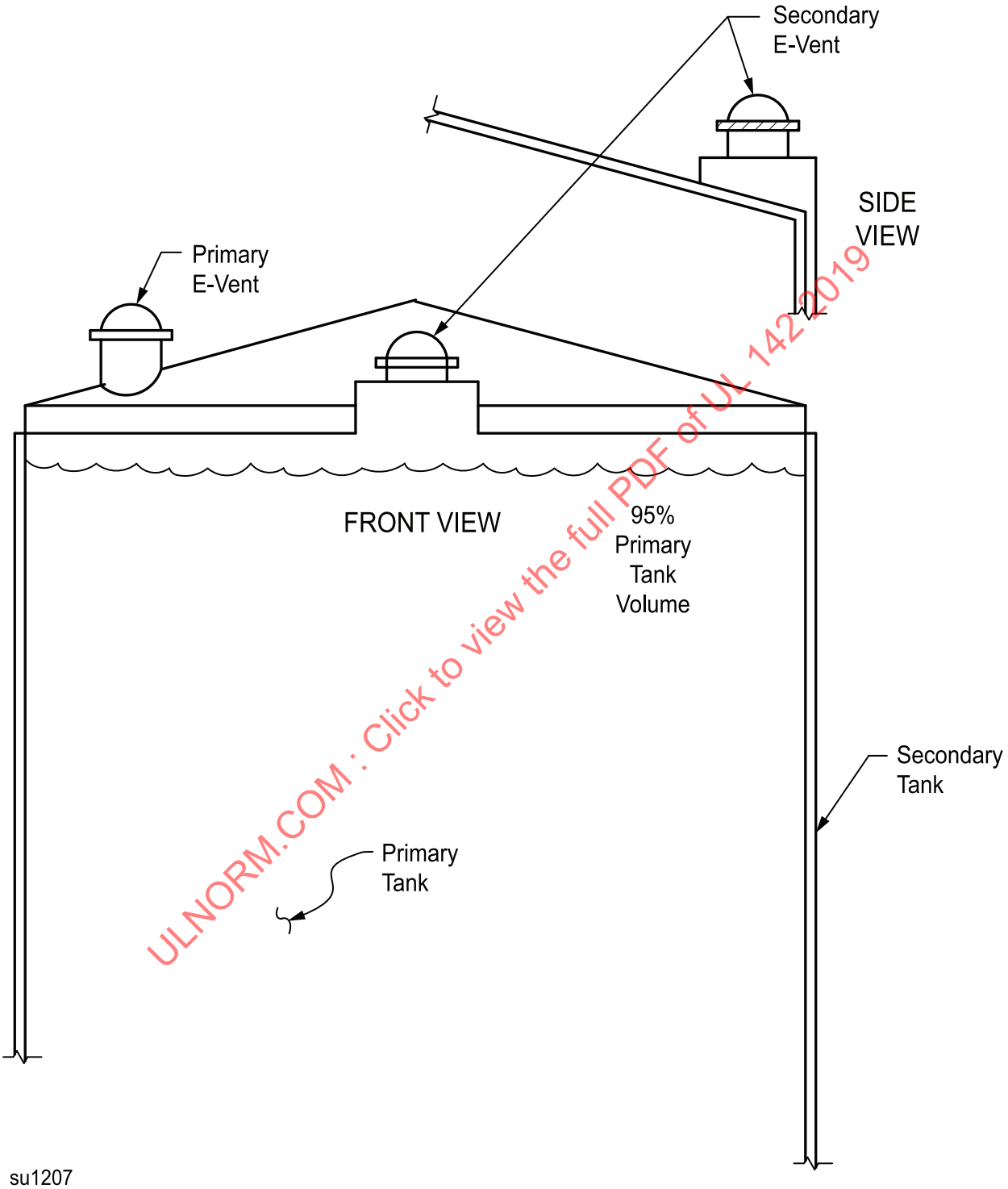
8.1 Each tank shall have normal and emergency openings for venting. These vent openings shall be in addition to the fill, withdrawal, and liquid level gauge openings, and shall terminate vertically above the top of the tank.

8.2 Each primary containment tank including each compartment of a compartment tank shall have provisions for both normal venting and emergency venting. The tank penetration openings for these vents shall be located on the top of the tank. Horizontal cylindrical tanks shall center these vents along the top longitudinal axis.

8.3 The interstitial space of a secondary containment tank shall have provisions for emergency venting. The tank penetration opening for this vent shall be located on the tank top, or near the top provided the penetration opening is above the liquid level should the primary tank leak at rated nominal capacity per 4.3 (a) into the interstitial space. See Figure 8.1 for one allowable option.

Figure 8.1

Tank e-vents



8.4 The normal venting shall be sized in accordance with Table 8.2 and shall be at least as large as the filling or withdrawal connection, whichever is larger, but in no case less than 1-1/4 inch (30 mm) nominal inside diameter.

8.5 The provision for emergency venting shall be an opening that complies with the requirements in 8.6.

8.6 A vent opening that provides for both emergency and normal venting shall have a capacity not less than that specified in Table 8.1. A vent opening that provides for both emergency and normal vents shall also have a total venting capacity not less than specified in Table 8.1, in addition to the requirements of 8.4. Emergency vents are not prohibited from use for normal venting of the primary tanks if the tanks are marked as specified in 52.1.1(e).

Table 8.1
Emergency venting capacity for primary tanks and interstitial space of secondary containment tanks

Wetted surface, square feet[a,b]	Venting capacity, cubic feet per hour[c,d]	Minimum opening, nominal pipe size, inches[e]
20	21,100	2
30	31,600	2
40	42,100	3
50	52,700	3
60	63,200	3
70	73,700	4
80	84,200	4
90	94,800	4
100	105,000	4
120	126,000	5
140	147,000	5
160	168,000	5
180	190,000	5
200	211,000	6
250	239,000	6
300	265,000	6
350	288,000	8
400	312,000	8
500	354,000	8
600	392,000	8
700	428,000	8
800	462,000	8
900	493,000	8
1000	524,000	10
1200	557,000	10
1400	587,000	10
1600	614,000	10
1800	639,000	10
2000	662,000	10

Table 8.1 Continued on Next Page

Table 8.1 Continued

Wetted surface, square feet[a,b]	Venting capacity, cubic feet per hour[c,d]	Minimum opening, nominal pipe size, inches[e]
2400	704,000	10
2800	742,000	10
3200	776,000	12
3600 and over	806,000	12

NOTE – Emergency venting capacity is based on atmospheric pressure of 14.7 psi and 60°F (101.4 kPa and 16°C).

[a] Interpolate for intermediate values.

[b] For SI units, 1.0 m^2 = 10.76 ft^2.

[c] These values taken from NFPA 30. See 1.3.

[d] For SI units, 1 m^3/hr = 35.315 ft^3/hr.

[e] These pipe sizes apply only to open vent pipes of the specified diameter not more than 12 inches (0.3 m) long and a gauge pressure in tank of not more than 2.5 psi (17.1 kPa). If a tank is to be equipped with a venting device or flame arrester, the vent opening is to accommodate the venting device or flame arrester sized in accordance with Column 2 of this table.

8.7 The wetted surface area for horizontal tanks with any head shape shall be 75 percent of the total external surface area (shell + heads). A value, to the nearest whole number, for wetted areas of flat-headed horizontal tanks of various diameters and lengths are included in Table A2 of Annex A.

8.8 The wetted surface area for vertical tanks with any bottom shape shall be the external surface area (shell and bottom) up to 30 feet (9.14 m) excluding the top. Values, to the nearest whole number, for wetted areas of vertical tanks of various diameters and heights are included in Table A3 of Annex A.

8.9 The wetted surface area for rectangular tanks shall be the total external surface area excluding the top (2H × (L+W) + (L × W)).

8.10 Each tank shall have a vent opening in the top of the tank for normal venting. The vent opening shall be in addition to the filling and withdrawal openings, and shall not be smaller than specified in Table 8.2.

Table 8.2
Size of opening for normal venting

Capacity of tank, U.S. gallons[a]	Minimum diameter, nominal pipe size, inches[b]
Under 2,500	1-1/4
2,500 – 3,000	1-1/2
3,001 – 10,000	2
10,001 – 20,000	2-1/2
20,001 – 35,000	3
35,001 – 50,000	4
50,001 – 75,000	6

[a] For SI units, gallons (U.S. gallons) × 3.8 = L.

[b] See Standard for Welded and Seamless Wrought Steel Pipe , ASME B36.10.

9 Manholes

9.1 Except as noted in 9.4, a manhole for attachment to the top of a tank shall be as illustrated in Figure 9.1 or Figure 9.3. A manhole attached to the shell at a location below the top of the tank or to the head of a tank shall comply with Figure 9.2 or Figure 9.4.

9.2 Each liquid containing compartment within a primary tank which is larger than the following dimensions shall incorporate a manhole:

a) Horizontal cylindrical tank with a minimum diameter of 76 inches.

