API Std 12A
Seventh Edition
March, 1941

Reissued
September, 1951

API
SPECIFICATION
for
OIL STORAGE TANKS
WITH RIVETED SHELLS

COPY PROVIDED FOR
HISTORICAL PURPOSES ONLY

AMERICAN PETROLEUM INSTITUTE
New York, N. Y.

Issued by
AMERICAN PETROLEUM INSTITUTE
Division of Production
Dallas 1, Texas

Price: $1.00

API SPECIFICATION FOR TANKS WITH RIVETED SHELLS FOR OIL STORAGE

Foreword to September, 1951 Reprint of the Seventh Edition

a. At the November, 1941 meeting the tank committee agreed that all committee activity involving modifications and revisions of Std 12A be suspended. Accordingly, a number of proposed changes in Std 12A, which were approved by the committee at the 1941 meeting (and subsequently) were not balloted. These changes are detailed below. It is recommended that agreement be reached between the purchaser and the manufacturer regarding the application of these proposed changes.

I. Location of Name Plate

(Adopted November, 1941)

Existing Par. 38, Std 12A revised to require the attachment of the name plate to the shell plate adjacent to the manhole by continuous welding or brazing, or by permanent attachment to an auxiliary plate, the latter to be affixed to the shell plate by a continuous weld.

II. Inspection and Repairs

(Adopted November, 1941)

Existing Par. 88 and 89, Std 12A revised to require that weld quality and repair of defective welds conform to the applicable provisions of Std 12C.

III. Welded Appurtenances

(Adopted November, 1941)

Std 12A revised to permit the use of welded appurtenances conforming to Std 12C as an alternative to existing appurtenance requirements.

IV. Purchaser's Requirements on Appurtenances

(Adopted November, 1941)

Std 12A revised by the deletion of Table 17 which covers the purchaser's appurtenance requirements and Fig. 7 which covers location of appurtenances.

V. Plate Thickness

(Adopted November, 1941)

Par. 3, Std 12A revised to require that plates be specified on a thickness basis, where the thickness is such that the anticipated under-run on plates ordered on a weight basis will be sufficient to increase the joint stresses beyond the allowable maximum. (See Par. 2.2, Std 12C, 10th Edition.)

VI. Appendix B: Order Form

(Adopted November, 1941)

Appendix B: Order Form, Std 12A revised by changing the method of indicating the height of tank from "number of rings" to "feet."

VII. Appendix D: Recommended Practice

(Adopted November, 1941)

Par. f, Appendix D: Recommended Practice, Std 12A revised by changing the word "shall" to "should."

VIII. Rivets ¾ in. in Diameter and Smaller

(Adopted June, 1949)

Par. 67, Std 12A revised to permit rivets ¾ in. in diameter and smaller to be driven cold or hot, except that bottom rivets shall be driven hot, unless special conditions make cold driving necessary, and that rivets larger than ¾ in. in diameter shall be driven hot.

IX. Attachment of Outside Butt Plate to Adjoining Plate

(Adopted June, 1949)

Std 12A revised to permit the welding of outside butt plate directly to the adjoining shell plate as an alternative to scarfing.

X. Wind Girders for Open-Top Tanks

(Adopted June, 1949)

Std 12A supplemented by the addition of requirements on wind girders for open-top tanks as set forth in Std 12C.

b. Certain ASTM specifications are referenced in Std 12A. Changes in such specifications, which have been adopted by the tank committee for API Std 12C and which are applicable also to Std 12A, are detailed below. It is suggested that agreement be reached between the purchaser and the manufacturer regarding the application of any of these changes.

I. ASTM A 283, grade D

This specification covers carbon steel plates of a quality equivalent to ASTM A 7.

II. ASTM A 10

This specification has been withdrawn by ASTM and replaced by ASTM A 283, grade C.

III. ASTM A 27, grade A 3

Grade A 3 applied to steel castings in the full annealed condition with a minimum yield point of 30,000 psi. and a minimum tensile strength of 60,000 psi. This specification grade was dropped in the 1944 revision of A 27. The corresponding current grade designation is "60—30, full annealed."

Foreword to the Seventh Edition

(a) This Specification was prepared by the API Committee on the Standardization of Steel Tanks for Oil Storage, and is recommended for the use of the oil industry in all districts of the United States.

(b) This Specification is designed to provide the industry with tanks of adequate safety and reasonable economy in a sufficient range of sizes to cover usual operating requirements, so designed that the entire range of sizes can be built with a minimum number of plate sizes, and with details conforming with modern manufacturing practice.

