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Subjects 58 (1746)
 (In reply, refer to Subject 58)

333 Pfingsten Road
 Northbrook, IL 60062
 May 31, 1996

TO: Casualty Council of Underwriters Laboratories Inc.,
 Fire Council of Underwriters Laboratories Inc.,
 Subscribers to UL's Standards Service for Steel Underground Tanks for Flammable and
 Combustible Liquids

SUBJECT: Request for Comments on Proposed Requirements for the Proposed Ninth Edition of the
 Standard for Steel Underground Tanks for Flammable and Combustible Liquids, UL 58;
 PROPOSED EFFECTIVE DATE

SUMMARY OF TOPICS

This bulletin proposes the following changes in requirements for the proposed Ninth Edition of UL 58:

1. Deleting unflanged flat heads and unflanged bulkheads.
2. Referencing Roark's Equation for calculating steel thickness for tanks covered by UL 58.
3. Use of stiffeners to increase the maximum length of the tank.
4. Addition of the External Pressure Test and Lift Lug Test.
5. Requiring that the length of all tanks be limited to 6 times their diameter.
6. Mandatory Language Revisions

COMMENTS DUE: September 3, 1996

Attached as Appendix A for your review and comment is the proposed Ninth Edition for UL 58. Questions regarding interpretation of requirements should be directed to the responsible UL Staff. Please see Appendix B of this bulletin regarding designated responsibility for the subject product categories.

Please note that proposed requirements are of a tentative and early nature and are for review and comment only. Current requirements are to be used to judge a product until these requirements are published in final form.

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 committed to quality service

PROPOSED EFFECTIVE DATE

If the material has been revised or renumbered, the old paragraph or section numbers from the eighth edition is included inside the parentheses for your reference.

The proposed requirements specified in 9.2 (6.2), 13.4 (7.4) and Sections 5, 6, 14, 18 and 19 will not require a review and retest of currently Listed products. However, future products shall reflect these changes in requirements therefore, UL proposes that the new requirements become effective 6 months after publication. This is intended to provide manufacturers with sufficient time to implement the necessary changes in production.

The remainder of the requirements will not require a review or additional testing of currently Listed products. Therefore, UL proposes that these requirements become effective upon publication.

The changes from the eighth edition to the proposed ninth edition are as follows:

1. SCOPE

RATIONALE

UL proposes to revise 1.2 to clarify that this standard covers single wall, double wall, and compartment tanks.

IMPACT

Since the proposal is a clarification of present practice, if it is adopted, it will not require a review, retest or modification of the presently Listed equipment.

2. UNFLANGED FLAT HEADS AND BULKHEADS

RATIONALE

Based on industry input, UL proposes to delete the requirements contained in 6.4 of the eighth edition of UL 58 for unflanged flat heads and 7.1 for unflanged flat bulkheads. UL proposes to revise 9.2 (6.2) which will require the head of the tank to be flanged, dished, or conical.

IMPACT

The proposal will not require a review of the presently Listed equipment. However, future production tanks shall reflect this change in requirements no later than the effective date.

3. UPDATING CODES AND ASTM STANDARD REFERENCES

RATIONALE

UL proposes to revise 1.2 (1.1A), 7.2 (4.2), and 7.3 (4.3) to update the references to the new edition of installation codes and ASTM Standard references.

IMPACT

The proposals, if adopted, will not require a review or modification of the presently Listed equipment.

4. ROARK'S EQUATION, EXTERNAL PRESSURE TEST AND STIFFENERS

At the end of 1994, UL received a proposal from industry to use Roark's equation to calculate minimum steel thickness in design of tanks covered by UL 58. The steel thickness is derived by equating the calculated tank buckling pressure to the external pressure at the bottom of the tank submerged in water, with no backfill support. UL proposes that a minimum burial depth of 5 feet (1.52 m) be used with Roark's equation unless the manufacturer specifies a greater value for the burial depth.

After a review and analysis of developmental testing, UL proposes to revise UL 58 to include Roark's equation for calculating minimum steel shell thicknesses. Manufacturers will have the option of designing tanks covered by UL 58 either using Roark's equation or conducting an External Pressure Test to evaluate strength.

UL is proposing that the External Pressure Test be conducted at the maximum burial depth in water, but not less than 5 feet (1.52 mm) with no backfill. The proposed test will be conducted for one hour.

The proposed Roark's equation and its application to tanks covered by UL 58 are explained in detail in the following paragraphs:

$$\text{Roark's equation: } P = [.807Et^2 / (lr)] [(1-u^2)^{-3} (t/r)^2]^{.25}$$

$$\text{or } t = [(Plr^{3/2} (1-u^2)^{3/4}) / (.807E)]^{.4}$$

$$\text{or } l = [0.807 Et^2 / (Pr)] [(1 - u^2)^{-3} (t/r)^2]^{.25}$$

in which:

P is calculated external pressure at the bottom of a submerged tank in water, psi. The water depth equals 5 feet (1.52 m) or the maximum burial depth for the tank, whichever is greater, plus the tank diameter.

E is modulus of elasticity of steel, 30×10^6 psi

t is thickness of steel, inches

l is length of tank, inches

r is radius of tank, inches

u is Poisson's Ratio, .287

Reference: Roark's Formulas for Stress and Strain, 6th Edition, Warren Young, Table 35, Case 19b, Page 690.

For a given burial depth, length and radius, the steel thickness can be calculated using the above equation for "t". This equation applies to carbon steel as well as stainless steel.

The equivalent steel thickness (t_{eq}) for a Type I double wall steel tank is $(t_{inner}^{2.5} + t_{outer}^{2.5})^{.4}$. This value is substituted into the Roark's Equation.

The steel thickness for the inner and outer walls of a Type II tank is calculated independently using Roark's Equation.

Steel shell thickness can be established using calculations, however, the proposed minimum steel thickness for a primary tank is 0.123 inches (3.12 mm) and the minimum steel thickness for a secondary tank is 0.093 inches (2.36 mm).

The proposal also addresses the use of stiffeners. The maximum length of the tank can be increased up to 25% with one stiffener added to the midpoint of the tank. If two stiffeners are placed at the 1/3 and 2/3 positions of a tank, the tank length may be increased by 40%. The length may be increased up to a length to diameter ratio of 6:1. The stiffeners would be intermittently welded and extend 360-degrees around the tank. The stiffeners shall have an opening at the top and bottom so that liquid and vapor can move past the stiffener. The required moment of inertia (I_{req}) of the stiffener is described below.

$$I_{req} = (1.1PID^3F) / (24E) \text{ in}^4$$

in which:

P is calculated external pressure at the bottom of a submerged tank in water, psi. The water depth equals 5 feet (1.52 m) or the maximum burial depth for the tank, whichever is greater, plus the tank diameter.

I is rib spacing, inches

D is outer diameter of tank, inches

E is modulus of elasticity of steel, 30×10^6 psi

F is safety factor of 2.5

UL was also requested to consider whether UL 58 could be revised to allow for head thicknesses of underground tanks to vary as a function of diameter and tank head stiffness. Currently, the head thickness of underground tanks is required to be equal to or greater than the shell thickness. UL is proposing that the head thickness be equal to or greater than the values in Table 5.1 of this proposal. Also, only the tank diameter will be considered when establishing head steel thickness, i.e. tank volume/length will be removed as a consideration.

Table 5.1
Tank head thickness

Tank diameter,		Minimum head thickness,	
Inches	m	Inches	mm
Up to 64	Up to 1.62	.123	3.12
64.1 to 90	1.63 to 2.28	.167	4.24
90.1 to 126	2.29 to 3.20	.240	6.10
126.1 to 144	3.20 to 3.66	.302	7.67

IMPACT

This proposal, if adopted, will not require a review of the presently Listed equipment. However, future production tanks shall reflect this change in requirement no later than the effective date.

5. LIFT LUGS

RATIONALE

UL proposes to add section 6 and section 19, Lift Lugs. These requirements will cover lift lugs and are intended to test for damage to the lift lugs or tank during the Lift Lug Test.