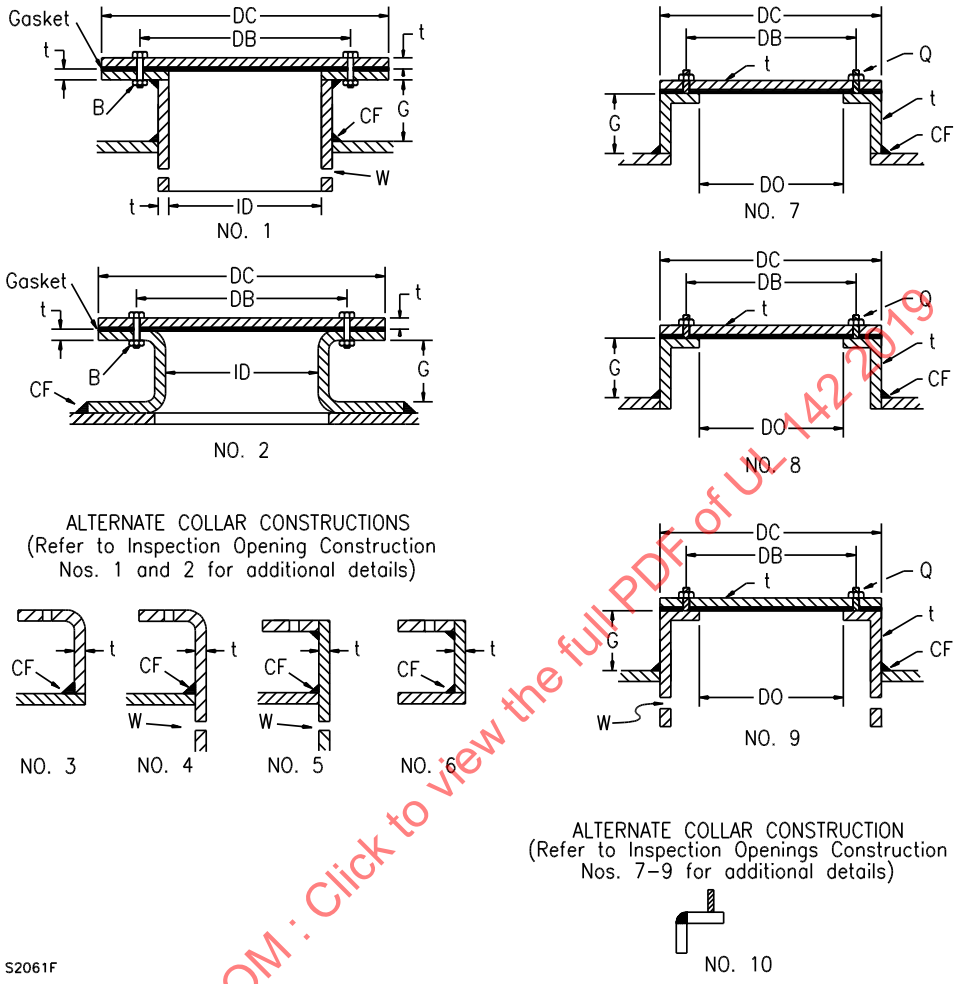
b) Vertical cylindrical tank with a minimum height of 76 inches and a minimum diameter of 60 inches.

c) Rectangular tanks with a minimum height of 76 inches and a minimum width of 60 inches.

9.3 Except as noted in Figure 9.3, a manhole for attachment to the roof or top of a vertical cylindrical tank shall be as illustrated in Figure 9.1, Figure 9.2 or Figure 9.3, and Table 9.1. The reinforcing plate and handles illustrated in Figure 9.3 are optional. A manhole attached to the shell of a vertical tank or side of a horizontal tank shall be as shown in Figure 9.2 or Figure 9.4. A manhole of the type illustrated in Figure 9.2 shall comply with Table 9.3 with regard to the minimum thickness of cover plate and bolting flange, and, if larger than 24 inches (0.6 mm) in size, shall also comply with Table 9.4 with regard to diameter of cover plate and bolt circle and the size and number of bolts.

Figure 9.1

Top manholes (See Table 9.1)



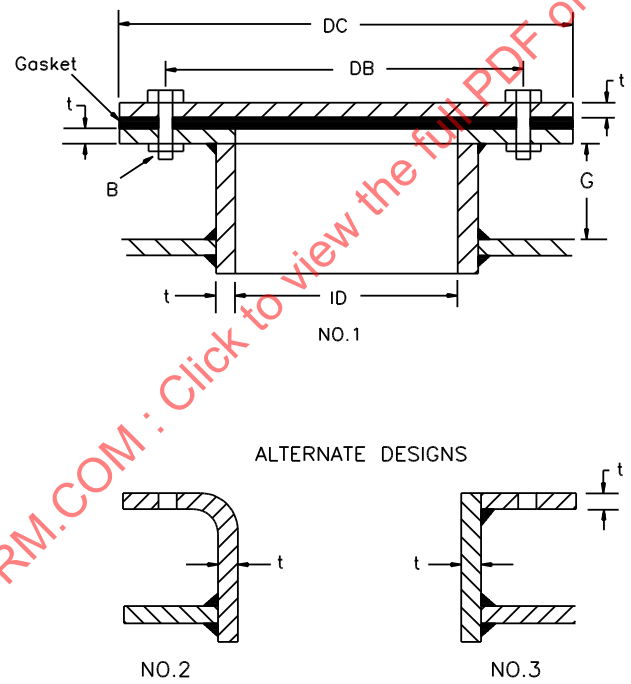
t – Not less than 0.167 inch (4.24 mm) thick.
B – Minimum 1/2-inch (12.7-mm) bolts in 9/16-inch (14.3-mm) holes. Quantity per Table 9.1.
CF – Continuous full fillet weld.
G – Minimum 2 inch (50.8 mm) for tanks larger than 76 inches (1.93 m) diameter.
Q – Minimum 1/2 inch (12.7 mm) threaded studs spaced per Table 9.1.
W – Optional weep holes. Two provided. Minimum 1/4 inch (6.4 mm) diameter through hole, adjacent to the tank shell at the highest point of the tank.
NOTE – Nos. 4 and 5 may be trimmed flush as shown in No. 8.

Table 9.1
Top manholes and shell or head manholes (See Figure 9.1 and Figure 9.2)

Size of manhole, inches	Nominal diameter of neck (ID) or opening (DO), inches	Nominal diameter of cover plate (DC), inches	Nominal diameter of bolt circle (DB), inches	Minimum number of bolts
16	16	20-1/2	19	16
18	18	22-1/2	21	18
20	20	24-1/2	23	20
22	22	26-1/2	25	22
24	24	28-1/2	27	24
30	30	35-1/2	33	42
36	36	41-1/2	39	52

Figure 9.2

Shell or head manholes (Horizontal Tanks – See Table 9.1; Vertical Tanks – See Table 9.3)



t – Not less than 0.240 inch (6.1 mm) thick.

B – Minimum 1/2-inch (12.7-mm) bolts in 9/16-inch (14.3-mm) holes.

G – Minimum 2 inches (50.8 mm) for tanks larger than 76 inches (1.93 m) diameter.

NOTE – All welds are to be full fillet welds.

Table 9.2
Roof manholes for vertical tanks (See Figure 9.3)

Size of manhole, inches[a]	Diameter of neck (ID), inches[a]	Diameter of cover plate (D_C), inches[a]	Diameter of bolt circle (D_B), inches[a]	Minimum number of bolts	Diameter of hole in roof plate or reinforcing plate (D_P), inches[a]	Outside diameter of reinforcing plate (D_B), inches[a]
16	16	20-1/2	19	16	16-5/8	38
18	18	22-1/2	21	18	18-5/8	40
20	20	24-1/2	23	20	20-5/8	42
22	22	26-1/2	25	22	22-5/8	44
24	24	28-1/2	27	24	24-5/8	46

[a] For SI units, 1 inch = 25.4 mm.

Table 9.3
Thickness of shell manhole cover plate and bolting flange (See Figure 9.2 and Figure 9.4)
All dimensions are in inches unless otherwise stated

Maximum tank height, feet[a]	Equivalent pressure[b], pounds per square inch[c]	Minimum thickness of cover plate			Minimum thickness of bolting flange after finishing		
		16-inch manhole[d]	18-inch manhole[d]	20-inch manhole[d]	16-inch manhole[d]	18-inch manhole[d]	20-inch manhole[d]
21	9.1	1/4	1/4	5/16	1/4	1/4	1/4
27	11.7	5/16	5/16	3/8	1/4	1/4	1/4
32	13.9	5/16	5/16	3/8	1/4	1/4	1/4
35	15.2	5/16	3/8	7/16	1/4	1/4	5/16
		24-inch manhole [d]	30-inch manhole [d]	36-inch manhole [d]	24-inch manhole [d]	30-inch manhole [d]	36-inch manhole [d]
21	9.1	3/8	7/16	1/2	1/4	5/16	3/8
27	11.7	7/16	1/2	9/16	5/16	3/8	7/16
32	13.9	7/16	9/16	5/8	5/16	7/16	1/2
35	15.2	1/2	5/8	11/16	3/8	1/2	9/16
50	21.7	5/8	3/4	7/8	1/2	5/8	3/4