IMPACT

If a manufacturer intends to provide lift lugs on currently Listed tanks, these tanks will need to be tested according to the added requirements in Sections 6 and 19.

6. MONITORING CONSTRUCTION FOR SECONDARY CONTAINMENT

RATIONALE

UL proposes to add Section 14, Interstitial Monitor Access, to describe monitoring construction for secondary containment.

IMPACT

The proposal will not require a review of the presently Listed equipment. However, future production tanks shall reflect this change in requirement no later than the effective date.

7. LENGTH TO DIAMETER RATIO FOR TYPE 1 SECONDARY CONTAINMENT

RATIONALE

UL proposes to revise 4.5 (3.5) to state that the length of all tanks be limited to 6 times their diameter.

IMPACT

The proposal, if adopted, will not require a review or modification of the presently Listed equipment.

8. CLARIFICATION

RATIONALE

UL proposes to revise:

- a) 10.1 (8.1) to include "All threads shall be standard NPT",
- b) 10.9 (8.9) to include plastic thread protectors, and
- c) Figures 8.1 (5.1), 9.1 (6.1), 11.1 (9.1), 13.1 (7.1), 15.1 (7A.1) and add Figure 14.1 to clarify the text.

IMPACT

The proposals, if adopted, will not require a review or retest of the presently Listed equipment.

9. MANDATORY LANGUAGE

RATIONALE

UL proposes to revise 2.1.1 (2.1), 3.2 (2.3), 9.2 (6.2), 13.1 (7.1), 13.2 (7.2), 15.6 (7A.1), 15.2 (7A.5), 10.7 (8.7), 12.1 (8A.1), 11.1 (9.1), 11.1(b), 20.2 (11.2), 21.1 (12.1), 21.2 (12.2), 21.3 (12.4) and Figures 8.1 (5.1) and 13.1 (7.1) to incorporate mandatory language.

IMPACT

The proposals covering mandatory language in the above paragraphs and Figures are editorial in nature and if adopted will not require a review or retest of the presently Listed Equipment.

REQUEST FOR COMMENTS ON PROPOSALS

Please provide the following:

- 1. Your comments concerning the proposed new edition; and
- 2. Your comments concerning the proposed effective dates, should the proposals be adopted.

Written comments should be sent to the attention of Jeff Prusko at UL's Northbrook office, 333 Pfingsten Road, Northbrook, IL 60062-2096. Please reference all correspondence to Subject 58.

All comments should be sent by September 3, 1996.

Subjects 58 (1746)

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May 31, 1996

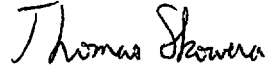
Unless specifically requested to do so, UL will not acknowledge comments indicating concurrence with these proposals.

UNDERWRITERS LABORATORIES INC.



JEFF PRUSKO (Ext. 43416)
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REVIEWED BY:



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SR:AM

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PROPOSED REQUIREMENTS ARE OF A TENTATIVE AND EARLY NATURE AND ARE FOR REVIEW AND COMMENT ONLY. CURRENT REQUIREMENTS ARE TO BE USED TO JUDGE A PRODUCT UNTIL THESE REQUIREMENTS ARE PUBLISHED IN FINAL FORM.

APPENDIX A

PROPOSED NINTH EDITION AND PROPOSED EFFECTIVE DATES FOR THE STANDARD FOR STEEL UNDERGROUND TANKS FOR FLAMMABLE AND COMBUSTIBLE FLUIDS, UL 58 MAY 31, 1996 DRAFT

In the enclosed draft, all paragraphs or sections, where appropriate, are identified by the following notations following the paragraph number or section title:

- (N) – New material not included in the previous edition of UL 58.
- (R) – Material revised from the previous edition of UL 58.
- (E) – Editorial changes that clarify but do not revise the requirements.

If the material has been revised or renumbered, the old paragraph or section numbers from the eighth edition is included inside the parentheses for your reference.

PROPOSALS

INTRODUCTION

1 Scope

1.1 (1.1) These requirements cover horizontal atmospheric-type steel tanks intended for the storage underground of flammable and combustible liquids.

1.2 (1.1A R) These requirements cover single wall tanks, secondary containment tanks, multiple compartment single wall and multiple compartment secondary containment tanks.

1.3 (1.2R) These tanks are intended for installation and use in accordance with the Standard for the Installation of Oil-Burning Equipment, NFPA 31, the Flammable and Combustible Liquids Code, NFPA 30, the Automotive and Marine Service Station Code, NFPA 30A, and the Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, NFPA 37.

1.4 (1.3) Tanks covered by these requirements are cylindrical tanks that are fabricated, inspected, and tested for leakage before shipment from the factory as completely assembled vessels.

1.5 (1.4) These requirements do not apply to tanks covered by the Standard for Welded Steel Tanks for Oil Storage, API 650, nor tanks intended for use in chemical and petrochemical plants.

1.6 (N) This Standard does not cover corrosion protection which may be required by local, state or federal authorities. Corrosion protection systems installed at the factory on carbon steel underground storage tanks are covered in UL 1746, External Corrosion Protection System for Steel Underground Storage Tanks.

1.7 (N) A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 General

2.1 Units of measurements

2.1.1 (2.1R) When a value for measurement is followed by a value in other units in parentheses, the first stated value is the requirement.

2.2 Components

2.2.1 (N) Except as indicated in 2.2.2, a component of a product covered by this standard shall comply with the requirements for that component.

2.2.2 (N) A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

2.2.3 (N) A component shall be used in accordance with its recognized rating established for the intended conditions of use.

2.2.4 (N) Specific components are recognized as being incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions for which they have been recognized.

2.3 Undated references

2.3.1 (N) 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 (N) For the purpose of this standard, the following definitions apply.

3.2 (2.3R) TYPE I TANK — A primary tank wrapped by an exterior steel shell that is in direct contact with the primary tank; where, the exterior shell is wrapped from 300 to 360 degrees of the primary tank circumference.

3.3 (2.4) TYPE II TANK — An outer tank physically separated from the inner primary containment tank by standoffs; where, the inner tank is completely contained within the outer tank.

CONSTRUCTION

ALL TANKS

4 Capacities and Dimensions

4.1 (3.1) Capacities, dimensions, and construction details shall comply with the applicable requirements of this standard.

4.2 (3.2E) Tables 1 and 2 of Appendix B give capacities for cylindrical tanks in gallons per foot of length and in liters per meter of length. For a tank with conical heads, the total capacity is obtained by adding one-third the height of the heads to the shell length. For a compartment tank, the total tank capacity is the sum of the capacity of each compartment.

4.3 (3.3) The total 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.

4.4 (3.4) The total capacity is to be determined at the level of the lowest opening when the tank is in the intended installation position.

4.5 (3.5R) The overall length of a tank shall not be greater than 6 times its diameter.

5 Steel Thickness

Section 5 effective (6 months after date of publication)

5.1 General

5.1.1 (N) Tanks shall comply with Roark's Equation or the External Pressure Test described in 18.1.

5.1.2 (N) The minimum steel thickness for a primary tank is 0.123 inches (3.12 mm). The minimum steel thickness for a secondary tank is 0.093 inches (2.36 mm).

5.1.3 (N) The minimum head thicknesses for primary and secondary tanks are noted in Table 5.1.

Table 5.1 (N)
Tank head thickness

Tank diameter,		Minimum head thickness,	
Inches	m	Inches	mm
Up to 64	Up to 1.62	.123	3.12
64.1 to 90	1.63 to 2.28	.167	4.24
90.1 to 126	2.29 to 3.20	.240	6.10
126.1 to 144	3.20 to 3.66	.302	7.67

5.2 Roark's equation

5.2.1 (N) The calculated pressure from Roark's equation shall be equal to or greater than the external pressure at the bottom of the tank surrounded by only water and submerged 5 feet (1.52 m) or at a depth equal to the manufacturer's specified maximum burial depth, whichever is greater. The buckling pressure shall be calculated using the following equation:

$$\text{Roark's equation: } P = [.807Et^2 / (lr)] [(1 - u^2)^{-3} (t / r)^2]^{.25}$$

in which:

P is buckling pressure, psi
E is modulus of elasticity of steel, 30×10^6 psi
t is thickness of steel, inches
l is length of tank, inches
r is radius of tank, inches
u is Poisson's Ratio, .287

Reference: Roark's Formulas for Stress and Strain, 6th Edition, Warren Young, Table 35, Case 19b, Page 690

5.2.2 (N) Using Roark's formula, minimum steel thickness ($t_{\min}$) or the maximum tank length ($l_{\max}$) can be calculated using the following equations, respectively:

$$t_{\min} = [(P_1 l r^{3/2} (1 - u^2)^{3/4}) / (.807 E)]^4$$

$$\text{or } l_{\max} = [.807 E t^2 / P_1 r] [(1 - u^2)^{-3} (t / r)^2]^{.25}$$

in which:

P_1 is calculated external pressure at the bottom of a submerged tank in water, psi. The water depth equals 5 feet (1.52 m) or the maximum burial depth for the tank, whichever is greater, plus the tank diameter.

E is Modulus of Elasticity of steel, 30×10^6 psi

t is thickness of steel, inches

l is length of tank, inches

r is radius of tank, inches

u is Poisson's Ratio, .287

5.2.3 (N) The equivalent steel thickness (t_{eq}) for a Type I double wall steel tank is $(t_{\text{inner}}^{2.5} + t_{\text{outer}}^{2.5})^{.4}$. This value is substituted into Roark's Equation.

5.2.4 (N) The steel thickness for the inner and outer walls of a Type II tank is calculated independently using Roark's Equation.

5.3 Stiffeners

5.3.1 (N) With the addition of one stiffener to the midpoint of a tank, the tank length can be increased 25%. When two stiffeners are placed at the 1/3 and 2/3 positions of a tank, the tank length can be increased 40%. Other arrangements of stiffeners will require an engineering evaluation.

5.3.2 (N) Stiffeners shall be intermittently welded and extend 360 degrees around the tank. The stiffeners shall have an opening at the top and bottom so that liquid and vapor can move past the stiffeners.

5.3.3 (N) The required moment of inertia (I_{req}) of the stiffener is described below:

$$I_{req} = (1.1PID^3F) / (24E) \text{ in}^4$$

in which:

P is calculated external pressure at the bottom of a submerged tank in water. The water depth equals the maximum burial depth for the tank plus the tank diameter. psi

I is rib spacing, inches

D is outer diameter of tank, inches

E is modulus of steel, 30×10^6 psi

F is safety factor of 2.5

5.3.4 (N) Bulkheads are considered to be stiffeners.

6 Lift Lugs

Section 6 effective (6 months after date of publication)

6.1 (N) Lift lugs, when provided, shall comply with the load test requirements in Section 19 and the marking requirements in 21.8.

7 Materials

7.1 (4.1E) A tank shall be constructed of commercial or structural grade carbon steel or of Type 304 or 316 stainless steel, as noted in 7.2 and 7.3. Only new material shall be used.

7.2 (4.2E) Carbon steel shall:

a) Comply with the Specification for Structural Steel, ASTM A36-81a; or Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip, Commercial Quality, ASTM A569/A569M-91a; or Specification for Hot-Rolled Carbon Steel Sheet and Strip, Commercial Quality, Heavy Thickness Coils (Formerly Plate), ASTM A635/635M-92; or

b) Have:

1) a carbon content of 0.3 percent or less, or a carbon equivalency of 0.53 percent or less, and

2) mechanical strength and welding characteristics at least equivalent to one of the steels specified in 7.2(a).

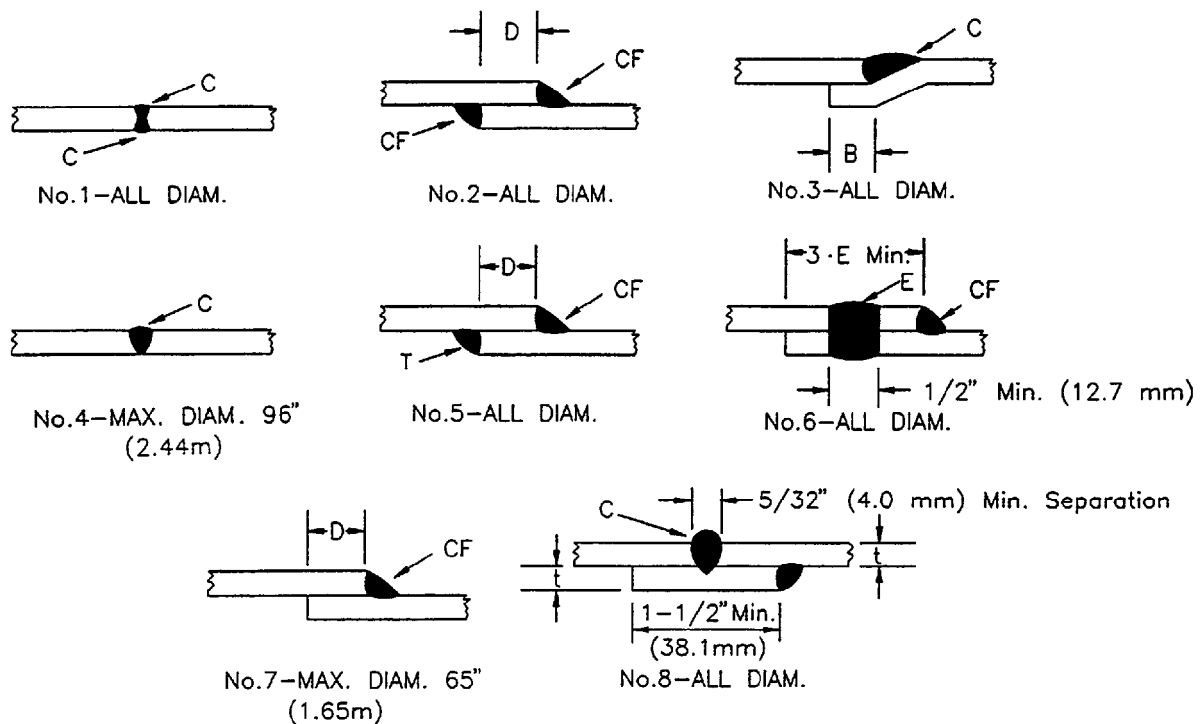
7.3 (4.3E) Stainless steel shall comply with the Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip, ASTM A167-92b; or Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels, ASTM A240-92b.

7.4 (3.7) 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 sheet not less than $\frac{3}{8}$ inch (9.5 mm) from a cut edge and not less than $\frac{3}{4}$ inch (19 mm) from a mill edge.

8 Shell Joints

8.1 (5.1) A shell joint of a tank shall be one of the constructions illustrated in Figure 8.1.

Figure 8.1 (5.1R)
Shell joints



S2779B

B — Overlap — 1/2 inch (12.7 mm) minimum.

C — Continuous welds.

CF — All lap welds shall be continuous full fillet welds.

D — Overlap — 1/2 inch (12.7 mm) minimum for diameters 48 inches (1.2 m) or less; 3/4 inch (19.1 mm) minimum for diameters over 48 inches.

E — 1/2 inch (12.7 mm) minimum diameter lock weld, not over 12 inches (305 mm) apart.

T — Tack weld 1 inch (25 mm) spots, not over 12 inches (305 mm) apart.

t — Thickness of backup bar to be same as shell thickness.

a — No. 7 weld shall not be used for double wall tanks.

b — Shell joint No. 4 shall not be used on a tank larger than 96 inches (2.44 m) in diameter.

c — Shell joint No. 7 shall not be used on a single wall tank larger than 65 inches (1.65 m) in diameter.

9 Heads and Head Joints

9.1 (6.1R) A head of a tank shall be constructed of not more than two pieces for diameters of 48 inches (1.22 m) or less, three pieces for diameters ranging from 49 to 96 inches (1.24 to 2.44 m), and four pieces for diameters ranging from 97 to 144 inches (2.46 to 3.66 m). When two or more pieces are used, joints shall comply with the requirements for shell joints in Figure 8.1, No.1.