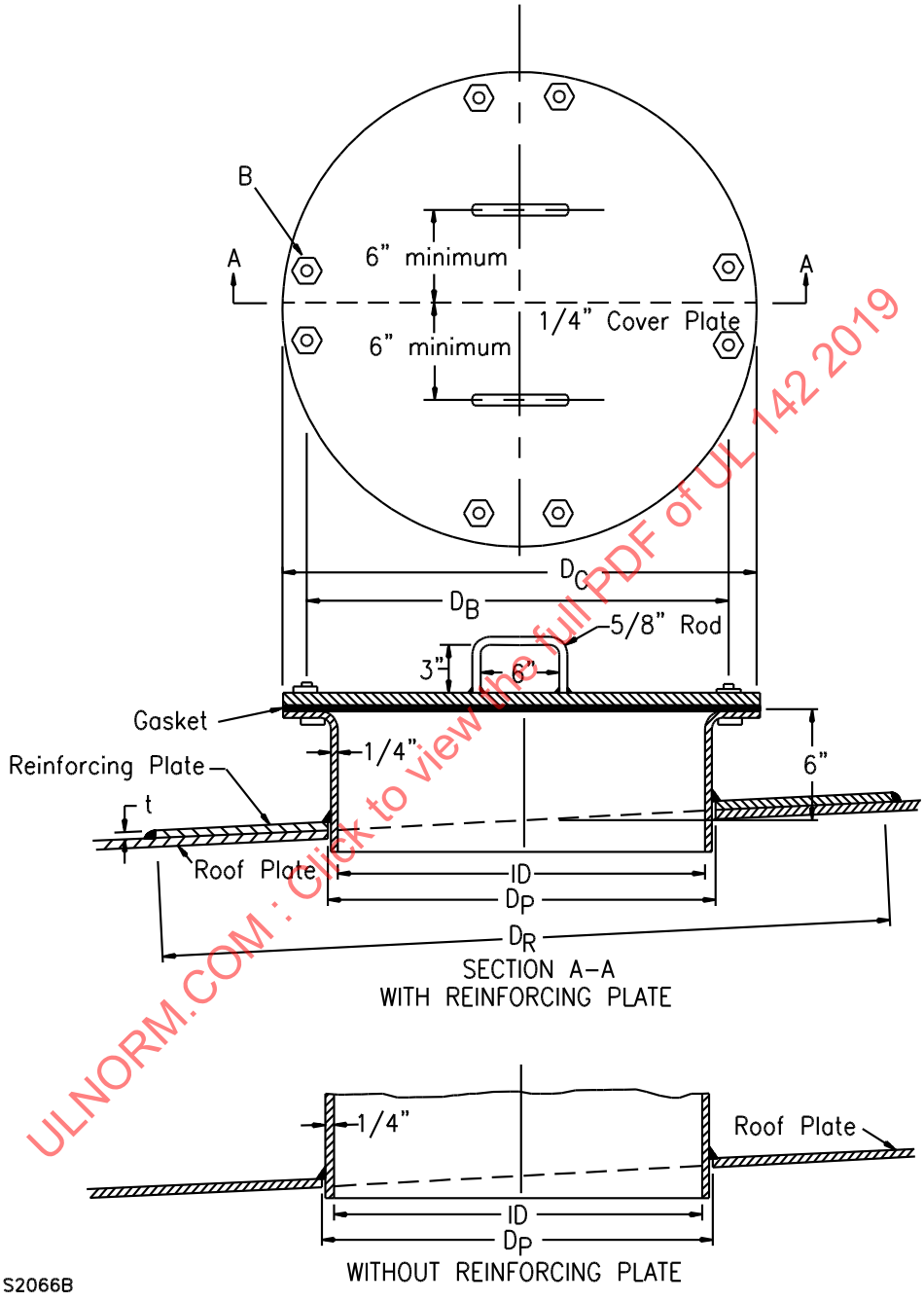
[a] For SI units, 1 foot = 0.3 m.
[b] Equivalent pressure is based on water loading.
[c] For SI units, a gauge pressure of 1 psi = 6.9 kPa.
[d] For SI units, 1 inch = 25.4 mm.

9.4 A cover for a manhole in the top of a tank may be of the self-closing type.

9.5 A manhole-cover joint shall be provided with a ring or face gasket of material determined to be acceptable for use with flammable liquids and having a thickness of not less than 1/8 inch (3.2 mm).

Figure 9.3

Roof manholes for vertical tanks (See Table 9.2)



t = 1/4 inch

NOTES –

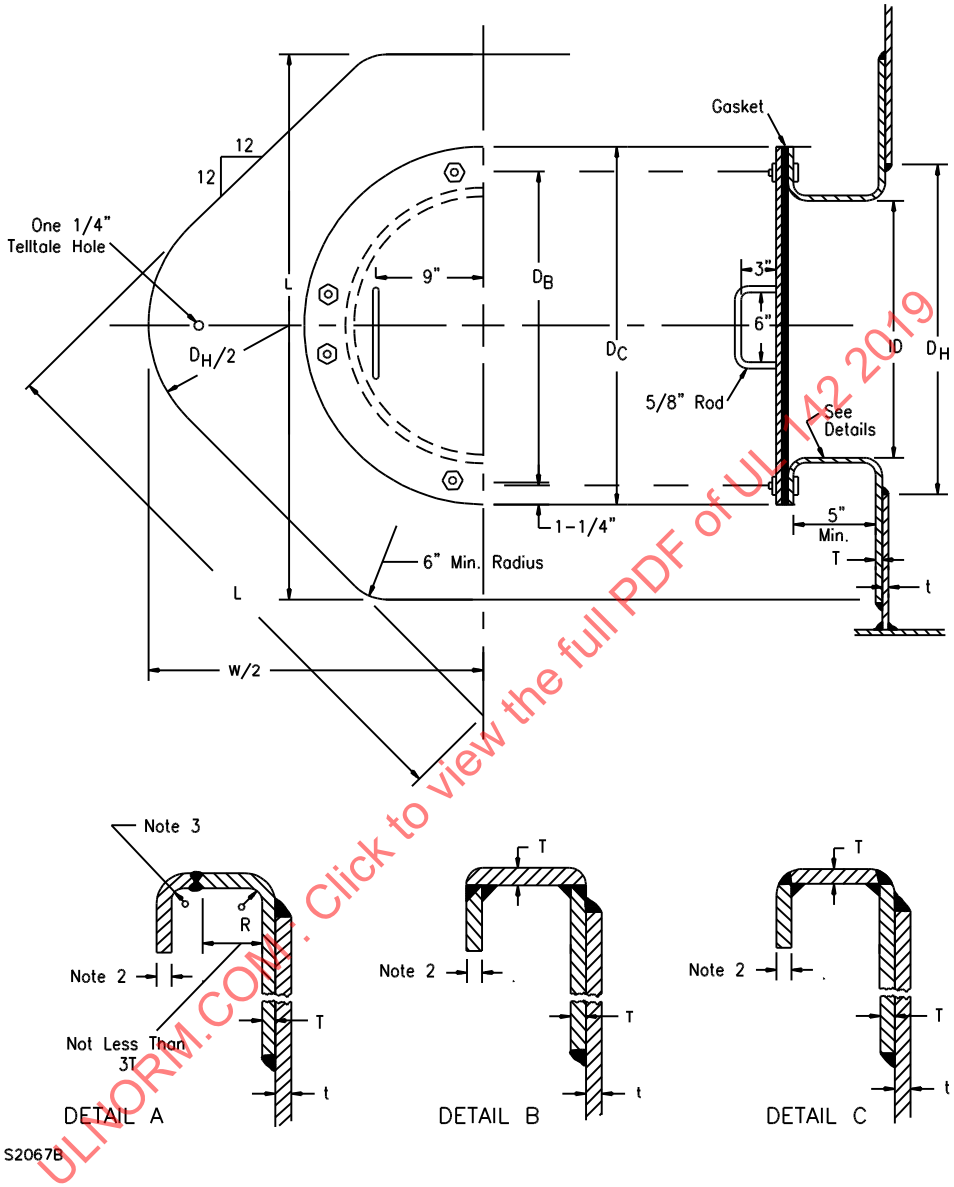
1 The manhole construction may be trimmed flush.

2 All welds are to be full fillet welds.

3 For SI units, 1 inch = 25.4 mm.

Figure 9.4

Shell manholes for vertical tanks (See Table 9.3 and Table 9.4)



NOTES –

1 All welds are to be full fillet welds.

2 For SI units, 1 inch = 25.4 mm.

Table 9.4
Shell manhole dimensions (See Figure 9.4)
All dimensions are in inches unless otherwise stated

Thickness of shell and manhole attachment flange (t) and (T)	Approxi-mate radius (R)	Attachment flange		Frame using constant-diameter ring die		Built-up frame or frame using constant diameter plug die	
		Length of side (L)	Width (W)	Inside diameter of manhole frame (ID)	Maximum diameter of hole in shell (D_H)	Inside diameter of manhole frame (ID)	Maximum diameter of hole in shell (D_H)
16-Inch Shell Manhole							
0.167	3/16	38	45-1/2	18-5/8	20-1/4	16	17-3/4
1/4	1/4	38	45-1/2	18-1/2	20-1/2	16	18
Diameter of bolt circle D_B = 22-1/4 inches, Diameter of cover plate D_C = 22-3/4 inches 20-3/4 inch diameter bolts in 7/8 inch diameter holes							
18-Inch Shell Manhole							
0.167	3/16	42	50-1/2	20-5/8	22-1/4	18	19-3/4
1/4	1/4	42	50-1/2	20-1/2	22-1/2	18	20
Diameter of bolt circle D_B = 24-1/4 inches, Diameter of cover plate D_C = 26-3/4 inches 20-3/4 inch diameter bolts in 7/8 inch diameter holes							
20-Inch Shell Manhole							
0.167	3/16	46	55	22-5/8	24-1/4	20	21-3/4
1/4	1/4	46	55	22-1/2	24-1/2	20	22
Diameter of bolt circle D_B = 26-1/4 inches, Diameter of cover plate D_C = 28-3/4 inches 28-3/4 inch diameter bolts in 7/8 inch diameter holes							
22-inch Shell Manhole							
0.167	3/16	50	60	24-5/8	26-1/4	22	23-3/4
1/4	1/4	50	60	24-1/2	26-1/2	22	24
Diameter of bolt circle D_B = 28-1/4 inches, Diameter of cover plate D_C = 30-3/4 inches. 28-3/4 inch diameter bolts in 7/8 inch diameter holes							
24-Inch Shell Manhole							
0.167	3/16	54	65	26-5/8	28-1/4	24	25-3/4
1/4	1/4	54	64-3/4	26-1/2	28-1/2	24	26
Diameter of bolt circle D_B = 30-1/4 inches, Diameter of cover plate D_C = 32-3/4 inches 28-3/4 inch diameter bolts in 7/8 inch diameter holes							
30-Inch Shell Manhole							
0.167	3/16	66	79-1/4	32-5/8	34-1/4	30	31-3/4
1/4	1/4	66	79-1/4	32-1/2	34-1/2	30	32
Diameter of bolt circle D_B = 36-1/4 inches, Diameter of cover plate D_C = 38-3/4 inches 42-3/4 inch diameter bolts in 7/8 inch diameter holes							
36-Inch Shell Manhole							
0.167	3/16	78	93-3/4	38-5/8	40-1/4	36	37-3/4
1/4	1/4	78	93-3/4	38-1/2	40-1/2	36	38
Diameter of bolt circle D_B = 42-1/4 inches, Diameter of cover plate D_C = 44-3/4 inches 52-3/4 inch diameter bolts in 7/8 inch diameter holes							
NOTE – For SI units, 1 inch = 25.4 mm.							

9.6 All shell manways in a vertical secondary containment tank, as well as head or below-liquid-level manways in a horizontal or rectangular secondary containment tank, may also be secondarily contained using a larger manway, meeting the dimensional requirements of Table 9.5 and as shown in Figure 9.5.

Figure 9.5

Secondary Containment Manholes

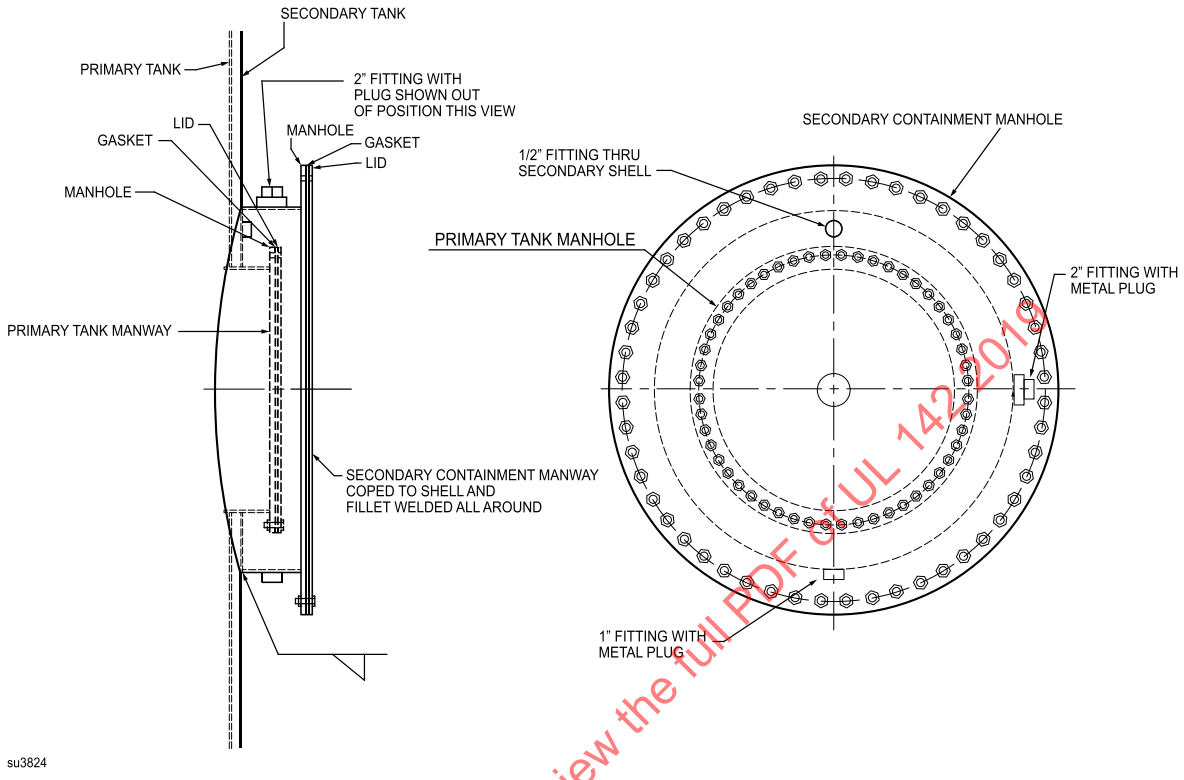


Table 9.5
Secondary Containment Manhole Dimensions

(See Figure 9.5)

Maximum tank height / diameter feet	Equivalent pressure pounds per square inch	Minimum thickness of cover plate			Minimum thickness of bolting flange after finishing		
		36-inch manhole	48-inch manhole	54-inch manhole	36-inch manhole	48-inch manhole	54-inch manhole
≤ 21	9.1	1/2"	5/8"	3/4"	3/8"	1/2"	5/8"
27	11.7	9/16"	11/16"	3/8"	7/16"	9/16"	11/16"
32	13.9	5/8"	3/4"	7/8"	1/2"	5/8"	3/4"
35	15.2	11/16"	7/8"	1"	9/16"	3/4"	7/8"
50	21.7	7/8"	1"	1-1/8"	3/4"	7/8"	1"

	Secondary Manway Dimensions		
	36-inch manhole	48-inch manhole	54-inch manhole
I.D.	36"	48"	54"
O.D.	44-3/4"	56-3/4"	62-3/4"
B.C.	42-1/4"	54-1/4"	60-1/4"
No. of Bolts	52	66	74
Size of Bolts	3/4" – 10	3/4" – 10	3/4" – 10

10 Fill, Drain, and Gauge Openings

10.1 In addition to vent openings each tank and each compartment of a multicompartment tank shall be provided with fittings to accommodate filling, inventory control and product withdrawal.

11 Painting

11.1 Unless made of stainless steel, a tank, after having been tested and found free from leakage, shall be given at least one coat of paint on exposed surfaces to protect them from atmospheric corrosion during storage at the factory premises and in transit to the installation site.

12 Tanks Storing Liquids with Specific Gravity Greater Than 1.0

12.1 Tanks optionally covered for storage of liquids with a specific gravity greater than 1.0 shall meet the following construction and performance requirements based on the maximum specific gravity identified in the 52.1.1(f) marking.

12.2 The steel thickness of tanks storing liquids with a specific gravity greater than 1.0 shall be determined by one of the following methods:

a) Vertical tanks with flat bottoms and without supports: Calculate the equivalent height of the tank by multiplying the desired tank height by the desired specific gravity. The resulting equivalent height shall be used in Table 17.1, footnotes a) and b), to determine the steel thickness. The same method shall be used for determining the secondary tank steel thickness for secondary containment tanks.

b) The tank shall be evaluated per the requirements of Section 43, Hydrostatic Strength Test, except the test pressure shall be two times the calculated tank bottom pressure based on the maximum anticipated specific gravity when the tank is filled to the maximum height.

c) Tank construction shall be evaluated by a Professional Engineer using calculations or analytical tools for approval using the maximum anticipated specific gravity. The calculations or analysis shall be based on two times the weight of a full tank containing the maximum specific gravity liquid.

d) *Deleted*

12.3 Integral supports for all tanks shall be evaluated per Part IV Tank Supports, except the support load test or evaluations shall be based on two times the weight of a full tank containing the maximum specific gravity load.

13 Tanks With Bottoms Other Than Flat

13.1 Tanks with bottoms other than flat, such as a cone, dish or wedge shape, shall be constructed with steel at least as thick as the shell, using any of the joints in Section 6.

13.2 The strength of the assembly of these tanks shall be determined by one of the following methods:

a) Tank design shall be tested to demonstrate the strength of the assembly per the Hydrostatic Strength Test in Section 43; or

b) Tank construction shall be evaluated by a Professional Engineer using calculations or analytical tools for approval. The calculations or analysis shall be based on two times the weight of a full tank.

13.3 These tanks shall be provided with integral supports that are evaluated to Part IV Tanks Supports.

PART I – PRIMARY CONTAINMENT TANKS

HORIZONTAL CYLINDRICAL CONSTRUCTIONS

14 General

14.1 In addition to complying with the applicable requirements in Sections 4 – 11 for all tank constructions, primary containment horizontal cylindrical tanks shall also comply with the requirements in Construction, Section 15.

15 Construction

15.1 Capacities and dimensions

15.1.1 A horizontal tank shall not exceed either the maximum capacity or the diameter for the corresponding thickness of steel specified in Table 15.1.