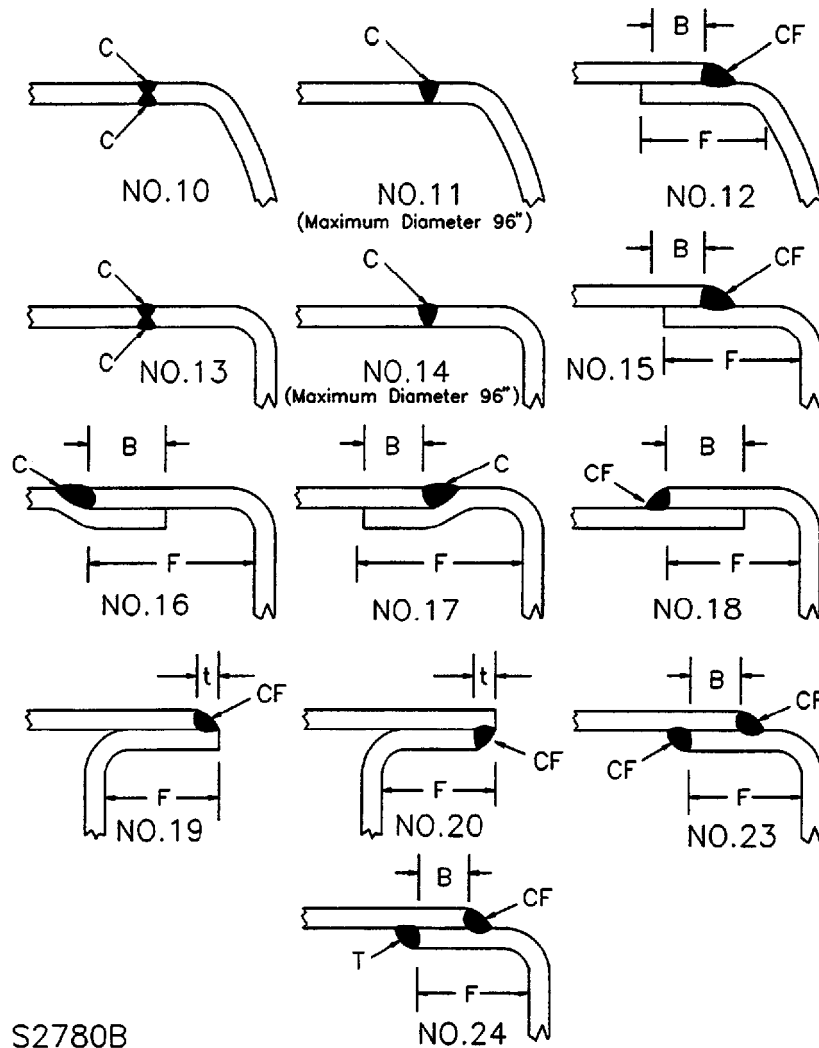
9.2 (6.2R) A head of a tank shall be flanged, dished, or conical.

9.2 effective (6 months after date of publication)

9.3 (6.3R) The knuckle radius shall be greater than or equal to 1.5 times the head plate thickness. A head of a tank shall be attached to the shell by one of the joints illustrated in Figure 9.1.

9.4 (6.6) A conical head shall have a height of not less than one-twelfth the diameter of the tank.

Figure 9.1 (6.1 R)
Head joints for all diameter tanks



B — Overlap — 1/2 inch (12.7 mm) minimum.

C — Continuous welds.

CF — Shall be continuous full fillet welds.

F — Not less than five times head thickness — minimum 1/2 inch (12.7 mm).

T — Tack weld 1 inch (25 mm) spots, not over 12 inches (305 mm) apart.

t — Minimum, 1 X shell thickness.

Heads shall be dished or cone.

Height of cones heads — not less than one-twelfth diameter.

Height of dished heads shall conform to Table 9.1.

9.5 (6.7E) The depth of dish of a dished head shall not be less than that specified in Table 9.1

Table 9.1 (6.1)
Dished heads — minimum height of dish

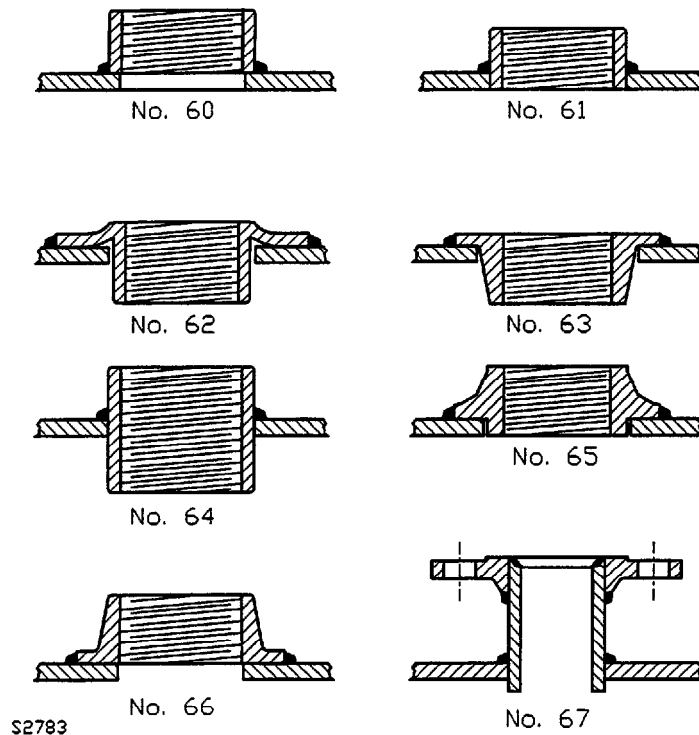
Diameter		Minimum dish		Diameter		Minimum dish	
Inches	m	Inches	mm	Inches	m	Inches	mm
Up to 60	Up to 1.52	1-1/2	38	97 — 108	2.46 — 2.74	4-1/2	114
61 — 72	1.55 — 1.83	2	51	109 — 120	2.77 — 3.05	5-1/2	140
73 — 84	1.85 — 2.13	2-1/2	64	121 — 132	3.07 — 3.35	7	178
85 — 96	2.16 — 2.44	3-1/2	89	133 — 144	3.38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

10 Pipe Connections

10.1 (8.1R) A pipe connection shall be provided by welding to the tank a standard threaded pipe coupling, a threaded flange, or a standard half pipe nipple, or by a bolted and gasketed flanged connection welded to a pipe nipple that in turn, is welded to the tank. All threads shall be standard NPT.

10.2 (8.2E) Conventional types of pipe connections are illustrated in Figure 10.1.

Figure 10.1 (8.1)
Pipe connections



All welds are to be full fillet welds, at least 1/8 inch (3.2 mm) radius.

No. 60 — Half pipe coupling.

No. 61 — Half pipe coupling.

No. 62 — Pressed steel, hub inside tank only.

No. 63 — Forged steel, hub inside tank.

No. 64 — Full pipe coupling.

No. 65 — Forged steel, with pilot.

No. 66 — Forged steel, without pilot.

No. 67 — Standard pipe nipple and welding flange.

10.3 (8.3E) The minimum length of thread in a pipe connection shall be specified in Table 10.1.

10.4 (8.4E) A pressed-steel pipe-connecting fitting shall be:

- a) Installed with the hub section on the inside of the tank only and
- b) Of the form illustrated in No. 62 of Figure 10.1.

The minimum thickness of the flange section shall be as specified in Table 10.1.

Table 10.1 (9.1)
Pipe connections

Pipe size ^a nominal	Minimum length of thread		Minimum thickness of flange 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	0.123	3.12
1	5/8	15.9	0.138	3.51
1-1/4	11/16	17.5	0.138	3.51
1-1/2	3/4	19.1	0.138	3.51
2	3/4	19.1	0.138	3.51
2-1/2	1	25.4	0.167	4.24
3	1	25.4	0.167	4.24
3-1/2	1	25.4	0.167	4.24
4	1-1/8	28.6	0.167	4.24
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, ANSI B36.10—1979(R1995).