Table 15.1
Minimum steel thickness – horizontal tanks

Actual capacity, U.S. gallons (kL)		Maximum diameter, inches (m)	Minimum steel thickness, inch (mm)	
			Carbon steel	Stainless steel
550 or less	(2.08)	48 (1.22)	0.093 (2.36)	0.071 (1.80)
551 – 1100	(2.14 – 4.16)	64 (1.63)	0.123 (3.12)	0.086 (2.18)
1101 – 9000	(4.17 – 34.07)	76 (1.93)	0.167 (4.24)	0.115 (2.92)
1101 – 35,000	(4.17 – 132.49)	144 (3.66)	0.240 (6.10)	0.158 (4.01)
35,001 – 50,000	(132.50 – 189.27)	144 (3.66)	0.365 (9.27)	0.240 (6.10)
50,001 – 75,000	(189.27 – 283.6)	156 (3.97)	0.365 (9.27)	0.365 (9.27)

15.1.2 The overall length of a horizontal tank shall not be greater than six times its diameter. Tank diameters exceeding 144 inches (3.66 meters) shall be further limited to a maximum of 72 feet (21.95 meters) in cylinder length.

15.2 Steel thickness

15.2.1 A horizontal tank shall be constructed from steel not thinner than specified in Table 15.1 for its capacity and diameter.

15.3 Heads and head joints

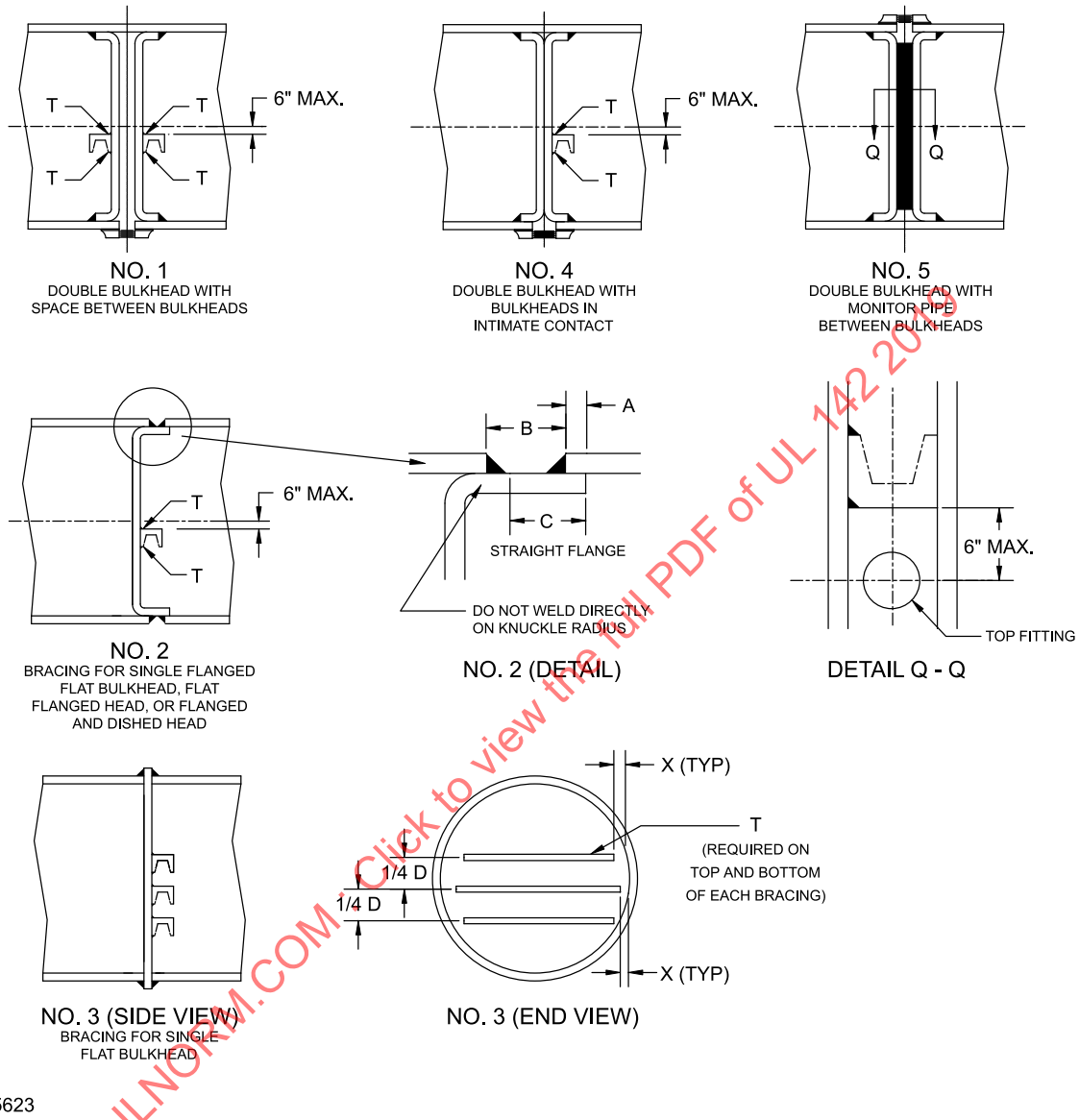
15.3.1 A head of a horizontal tank shall be constructed of not more than three pieces for tank diameters of 48 to 96 inches (1.2 to 2.4 m); and four pieces for diameters of 97 to 156 inches (2.42 to 3.9 m). When two or more pieces are used, joints shall be one of the shell joint constructions described in Figure 6.1, except joint No. 6 shall not be used.

15.3.2 A head of a horizontal tank shall be flat flanged or flanged and dished.

15.3.3 A flanged flat head of a horizontal tank more than 72 inches (1.8 m) in diameter shall be made of steel not less than 5/16 inch (7.9 mm) thick or it shall be braced in accordance with Figure 15.1.

Figure 15.1

Bracings for head and bulkheads (See Table 15.2)



A – 1/2 inch (12.7 mm) minimum
B – 3/4 inch (19.1 mm) minimum
C – 1-1/4 inch (31.8 mm) minimum
T – Tack welds, not over 12 inches (0.3 m) apart
D – Tank diameter
X – 4 inches (102 mm) maximum from shell

NOTES –
1 See Table 15.2 for bracing of flanged flat heads and bulkheads (Nos. 1 and 2) and Table 15.4 for bracing of unflanged flat bulkheads (No. 3).
2 For No. 1, the testing flange may be located on the top of the tank.
3 For No. 1 through No. 4 bracing may be oriented in any direction, but must be placed within 6 inches (0.15 m) of center of head or bulkhead. Bracing for No. 5 must be vertical.

Table 15.2
Bracing for flanged flat heads and bulkheads (See Figure 15.1)

Diameter of head, inches[a]	I-beams		Channels	
	Inches[a]	Pounds[b]	Inches[a]	Pounds[b]
72 to 84	3	5.7	3	4.1
85 to 96	3	5.7	4	5.4
97 to 108	4	7.7	5	6.7
109 to 120	5	10	5	6.7
121 to 132	5	10	6	8.2
133 to 144	5	10	6	8.2

[a] For SI units, 1 inch = 25.4 mm.
[b] For SI units, 1 kg = 2.2 pounds.

15.3.4 A flanged flat head shall have an inside knuckle radius equal to at least 2.0 times the head thickness.

15.3.5 The depth of dish of a dished head shall not be less than that specified in Table 15.3.

15.3.6 The head of a tank greater than 144 inches (3.66 meters) in diameter shall be flanged and dished, with a dished radius equal to the tank diameter, and a knuckle radius of at least 1/10 of the tank diameter.

Table 15.3
Dished heads – depth of dish

Diameter		Minimum depth		Diameter		Minimum depth	
Inches	m	Inches	mm	Inches	m	Inches	mm
Up to 60	(Up to 1.52)	1-1/2	(38)	97 – 108	(2.46 – 2.74)	4-1/2	(114)
61 – 72	(1.55 – 1.83)	2	(51)	109 – 120	(2.77 – 3.05)	5-1/2	(140)
73 – 84	(1.85 – 2.13)	2-1/2	(64)	121 – 132	(3.07 – 3.35)	7	(178)
85 – 96	(2.16 – 2.44)	3-1/2	(89)	133 – 144	(3.38 – 3.66)	8	(203)
97 – 108	(2.46 – 2.74)	4-1/2	(114)	144 – 156	(3.58 – 3.96)	20	(508)

15.4 Compartment tank construction

15.4.1 A bulkhead of a compartment tank shall be constructed so that leakage through any bulkhead joints will not be directed from one compartment to another. See Figure 15.1 for acceptable bulkhead constructions. Bulkheads are not allowed in tanks over 144 inches in diameter.

15.4.2 A bulkhead of a single or double bulkhead tank, shall be constructed of one piece for tank diameters under 72 inches, of not more than two pieces for tank diameters from 72 to 96 inches, and three pieces for diameters of from 97 to 144 inches (2.42 to 3.6 m). When two or more pieces are used, joints shall be in accordance with Figure 6.1 Joints No. 1 or No. 2.

15.4.3 The minimum thickness of metal used for a bulkhead shall not be less than 0.167 inch (4.24 mm) for diameters of 76 inches (1.9 m) or less and 1/4 inch (6.4 mm) for diameters of more than 76 inches.

15.4.4 An unflanged flat bulkhead of a compartment tank shall be braced in accordance with Figure 15.1 and Table 15.4.

Table 15.4
Bracing for unflanged flat bulkheads (See Figure 15.1)

Diameter of head, inches[a]	Channels		Angles, inches[a]					
	Inches	Pounds[b]						
Up to 60	3	4.1	2	× 2	× 3/8	or 2-1/2	× 2-1/2	× 1/4
61 to 72	3	4.1	3	× 3	× 7/16	or 3-1/2	× 3-1/2	× 5/16
73 to 84	4	5.4	3-1/2	× 3-1/2	× 1/2	or 4	× 4	× 3/8
85 to 96	5	6.7	4	× 4	× 1/2	or 5	× 3-1/2	× 3/8[c]
97 to 108	5	6.7	4	× 4	× 3/4	or 6	× 4	× 3/8[c]
109 to 120	6	8.2	5	× 5	× 5/8	or 6	× 4	× 1/2[c]
121 to 132	7	9.8	5	× 5	× 3/4	or 6	× 4	× 9/16[c]
133 to 144	7	9.8	5	× 5	× 3/4	or 6	× 4	× 9/16[c]

[a] For SI units, 1 inch = 25.4 mm.

[b] For SI units, 1 kg = 2.2 pounds.

[c] Short leg of angle welded to head.

15.4.5 A flanged flat bulkhead of a compartment tank more than 72 inches (1.8 m) in diameter shall be made of not less than 5/16 inch (7.9 mm) thick material or it shall be braced in accordance with Figure 15.1 and Table 15.2.

VERTICAL CYLINDRICAL CONSTRUCTIONS

16 General

16.1 In addition to complying with the applicable requirements in Sections 4 – 11 for all tank constructions, primary containment vertical cylindrical tanks shall also comply with the requirements in Construction, Section 17.

17 Construction

17.1 Capacities and dimensions

17.1.1 The minimum diameter of a vertical tank shall not be less than one-quarter of its height.

17.1.2 The shell height of a vertical tank shall not be more than 50 feet (15.24 m).

17.1.3 The capacity of a vertical tank shall not exceed 60,000 gallons (227 kL).

17.2 Steel thickness

17.2.1 A vertical tank shall be constructed from steel not thinner than specified in Table 17.1.

Table 17.1
Minimum steel thickness – vertical tanks

	Actual capacity U.S. gallon (kL)	Shell thickness, inch (mm)	Bottom thickness, inch (mm)	Top thickness, inch (mm)
Carbon steel sheet	1100 (4.16) or less	0.093 (2.36)	0.093 (2.36)	0.093 (2.36)[a]
	More than 1100 (4.16)	0.167 (4.24)[b]	0.240 (6.10)	0.123 (3.12)[a]
Stainless steel sheet	1100 (4.16) or less	0.086 (2.18)	0.086 (2.18)	0.086 (2.18)
	More than 1100 (4.16)	0.115 (2.92)[c]	0.158 (4.01)	0.086 (2.18)

[a] See 17.3.3.

[b] For a tank more than 25 feet (7.6 m) in height, all parts of the shell located more than 25 feet below the top edge of the shell shall not be less than 0.240 inch (6.1 mm) thick.

[c] For a tank more than 25 feet (7.6 m) in height, all parts of the shell located more than 25 feet below the top edge of the shell shall not be less than 0.158 inch (401 mm) thick.

17.3 Tank top (roof)

17.3.1 The top of a vertical cylindrical tank shall be constructed of not more than four pieces. If two or more pieces are used, joints shall be one of the shell joint constructions described in Figure 6.1.

17.3.2 The top of a single wall and outer shell of a secondary containment vertical tank shall be dished or conical.

Exception: Flat top roofs for vertical tanks are acceptable provided there is no leakage found during the Tank Leakage Test, Section 42, which is conducted after the Top Load Test, Section 44.

17.3.3 The height of a conical top shall not be less than one-sixth of the radius of the tank when the top is made of steel less than 0.167 inch (4.24 mm) thick and shall not be less than one-twelfth of the radius of the tank when the top is made of steel not less than 0.167 inch thick. A dished head shall have a depth of dish not less than that specified in Table 15.3.

17.4 Tank bottom (floor)

17.4.1 The bottom of a vertical cylindrical tank shall be constructed of not more than four pieces. If two or more pieces are used, joints shall be one of the shell joint constructions described in Figure 6.1, except that joint No. 6 shall not be used.

17.4.2 Vertical cylindrical tanks elevated on supports shall meet the requirements of 32.3.

RECTANGULAR CONSTRUCTIONS

18 General

18.1 In addition to complying with the applicable requirements in Sections 4 – 14 for all tank constructions, primary containment rectangular tanks shall also comply with the requirements in Construction, Section 19, and Performance, Section 20.

19 Construction

19.1 General

19.1.1 Stiffening bars may be attached to the tank wall either by intermittent or continuous welding and may be placed on the inside or outside of the tank walls.

19.1.2 Tie rods may be used inside of the tank.

19.1.3 Baffles shall be intermittently welded or continuously welded on the inside of the tank.

19.2 Steel thickness

19.2.1 Tanks of this type shall be constructed from steel not thinner than 0.093 inch (2.36 mm) if of carbon steel or 0.071 inch (1.80 mm) if of stainless steel.

20 Performance

20.1 Hydrostatic strength test

20.1.1 The tank shall be tested to demonstrate that the strength of the assembly and the welded joints are in accordance with these requirements.

20.1.2 The tank shall not rupture or leak when subjected to the Hydrostatic Strength Test, Section 43.

20.2 Top load test

20.2.1 After being subjected to the Top Load Test, Section 44, the tank shall then be subjected to the Leakage Test, Section 42, and shall not leak.

PART II – SECONDARY CONTAINMENT TANKS

ALL SECONDARY CONTAINMENT TANK CONSTRUCTIONS

21 General

21.1 All secondary containment tanks shall be constructed to provide a means for monitoring leakage into the interstitial (annular) space through either the interior or exterior walls, and so that liquid can flow freely within the interstitial space to the point of monitoring.

HORIZONTAL CYLINDRICAL CONSTRUCTIONS

22 General

22.1 In addition to complying with the applicable requirements in Sections 4 – 11 for all tank constructions, secondary containment horizontal cylindrical tanks shall also comply with the requirements in Construction, Section 23.

23 Construction

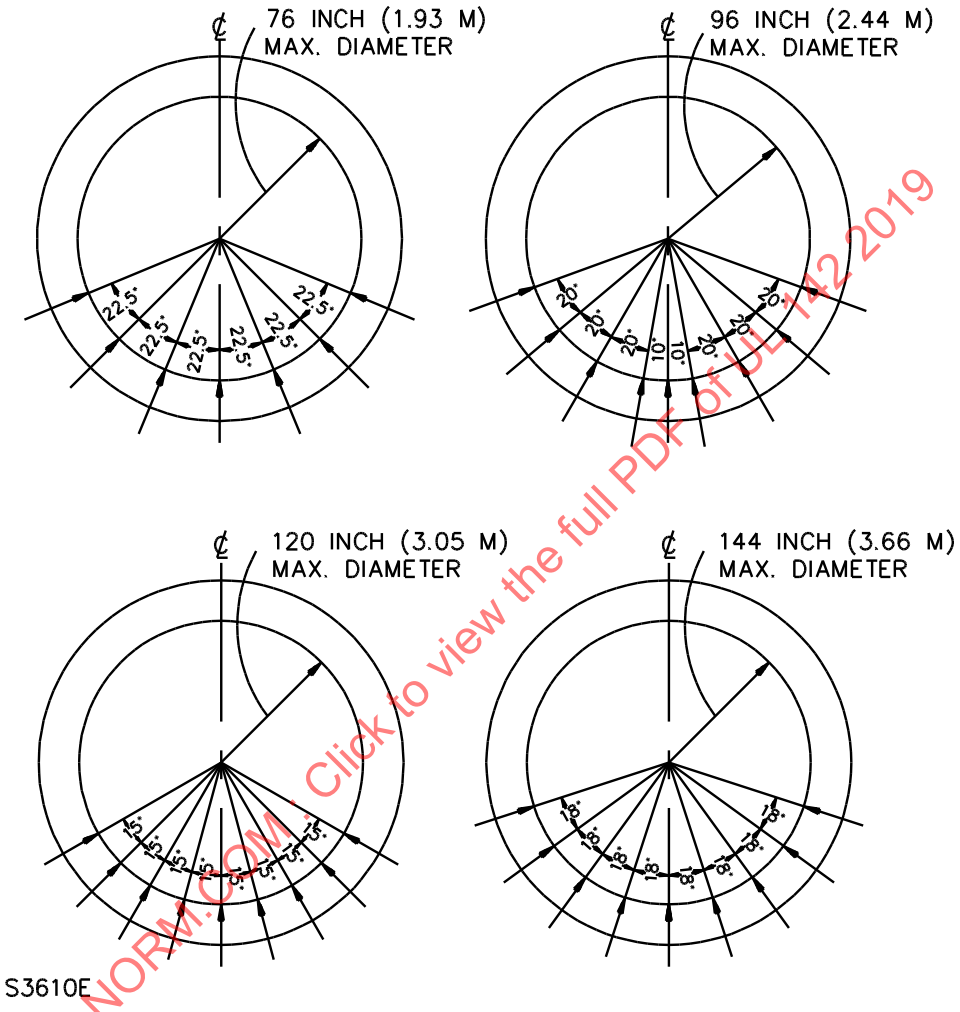
23.1 The primary containment tank shell of a secondary containment tank shall be constructed in accordance with Part I – Primary Containment Tanks, Horizontal Cylindrical Constructions, Sections 14 and 15.

23.2 The outer shell and head of a secondary containment tank shall meet the requirements specified for Part I – Primary Containment Tanks, Horizontal Cylindrical Constructions, Sections 14 and 15, except that a direct contact secondary shell and heads may wrap a minimum of 300 degrees or provide a minimum of 95 percent containment, whichever is greater.