10.5 (8.5E) A half pipe nipple shall be welded to the tank as illustrated in No. 67 of Figure 10.1.

10.6 (8.6E) Except as indicated in 10.7 and 10.8, all openings in a tank shall be located in the top, parallel with the longitudinal axis of the tank.

10.7 (8.7E) When the application of a tank is such that pipe-connecting openings in the top are required to be grouped, the openings may be located off center of the longitudinal axis under the conditions specified in 10.8.

10.8 (8.8E) No opening in the shell of a tank shall be located more than 12 inches (305 mm) from the longitudinal centerline of the top, and the upper end of the pipe coupling or other pipe-connecting fitting welded to the tank shall terminate above the top of the shell.

10.9 (8.9R) All openings in a tank shall be closed with wooden plugs, metal covers, plastic thread protectors, or the equivalent, to protect the threads and exclude foreign matter while the tank is in storage or in transit.

10.10 (8.10E) Each tank shall have a pipe connection of a size not less than that specified in Table 10.2 for attachment of a vent pipe.

Table 10.2 (8.2)
Size of vent-pipe fitting

Capacity of tank		Nominal pipe size ^a inches
U.S.Gallons	L	
0 to 500	Up to 1895	1-1/4
500 to 3000	1900 to 11355	1-1/2
3001 to 10000	11360 to 37855	2
10001 to 20000	37860 to 75710	2-1/2
20001 to 35000	75715 to 132490	3
35001 to 50000	132495 to 189270	4

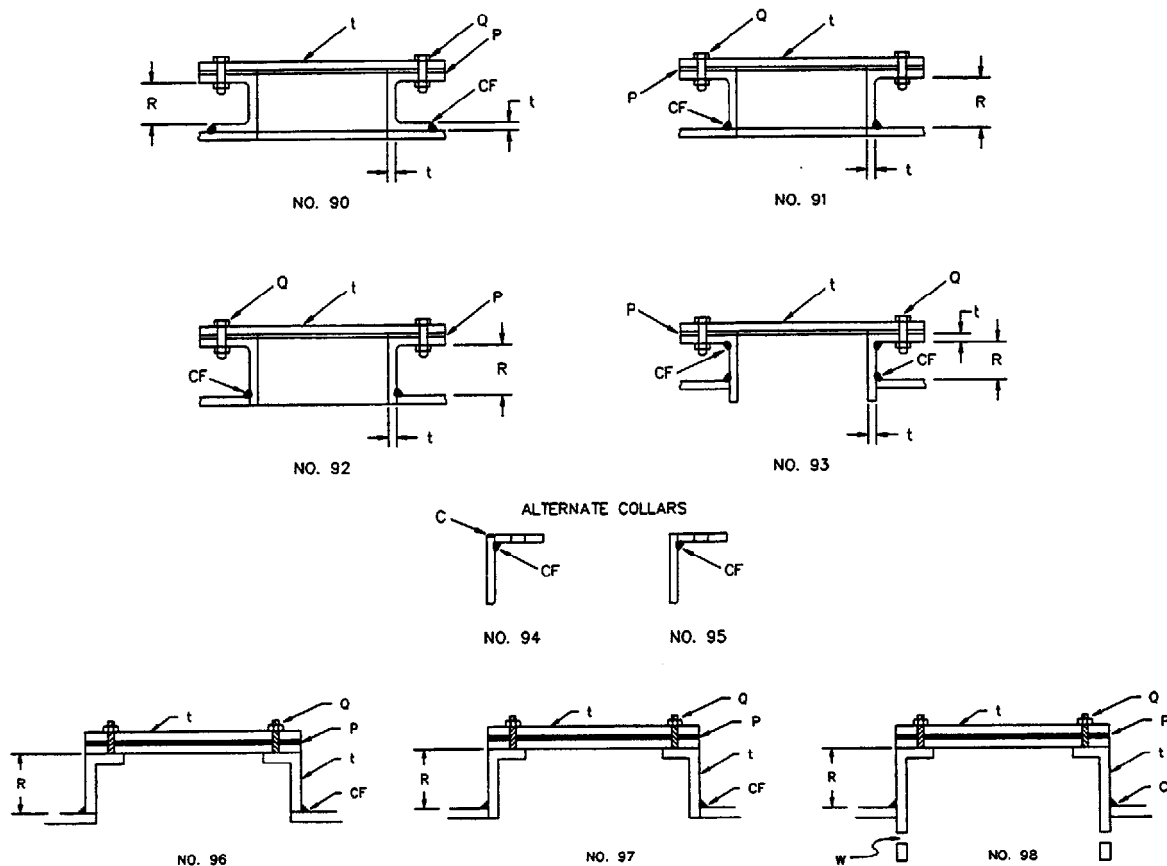
^a Standard for Welded and Seamless Wrought Steel Pipe, ANSI B36.10—1979(R1995).

10.11 (8.11E) An opening for connection of a vent pipe which is located in a manway cover shall be grouped with at least one other opening.

11 Manways

11.1 (9.1E) A manway, when provided in a tank, shall be located above the highest intended liquid level and shall be of the bolted-cover type as illustrated in Figure 11.1.

Figure 11.1 (9.1R)
Conventional manways



S3617A

C — Continuous weld.

CF — Continuous full fillet weld.

P — Gasket material, 1/8 inch (3.2 mm) thick minimum - ring or face gasket.

Q — Minimum, 1/2 inch (12.7 mm) bolts spaced 4 inch (102 mm) centers maximum.

R — Minimum, 2 inches (51 mm) for tanks 6 feet (1.8 m) in diameter or larger.

t — Not less than 0.167 inch (4.50 mm) thick.

11.2 (9.2R) A manway-cover joint shall be provided with a gasket of material determined to be suitable for the liquid to be stored and shall not be less than 1/8 inch (3.2 mm) thick.

12 Striker Plates

12.1 (8A.1R) A tank shall have a striker plate of steel at least 0.240 inch (6.10 mm) thick. Each striker plate shall be at least 8 inches (204 mm) wide, and at least 64 square inches (0.04 m²) in area directly centered under:

- a) Each opening, or
- b) One opening that is marked as specified in 21.3.

13 Compartment tanks

13.1 (7.1E) Bulkheads of a compartment tank shall be constructed so that any leakage through joints shall not result in leakage from one compartment to another. See Figure 13.1 for acceptable bulkhead constructions.

13.2 (7.2E) A single bulkhead of a compartment tank, illustrated in No. 2 of Figure 13.1, shall be constructed of one piece of material and shall be flat-flanged or dished. The height of a dished bulkhead shall not be less than that specified in Table 9.1.

13.3 (7.3E) A bulkhead of a double bulkhead tank, illustrated in No. 1 of Figure 13.1, shall be constructed of not more than two pieces for diameters of 48 inches (1.22 m) or less, three pieces for diameters ranging from 49 to 96 inches (1.24 to 2.44 m), and four pieces for diameters ranging from 97 to 144 inches (2.46 to 3.66 m). When two or more pieces are used, joints shall comply with the requirements for shell joints in 8.1.

13.4 (7.4R) The minimum thickness of metal employed for a bulkhead shall be calculated using the Roark Equation.

13.4 effective (6 months after date of publication)

13.5 (7.6R) A flanged flat bulkhead of a compartment tank more than 72 inches (1.83 m) in diameter shall be made of steel not less than 0.302 inch (7.67 mm) thick or it shall be braced as illustrated in Figure 13.2 and shall comply with Table 13.1.

13.6 (7.7) A flanged flat bulkhead 72 inches (1.83 m) or less in diameter does not require bracing.

Figure 13.1 (7.1R)
Bulkheads for compartment tanks

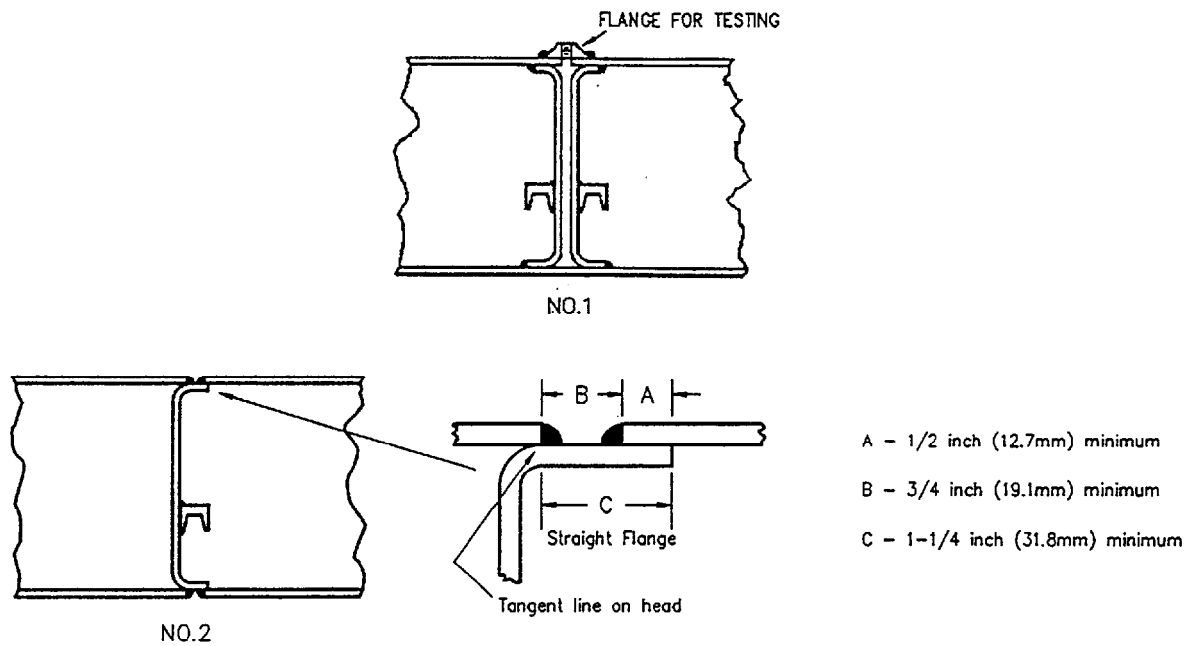
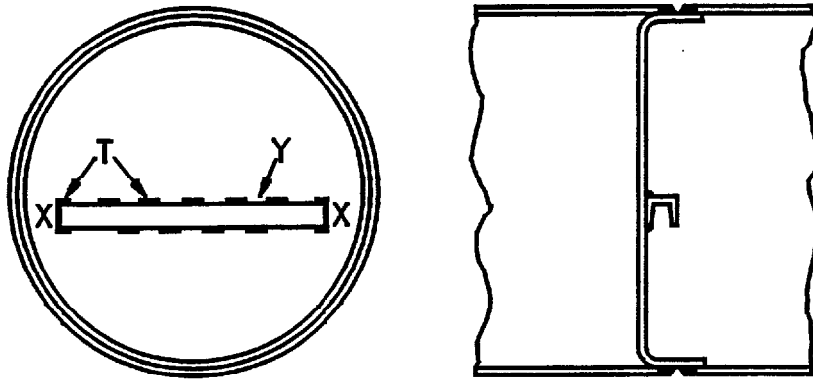


Figure 13.2 (7A.2)
Surface bracing for flanged flat bulkheads



- T – Tack welds, not over 12 inches (0.3m) apart.
X – Not over 4 inches (102mm) from shell.
Y – Bracing [locate 6 inches (152mm) below center of head].

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Table 13.1 (6.4R)
Surface bracing for flanged flat bulkheads

Diameter head		I-Beams	Channels
Inches	m	Section modulus(s) in. ³	Section modulus(s) in. ³
72 — 84	1.83 — 2.13	1.7 ^a	1.1 ^a
85 — 96	2.16 — 2.44	1.7 ^a	1.9 ^a
97 — 108	2.46 — 2.74	3.0 ^a	3.0 ^a
109 — 120	2.77 — 3.05	4.8 ^a	3.0 ^a
121 — 132	3.07 — 3.35	4.8 ^a	4.3 ^a
133 — 144	3.38 — 3.66	4.8 ^a	4.3 ^a
^a Flange of I-beam or channel welded to bulkhead.			

SECONDARY CONTAINMENT TANKS

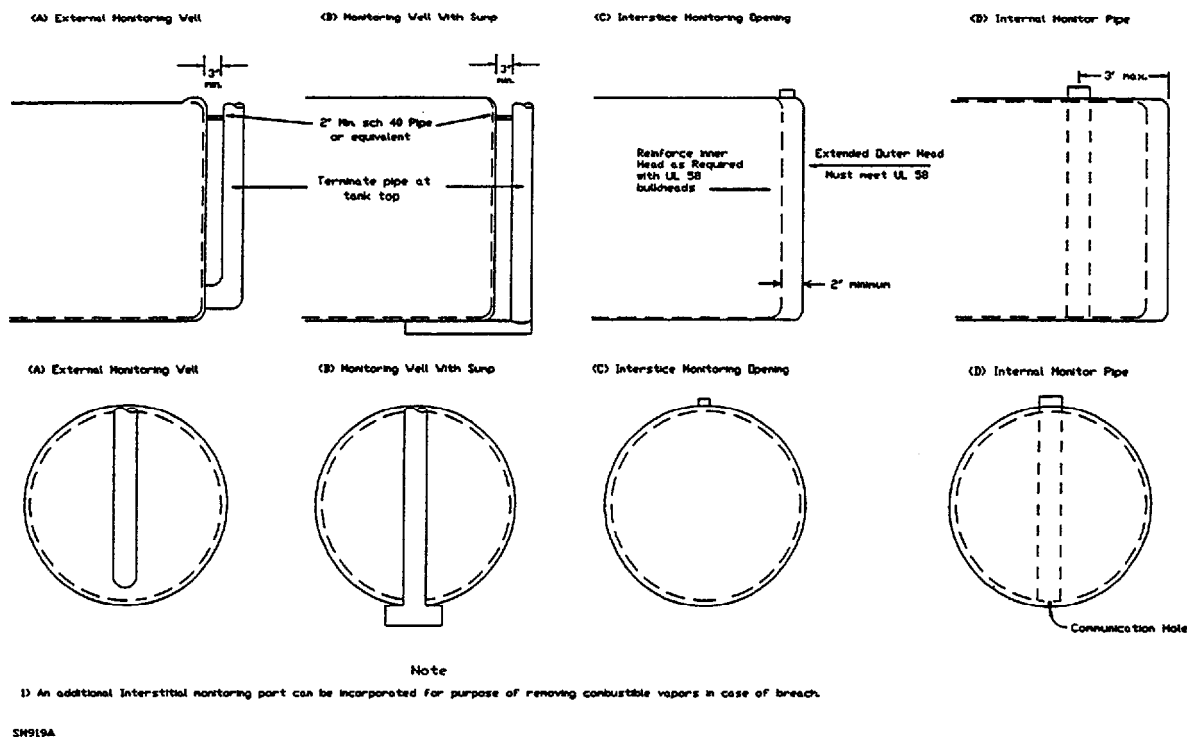
14 Interstitial monitor access

Section 14 effective (6 months after date of publication)

14.1 (2.5E) All secondary containment tanks shall be capable of being monitored for leakage from the interior or exterior into the annulus area.

14.2 (N) External monitoring-well pipe and fittings shall be attached to the tank in such a manner so as not to affect the structural integrity of the tank. See Figure 14.1. Other designs of interstitial monitor access will require an engineering investigation.

Figure 14.1 (N)
Monitor construction for secondary containment



14.3 (N) For 360° containment, all monitoring pipe connections to the inner tank, shall be welded to both the inner tank and the outer wrap where it exits the tank.