23.3 A secondary tank shell that is not in direct contact with the primary tank shall have standoffs positioned as shown in Figure 23.1. This construction is not allowed for tanks over 144 inches in diameter.

Figure 23.1

Secondary containment tank standoff positioning



23.4 The standoffs with locations shown in Figure 23.1 may be oriented with the web either parallel or perpendicular to the shell and shall be a minimum of 3 by 1-1/2 inch (76.2 by 38.1 mm) channel [1/4 inch (6.4 mm) flange by 3/16 inch (4.8 mm) web] weighing 4.1 pounds per foot (6.1 kg per m).

23.5 If the outer shell of the secondary containment tank is in direct contact with the primary containment tank shell, the secondary containment shell may be constructed of steel with a thickness as specified in Table 23.1.

Table 23.1
Minimum steel thickness for outer shell of horizontal secondary containment tanks in direct contact with primary containment tank shell

Capacity		Maximum diameter of primary tank, inches (m)		Minimum metal thickness, inch (mm)			
				Carbon steel		Stainless steel	
U.S. gallons	(kL)						
550 or less	(2.08)	48	(1.22)	0.093	(2.36)	0.071	(1.80)
551 – 1100	(2.09 – 4.16)	64	(1.63)	0.093	(2.36)	0.071	(1.80)
1101 – 9000	(4.17 – 34.07)	76	(1.93)	0.123	(3.12)	0.086	(2.18)
1101 – 35,000	(4.17 – 132.49)	144	(3.66)	0.167	(4.24)	0.115	(2.92)
35,001 – 50,000	(132.50 – 189.27)	144	(3.66)	0.240	(6.10)	0.158	(4.01)
50,001 – 75,000	(189.28 – 283.91)	156	(3.96)	0.240	(6.10)	0.158	(4.01)

23.6 If the heads of the secondary containment tank are not in direct contact with the heads of the primary tank, the heads of the secondary tank shall have a minimum thickness as stated in Table 15.1 and be braced in accordance with Figure 15.1.

23.7 If the exterior steel shell extends more than 12 inches (0.3 m) past the head of the primary tank, the portion of the shell that is not in direct contact with the primary tank shall comply with the material and construction requirements specified in Construction, Section 15.

23.8 The thickness of a secondary head that is in direct contact with the primary head may be reduced to the thickness specified in Table 23.1. Unflanged flatheads shall not be used in this type of construction.

VERTICAL CYLINDRICAL CONSTRUCTIONS

24 General

24.1 In addition to complying with the applicable requirements in Sections 4 – 11 for all tank constructions, secondary containment vertical cylindrical tanks shall also comply with the requirements in Construction, Section 25.

25 Construction

25.1 General

25.1.1 The primary containment tank shell of a secondary containment tank shall be constructed in accordance with Part I – Primary Containment Tanks, Vertical Cylindrical Constructions, Sections 16 and 17.

25.1.2 The outer shell of a secondary containment tank shall comply with the requirements specified for Primary Containment Tanks, Vertical Cylindrical Constructions, Sections 16 and 17.

25.1.3 A secondary containment tank shell that is not in direct contact with the primary tank shall have a means to securely position the primary tank within the secondary containment shell.

25.1.4 If the outer shell of the secondary containment tank is in direct contact with the primary containment tank shell, the secondary containment shell may be constructed of steel with a thickness as specified in Table 25.1.

Table 25.1
Minimum steel thickness for outer shell of vertical secondary containment tanks in direct contact with primary containment tank shell

Capacity, U.S. gallons[a]	Carbon steel sheet minimum thickness, inch (mm)	
	Shell	Bottom
1100 or less	0.093 (2.36)	0.093 (2.36)
Over 1100	0.123[b] (3.12)	0.240 (6.10)

[a] For SI units, 1 U.S. Gallon = 3.78 L.

[b] For a tank more than 25 feet (7.5 m) high, all parts of the shell located more than 25 feet below the top edge of the shell are not to be less than 0.167 inch (4.24 mm) thick.

25.2 Tank bottom (floor)

25.2.1 The floor of the secondary containment shall be separate from and in addition to that of the primary containment shell.

RECTANGULAR CONSTRUCTIONS

26 General

26.1 In addition to complying with the applicable requirements in Sections 4 – 11 for all tank constructions, secondary containment rectangular tanks shall also comply with the requirements in Construction, Section 27, and Performance Tests, Section 28.

27 Construction

27.1 The primary containment tank shell of a secondary containment tank shall be constructed in accordance with Part I – Primary Containment Tanks, Rectangular Constructions, Sections 18 and 19.

27.2 The outer shell of a secondary containment tank shall comply with the requirements specified for Part I – Primary Containment Tanks, Rectangular Constructions, Sections 18 and 19.

27.3 The floor of the secondary containment shell shall be separate from and in addition to that of the primary containment shell.

28 Performance Test

28.1 Hydrostatic strength test

28.1.1 The secondary containment tank shall be tested to demonstrate that the strength of the assembly and welded joints are in accordance with these requirements.

28.1.2 Neither the primary or secondary containment tanks shall rupture or leak when subjected to the Hydrostatic Strength Test, Section 43.

28.2 Top load test

28.2.1 After being subjected to the Top Load Test, Section 44, the tank shall then be subjected to the Leakage Test, Section 42, and shall not leak.

PART III – DIKED TANKS

29 General

29.1 Details

29.1.1 The requirements in this Section cover open and closed top dike tank constructions.

29.1.2 In addition to complying with the applicable requirements in Sections 4 – 11 for all tank constructions and Part I (primary containment tanks) or II (secondary containment tanks) of this standard, a diked tank shall also comply with the requirements in 29.2.1; Construction, Section 30; and Performance Tests, Section 31.

29.2 Dike capacity

29.2.1 The actual dike capacity less the volume displaced by the supports or other internal apparatus except the tank shall be at minimum, 110 percent of the actual capacity of the tank.

30 Construction

30.1 All diked tanks

30.1.1 The dike walls and floor shall be constructed of steel not thinner than 0.093 inch (2.36 mm) if of carbon steel or 0.071 inch (1.80 mm) if of stainless steel.

30.1.2 Buttresses used to stiffen the side walls shall be at least the thickness of the side wall.

30.1.3 Horizontal cylindrical tanks shall be provided with supports that comply with the requirements of Part of this standard. If supports are provided for other tank constructions, they shall comply with the requirements of Part IV of this standard.

30.1.4 The supports shall be constructed so that liquid can flow freely at the lowest level in the dike area and shall not become easily blocked by debris.

30.1.5 The supports, tank, or both shall be mechanically secured to, or integral with, the dike to prevent rotation and uplift of the tank.

30.2 Open top dike constructions

30.2.1 Access and egress devices (ladder or stairs) shall be provided for the diked area if the height of the interior dike wall exceeds 6 feet (1.8 m).

30.3 Closed top dike constructions

30.3.1 Closed top dike tanks shall be provided with steel covers over the dike area to keep precipitation, debris, or other elements from entering the diked area, while also allowing for inspection.

30.3.2 The dike shall be designed such that it cannot be pressurized, should fittings be capped.

30.3.3 Closed top dike constructions shall be provided with a means for emergency venting in accordance with Venting, Section 8.

30.3.4 Closed top dike constructions with covers intended to lift for emergency venting shall not be provided with a means for securement or provision for locking (if locking interferes with the operation of the emergency vent) and shall be marked in accordance with 52.4.1. Vent openings shall be constructed to direct venting upward away from the tank.

30.3.5 Covers shall be constructed so as to reduce the risk of injury to persons during intended use.

31 Performance Tests

31.1 General

31.1.1 Open and closed top dike tanks shall be subjected to the following tests.

31.2 Buoyancy test

31.2.1 When subjected to the Buoyancy Test, Section 45, there shall be no evidence of structural damage, and the tank shall show no evidence of uplifting from the dike floor.

31.3 Hydrostatic load test

31.3.1 When subjected to the Hydrostatic Load Test, Section 46, there shall be no structural damage or deflection of the dike walls exceeding L/250, where L is the length of the side wall. In addition, there shall be no leakage as evidenced by visual inspection of the dike.

PART IV – TANK SUPPORTS

32 General

32.1 All constructions

32.1.1 These requirements cover supports integral to or secured to a tank or dike.

32.1.2 Tanks on supports shall be constructed to withstand, at minimum, a static load of two times the weight of the full tank without permanent deformation to the tank or supports, or both.

32.1.3 Supports provided with thruholes for tiedown shall be slotted or open-ended to allow for thermal expansion and contraction.

32.2 Horizontal cylindrical tank constructions

32.2.1 Saddles may be constructed as described in Construction, Section 33. Other saddle constructions or means of support are to be evaluated by conducting structural analysis using calculations[a], or tested in accordance with Performance Tests, Section 34. Other methods of structural analysis calculations, such as finite element, are not prohibited from being used.

[a] L.P. Zick's paper entitled "Stresses in Large Horizontal Pressure Vessels on Two Saddle Supports" and many published sources based on his paper are useful references for this purpose.

32.3 Vertical cylindrical tank constructions

32.3.1 Vertical cylindrical tanks on supports such as skirts or legs are to be evaluated by structural analysis using calculations[b] or tested in accordance with Performance Tests, Section 34.

[b] "The Pressure Vessel Design Handbook" by Henry H. Bednar is a useful reference for this purpose.

32.4 Rectangular tank constructions

32.4.1 Rectangular tanks on supports are to be evaluated by structural analysis using calculations or tested in accordance with Performance Tests, Section 34.

33 Construction

33.1 General

33.1.1 Supports shall be constructed of material as described in Materials, Section 5.

33.2 Saddles

33.2.1 The minimum material thickness of saddles constructed in accordance with Figure 33.1 shall be as specified in Table 33.1.

Figure 33.1

Saddles for horizontal cylindrical tanks

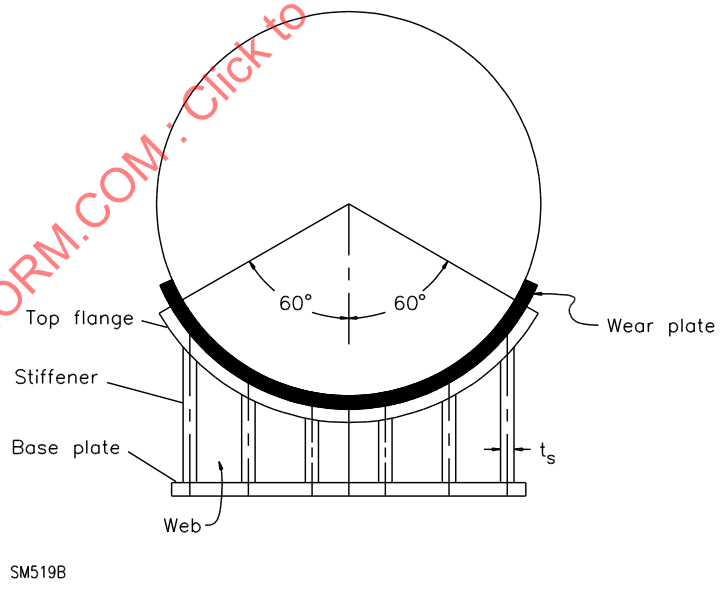


Table 33.1
Minimum material thicknesses for saddle constructions in inches

Part	550 or less	551 – 1100	1101 – 9000	1101 – 35,000	35,001 – 50,000	50,001 – 75,000
Maximum Tank Diameter	48	64	76	144	144	156
Top Flange Thickness	0.093	0.123	0.24	0.560	0.60	1.24
Wear Plate Thickness	0.093	0.123	0.24	0.240	0.365	0.49
Saddle Width	4.5	6.0	6.0	9.0	10	12
Base Plate Thickness	0.123	0.167	0.50	0.75	0.9	1.24
Base Plate Width	6.5	7.5	7.5	10	11	12
Web Thickness	0.093	0.123	0.167	0.240	0.365	0.365
Minimum Number of Stiffeners	3	3	4	6	6	6

33.2.2 Maximum height of saddles, when measured from the lowest portion of the tank shell, shall be 12 inches (305 mm) unless protected by materials having a fire resistance rating of not less than two hours.

33.2.3 The base plate length shall be at least 90 percent of the tank diameter.

33.2.4 The stiffener thickness shall be a minimum of 3/8 inch (9.5 mm) for tank diameters 6 feet (1.8 m) or less and a minimum of 1/2 inch (12.7 mm) for tank diameters greater than 6 feet.

33.2.5 The saddles shall be positioned a distance of D/4 from the end of the primary tank, where D is the diameter of the tank.

33.2.6 Wear plates shall be used for tanks with capacities greater than 550 gallons (2.09 kL), and shall extend a minimum of 0.1 times the radius, in inches, above the saddle tips and have a minimum width of b + 10t inches, where b is the width of the saddle and t is the thickness of the shell. Wear plates for saddles of tanks above 144 inch (3.66 meter) diameter shall be at least 38 inches (965 mm) wide.

34 Performance Tests

34.1 As an option to structural analysis of the support, the tank may be subjected to the Tank Support Load Test, Section 47. There shall be no damage to or permanent deformation of the tank or supports.

PART V – TANK ACCESSORIES, COMPONENTS, AND SPECIAL CONSTRUCTIONS

35 General

35.1 All types

35.1.1 The requirements in this section cover optional tank accessories, components, and special constructions.

35.2 Materials

35.2.1 All materials used in fabrication of the accessory shall be compatible with the base tank, flammable and combustible liquid, and the physical and atmospheric conditions where the device may be used.

35.2.2 Polymerics and elastomers shall be evaluated for compatibility with fluids, surfaces, or atmospheric conditions with which the part comes in contact. These materials shall comply with the requirements for Gaskets and Seals, UL 157.

35.2.3 All accessories shall be constructed to minimize the stresses on the base tank.

36 Ladders

36.1 Exterior ladders shall comply with the construction and performance requirements in accordance with Occupational Safety and Health Standards, Title 29 of the Code of Federal Regulations, Part 1910, Subpart D, Section 1910.23 Ladders Subsections (b) General Requirements for All Ladders items (2) and (7), and (d) – Fixed Ladders items (1), (2), (3), (7), (8), (11) and (13), and Section 1910.24 Step Bolts and Manway Steps Subsections (a) and (b).

36.2 Interior ladders shall comply with the exterior ladder requirements except that the climbing surface must be vertical and directly in line with the edge of the tank manhole. Manholes shall not be less than 24 inches (0.6 m) in diameter. Hatch covers, if used, shall not be of the self-locking type if they can be opened only from the outside of the tank.

36.3 All ladders shall be tested or calculated to withstand, the minimum static loads as described in 36.5 applied to 3-1/2 inch wide blocks for 1 min without damage to or permanent deformation of the ladder or tank.

36.4 *Deleted*

36.5 Static Load (Ladders) – Ladders with a length of climb of 10 feet (3 m) or less shall support a static load of 1000 pounds (454 kg) applied for 1 minute to the center of the longest rung. Ladders with a length of climb of greater than 10 feet shall support a static load of 2000 pounds (909 kg) applied to the center of two rungs spaced 10 feet apart.

37 Stairs and Runways

37.1 Stairs shall comply with the construction and performance requirements in accordance with Occupational Safety and Health Standards, Title 29 of the Code of Federal Regulations, Part 1910, Subpart D, Section 1910.25 Stairways Subsections (b) General Requirement items (1) to (9) except ship stair, and (c) Standard Stairs items (1) to (4), or for vertical cylindrical tanks (d) Spiral Stairs items (1) to (5).

37.2 Runways shall comply with the construction and performance requirements in accordance with Occupational Safety and Health Standards, Title 29 of the Code of Federal Regulations Part 1910, Subpart D, Sec 1910.28 Subsections (a) General item (1), (b) Protection from Fall Hazards items (5) runways and similar walkways (i) & (ii) and (11) stairways items (i) & (ii).

37.3 Guardrails on Stairs and Runways shall be provided for fall protection in accordance with Section 38. Runways used below the top level of the tank are only required to have a guardrail on one side

37.4 All stairs and runways shall withstand the loads described in 37.5 and 37.6, respectively, without damage to or permanent deformation of the accessory or tank.

37.5 Stair Static Load – A static load of 5X the rated load or minimum 1000 pounds (454 kg) is to be evenly distributed over a 1.0 ft x 2.0 ft area on the center of the longest unsupported span of the runway for a period of one minute.

37.6 Runway Static Load – A static load of the rated load or at least 1000 pounds (454 kg) is to be evenly distributed over a 1.0 ft x 2.0 ft area on the center of the longest unsupported span of the runway for a period of one min.

38 Guardrails

38.1 Guardrails shall comply with the construction and performance requirements in accordance with the Occupational Safety and Health Standards, Title 29 of the Code of Federal Regulations, Part 1910, Subpart D, Section 1910.29 Subsections (a) General Requirements item (1) and (b) Guardrail Systems items (1) to (14).

38.2 All guardrails shall withstand the loads described in 38.3 and 38.4 applied using a 3-1/2 by 3-1/2 inch (89 by 89 mm) steel plate, without damage to or permanent deformation of the guardrail.

38.3 Guardrail Static Load – A static load of 200 pounds (91 kg) shall be applied downward and outward within 2 inches (5 cm) of the top edge, at a point on top of the rail located midway between the supports for at least one minute. The top rail shall aslo not deflect to less than 39 inches (99 cm) above the walking surface.

38.4 Midrail Static Load – A static load of 150 pounds (68.3 kg) shall be applied downward or outward on midrails, screens, mesh, intermediate vertical members, solid panels, and other equivalent intermediate members located midway between the supports for at least one minute.

39 Heating Coils and Hot Wells

39.1 A heating coil or hot well that is provided as part of a tank assembly and handles a fluid other than that stored in the tank, such as steam or hot water, shall have no joints in that portion located within the tank unless such joints are continuously welded or brazed. The coil or hot well connection shall exit from the tank above the liquid level, unless made of steel having a wall thickness not less than specified for that portion of the tank shell through which the connection exists. A continuous full fillet weld shall be made on the inside and outside of the tank where a connection pierces the tank or a manhole cover.

40 Sumps

40.1 A sump that is provided as part of a tank assembly shall be of steel having a thickness not less than that of the tank shell or bottom. It shall be attached to the tank using a continuous full fillet weld, inside and outside, or the equivalent.

40.2 As an option, sumps with a maximum 24 inch (60.96 cm) diameter and maximum 12 inches (30.4 cm) depth shall be permitted in primary and/or secondary tanks along the bottom center line. The thickness of the sump material shall, at a minimum, be the same thickness of the tank shell or bottom, depending on the location of the sump and the type/orientation of the tank.

40.3 All internal welds are to be full seal welds.

40.4 Sump welds shall be a minimum 6 inches (15.2 cm) from a head or bulkhead weld.