15 Construction

15.1 (7A.3) An inner head of a secondary containment tank which is not in direct contact with the outer head 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 144 inches (2.42 to 3.6 m). When two or more pieces are used, joints shall be one of the constructions shown in Figure 8.1 except joint Nos. 4, 7, and 8 shall not be used.

15.2 (7A.5R) An inner head of a secondary containment tank which is not in direct contact with the outer tank head shall be flat-flanged or dished.

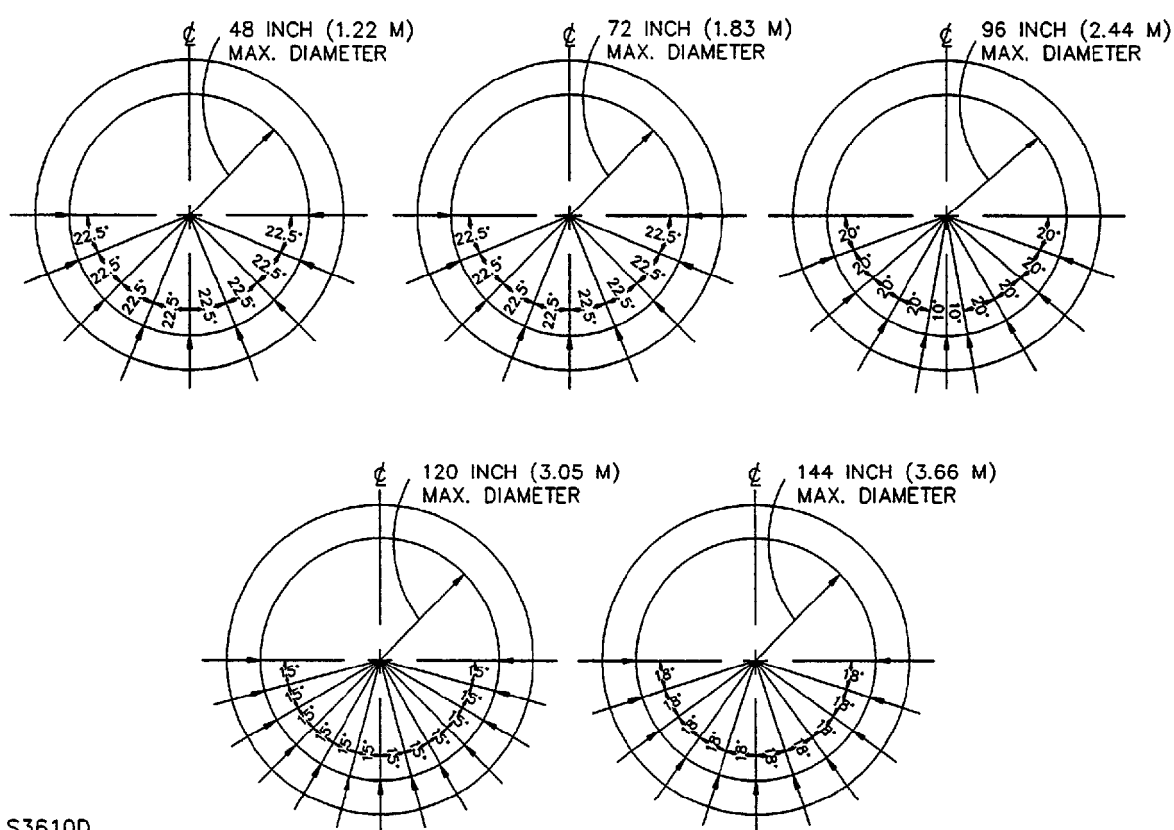
15.3 (7A.6R) A flanged flat inner head of a secondary containment tank more than 72 inches (1.8 m) in diameter which is not in direct contact with the outer tank head shall be made of not less than .302-inch (7.67-mm) thick material or it shall be braced in accordance with Figure 13.2 and Table 13.1.

15.4 (7A.7) A flanged flat inner head shall have an inside knuckle radius equal to at least 1.5 times the head thickness.

15.5 (7A.8E) The depth of dish of a dished inner head shall not be less than that specified in Table 9.1.

15.6 (7A.1R) Suitable standoffs shall consist of 3" x 1.5" (76.2 x 38.1 mm) channels at 4.1 pounds per foot (6.1 kg per meter), or larger with minimum material specifications equal to A-36 carbon steel.

Figure 15.1 (7A.1R)
Type II secondary containment tanks



S3610D

15.7 (N) The channel standoffs shall be placed longitudinally, Figure 15.1, or circumferentially.

15.8 (N) The channel standoffs shall be stitch welded to the primary storage tank in the leg down position. The channel placement shall not result in the channel straddling a shell or head weld joint for a length greater than the width of the channel.

15.9 (N) Holes in the standoffs are required for fluid communication.

16 Tank Accessories, Components, and Special Constructions

16.1 (N) The requirements in this section cover optional tank accessories, components, and special constructions.

16.2 (N) 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.

16.3 (N) Polymerics and elastomers such as o'rings and gaskets 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 in the Standard for Gaskets and Seals, UL 157.

16.4 (N) All accessories shall be constructed to minimize the stresses on the base tank.

17 Heating Coils and Hot Wells

17.1 (10.1) A heating coil or hot well that is provided as a part of a tank assembly and that handles a fluid other than that stored in the tank, such as steam or hot water, shall have no joints in the portion of the coil or well that is located within the tank unless the joints are continuously welded or brazed.

17.2 (10.2) Inlet and outlet connections of a heating coil or a hot well shall be located above the highest intended liquid level. A continuous weld shall be made where a connection pierces the shell of the tank or a manhole cover.

PERFORMANCE

18 External Pressure Test

Section 18 effective (6 months after date of publication)

18.1 (N) A tank shall not leak, collapse or implode when subjected to the External Pressure test described in 18.2.

18.2 (N) An empty tank is to be installed in a test fixture that will facilitate the tank to be submerged in water. The support structure for the test tank shall not add additional tensile or compressive stresses to the bottom of the test tank. Clean water is then added to the test fixture until the tank is submerged 5 feet (1.52 m) or to a depth equal to the manufacturer's specified maximum burial depth, whichever is greater. The tank is to remain submerged for 1 hour.

19 Lift Lugs

Section 19 effective (6 months after date of publication)

19.1 (N) Lift lugs shall support two times the weight of the empty tank.

19.2 (N) All lift lugs shall withstand the load described in 19.3 without leakage or permanent deformation of the lift lugs or the tanks.

19.3 (N) The lift lugs are to be subjected to a two times load test on the empty tank for 2 minutes. After unloading, the tank is to be subjected to a 5 psi leakage test as described in Section 20 and examined for permanent deformation.

MANUFACTURING AND PRODUCTION TESTS

20 General

20.1 (11.1R) Each primary and secondary containment tank, before painting, shall be tested by the manufacturer and proved tight against leakage using the following method:

a) Single Wall Tank

- 1) Applying internal air pressure and using soapsuds, linseed oil, or equivalent material for the detection of leaks. The test pressure is to be a gauge pressure of 3 – 5 psi (20.7 – 34.5 kPa); or
- 2) Completely filling the tank with water and applying an additional gauge pressure of 5 psi (34.5 kPa) pressure while the tank is placed in the position in which it shall be installed.

b) Secondary Containment Tank

- 1) After completion of the primary tank, and before assembling the secondary tank, the primary tank shall be checked for leakage by applying internal air pressure and using soap suds, linseed oil or equivalent material for detection of leaks. The test pressure is not to be less than a gauge pressure of 3 psi (20.7 kPa) nor more than 5 psi (34.5 kPa).
- 2) Upon completion of the finished tank, the primary tank shall again be pressurized to a gauge pressure of 5 psi (34.5 kPa) and held for 1 hour to check for leakage. A continuous drop in pressure will be considered to be evidence of leakage.
- 3) While maintaining a gauge pressure of 5 psi (34.5 kPa) on the primary tank, the space bounded by the primary and secondary tank shall be pressurized to a gauge pressure of 5 psi (34.5 kPa). The secondary tank shall be checked for leakage by applying a soap suds solution.

20.2 (11.2E) When leaks are noted during the test, the tank shall be made tight by welding and retested. Defects in welds shall be repaired by chipping or melting out from one or both sides of the joint, as required, and rewelding.

20.3 (11.3) Each compartment of compartment tanks shall be separately tested for leakage.

MARKING**21 General**

21.1 (12.1R) Each tank shall be legibly and permanently marked with:

- a) The name of the manufacturer or a distinctive marking, or code, by which it is identified as the product of a particular manufacturer.
- b) A distinctive catalog number or the equivalent; and
- c) The date or other dating period of manufacture not exceeding any three consecutive months.
- d) The tank installation instructions.

Exception No. 1: The date of manufacture may be abbreviated; or may be in a nationally accepted conventional code or in a code affirmed by the manufacturer provided that the code:

- a) Does not repeat in less than 30 years.*
- b) Does not require reference to the production records of the manufacturer to determine when the product was manufactured.*

21.2 (12.2E) When a manufacturer produces tanks at more than one factory, each tank shall have a distinctive marking to identify it as the product of a particular factory.

21.3 (12.4E) When a tank has a steel striker plate, as covered in 12.1, under only one opening, the opening shall be marked to indicate that dipstick measurements shall be made only at that location.

21.4 (N) Each tank shall be marked with the maximum burial depth.

21.5 (N) All markings shall be legible and permanent as afforded by a stamped or printed metal nameplate or label, by a decalcomania transfer, by permanent ink applied by stencil, by a pressure-sensitive label or label secured with cement or adhesive, or the equivalent. The label or nameplate shall be permanently secured to the outer surface of the coating, jacket or composite system.

21.6 (N) A pressure-sensitive label or a label secured by cement or adhesive shall comply with the applicable requirements for "Outdoor" use labels in the Standard for Marking and Labeling Systems, UL 969.

21.7 (N) Each tank shall be marked with the following or equivalent:

- a) "Follow Installation Instructions"
- b) "Lift Tank Only With Lift Fitting Provided." (For tanks with welded lift lugs).

APPENDIX A **TABLES FOR STEEL THICKNESS USING ROARK'S EQUATION**

The following table has been generated using Roark's Equation. Steel thicknesses for other tank diameters can also be generated using this equation. These tables are only for informational purposes.

Table 1
Steel Thicknesses

Volume Gallons	Diameter Inches	Length Inches	Single wall tanks Min. thickness (inches)			Secondary containment tanks minimum thickness (inches)					
			Stiffener(s)			Stiffeners					
			0	1	2	0		1		2	
						Primary	Secondary	Primary	Secondary	Primary	Secondary
1000	48	128	0.088	0.080	0.077	0.123	0.093	0.123	0.093	0.123	0.093
2000	64	144	0.115	0.106	0.101	0.123	0.093	0.123	0.093	0.123	0.093
3000	64	215	0.136	0.124	0.119	0.123	0.123	0.123	0.093	0.123	0.093
4000	64	287	0.152	0.139	0.133	0.123	0.123	0.123	0.123	0.123	0.123
5000	64	359	0.166	0.152	0.146	0.129	0.123	0.123	0.123	0.123	0.123
5000	72	284	0.167	0.152	0.146	0.130	0.123	0.123	0.123	0.123	0.123
6000	72	340	0.179	0.164	0.157	0.147	0.123	0.126	0.123	0.123	0.123
6000	96	191	0.181	0.166	0.158	0.149	0.123	0.128	0.123	0.123	0.123
8000	96	255	0.203	0.186	0.178	0.178	0.123	0.156	0.123	0.145	0.123
8000	120	163	0.206	0.188	0.180	0.181	0.123	0.159	0.123	0.148	0.123
10000	96	319	0.222	0.203	0.194	0.170	0.167	0.139	0.167	0.123	0.167
10000	120	204	0.225	0.206	0.197	0.174	0.167	0.143	0.167	0.127	0.167
12000	96	383	0.239	0.218	0.209	0.194	0.167	0.164	0.167	0.149	0.167
12000	120	245	0.242	0.221	0.211	0.198	0.167	0.168	0.167	0.153	0.167
15000	144	213	0.268	0.245	0.234	0.232	0.167	0.202	0.167	0.187	0.167
20000	144	284	0.301	0.275	0.263	0.271	0.167	0.240	0.167	0.225	0.167
30000	144	426	0.354	0.324	0.309	0.331	0.167	0.297	0.167	0.281	0.167
40000	144	567	0.397	0.363	0.347	0.378	0.167	0.341	0.167	0.323	0.167
50000	144	709	0.434	0.397	0.379	0.418	0.167	0.378	0.167	0.359	0.167

Notes –

1) Table 1 is based on $E = 30 \times 10^6$, $u = .287$

The burial depth is 5 feet (1.52 m)

2) Thickness of stainless steel can be calculated using the appropriate E and a values.

APPENDIX B

Capacity Tables

Table 1
Gallon capacity per foot of length

Diameter in Inches	U.S. Gallons 1-Foot Length	Diameter in Inches	U.S. Gallons 1-Foot Length	Diameter in Inches	U.S. Gallons 1-Foot Length
24	23.50	65	172.38	105	449.82
25	25.50	66	177.72	106	458.30
26	27.58	67	183.15	107	467.70
27	29.74	68	188.66	108	475.89
28	31.99	69	194.25	109	485.00
29	34.31	70	199.92	110	493.70
30	36.72	71	205.67	111	502.70
31	39.21	72	211.51	112	511.90
32	41.78	73	217.42	113	521.40
33	44.43	74	223.42	114	530.24
34	47.16	75	229.50	115	540.00
35	49.98	76	235.66	116	549.50
36	52.88	77	241.90	117	558.51
37	55.86	78	248.23	118	568.00
38	58.92	79	254.63	119	577.80
39	62.06	80	261.12	120	587.52
40	65.28	81	267.69	121	597.70
41	68.58	82	274.34	122	607.27
42	71.97	83	281.07	123	617.26
43	75.44	84	287.88	124	627.00
44	78.99	85	294.78	125	638.20
45	82.62	86	301.76	126	647.74
46	86.33	87	308.81	127	658.60
47	90.13	88	315.95	128	668.47
48	94.00	89	323.18	129	678.95
49	97.96	90	330.48	130	690.30
50	102.00	91	337.86	131	700.17
51	106.12	92	345.33	132	710.90
52	110.32	93	352.88	133	721.71

(Continued)

Table 1 (Cont'd)
Gallon capacity per foot of length

Diameter in Inches	U.S. Gallons 1-Foot Length	Diameter in Inches	U.S. Gallons 1-Foot Length	Diameter in Inches	U.S. Gallons 1-Foot Length
53	114.61	94	360.51	134	732.60
54	118.97	95	368.22	135	743.58
55	123.42	96	376.01	136	754.64
56	127.95	97	383.89	137	765.78
57	132.56	98	391.84	138	776.99
58	137.25	99	399.88	139	788.30
59	142.02	100	408.00	140	799.68
60	146.88	101	416.00	141	811.14
61	151.82	102	424.48	142	822.69
62	156.83	103	433.10	143	834.32
63	161.93	104	441.80	144	846.03
64	167.12				

Table 2
Liter capacity per meter of length

Diameter in mm	Liters 1-meter length
600	282.7
700	384.8
800	502.7
900	636.2
1000	785.4
1100	958.2
1200	1131.0
1300	1327.3
1400	1539.4
1500	1767.2
1600	2010.6
1700	2269.8
1800	2544.7
1900	2835.3
2000	3141.6
2100	3463.6
2200	3801.3
2300	4154.8
2400	4523.9
2500	4908.8
2600	5309.3
2700	5725.6
2800	6157.5
2900	6605.2
3000	7068.6

(Continued)

Table 2 (Cont'd)
Liter capacity per meter of length

Diameter in mm	Liters 1-meter length
3100	7547.7
3200	8042.5
3300	8553.0
3400	9079.2
3500	9621.2
3600	10178.8
3700	10752.1
3800	11341.2