(c) The detail drawings (bound separately) listed in Appendix E, which form a part of this specification, provide working designs in accordance with the Specifications for tanks having diameters of 36, 48, 60, 78, 102, 120 and 144 ft. built with 72-in. courses. Detail construction drawings for tanks of 12, 18, 24, 30, and 168 ft. diameter.

and for 9th and 10th courses, are not available†. See Par. 14 and 42. Detail drawings also provide designs for manholes, oil connections, drain connections, roof openings, and stairways. The use of appurtenances shown on these drawings, or designs of equivalent strength and tightness, will be required on tanks to which the API monogram is attached.

(d) Tables 1 and 2 herein show the sizes and capacities of tanks that may be obtained under this specification.

(e) Other standards, under the jurisdiction of the Committee on Standardization of Tanks for Oil Storage, include the following:

12B: Specification for Bolted Tanks

Covers dimensional details for bolted tanks and their appurtenances, including stipulations on walkways and stairways.

12C: Specification for Welded Oil Storage Tanks

Covers materials, design, fabrication, and erection of welded oil storage tanks, including requirements for welding procedure and operator qualification. Includes also recommended practices for use of aluminum alloys and low-alloy, high-strength steels.

12D: Specification for Welded Production Tanks (Tentative)

Includes requirements on materials, plate thicknesses, and design factors for welded production tanks and, by reference, covers design, fabrication, and erection details, and other data.

12E: Specification for Wooden Tanks (Tentative)

Covers major dimensions, quality of material, and sizes for wooden tanks, including stipulations on bolted piping flanges, and on bolting patterns for thief hatches and relief valves.

---

†This specification provides major design details for 8-ring tanks with 100-in. plates, sizes 36 to 168 ft. diameter; for 9th and 10th courses of tanks with 72-in. plates, sizes 36 to 144 ft. diameter; and for all courses (1st to 10th inclusive) 72-in. plates, 168-ft. diameter tanks. These design details are based upon drilled holes and hot driven rivets, except where alternate lap joints are shown for hot and cold driven rivets. Slight improvements in design methods account for the differences in edge distance, back pitch, and rivet pitch between this group of tanks and those for which design details had been published previously. No changes have been made in the existing standard designs.

TABLE 1
TANK SIZES—72" COURSES
APPROXIMATE CAPACITIES IN 42-GAL. BARRELS, TANK LEVEL FULL

Diameter (Ft.)	Nominal Height (Ft.) (1)								
	11.8	17.6	23.4	29.2	34.9	40.7	46.4	52.1 (4)	57.8 (4)
	Number of Courses								
	2	3	4	5	6	7	8	9	10
12(2)	240	360	480	590	720	———	———	———	———
18(2)	540	810	1070	1340	1600	———	———	———	———
24(2)	960	1440	1910	2380	2850	———	———	———	———
30(2)	1500	2240	2980	3710	4450	———	———	———	———
36(3)	2140	3190	4240	5290	6330	7380	8410	9440	10500
48(3)	3800	5670	7540	9410	11300	13100	15000	16800	18600
60(3)	6040	9000	12000	14900	17900	20800	23700	26700	29600
78(3)	10000	15000	19900	24900	29700	34600	39500	44300	49200
102(3)	17200	25600	34100	42500	50800	59200	67500	75800	84100
120(3)	23800	35500	47100	58800	70300	82000	93500	105000	116000
144(3)	34200	51100	67900	84700	101000	118000	135000	151000	168000
168(4)	46000	69000	91000	114000	136000	159000	181000	203000	225000

(1) Heights shown are approximate and are based on 72" sheets; see detail drawings for exact heights.
(2) Sizes having diameters 12' to 30', inclusive, adopted December, 1928; detail drawings not available; see Par. 42.
(3) Detail drawings available for sizes 36' to 144', inclusive, up to and including 8 courses; see Appendix "E".
(4) 9th and 10th courses, and 168-ft. diameter tank, adopted June, 1937; detail drawings not available. Use of these sizes of tanks is classed as a "Permissible Alternate", subject to agreement between supplier and purchaser. See Par. 14, 16, and 42, and Appendix "C". Joint details shall be in accord with Tables 6-A, 6-B, and 7 herein. See footnote to Par. (e) of Foreword.

TABLE 2
TANK SIZES—100" COURSES (1)
APPROXIMATE CAPACITIES IN 42-GAL. BARRELS, TANK LEVEL FULL

Diameter (Ft.)	Nominal Height (Ft.)						
	16.3	24.4	32.5	40.6	48.6	56.6	64.7
	Number of Courses						
	2	3	4	5	6	7	8
36	2950	4420	5890	7360	8810	10300	11700
48	5250	7860	10500	13100	15700	18200	20900
60	8340	12500	16600	20800	24900	29000	33000
78	13300	19900	26500	33100	39600	46100	52700
102	23700	35500	47300	59100	70700	82400	94200
120	32800	49200	65500	81800	97900	114000	130000
144	47300	70800	94300	118000	141000	164000	188000
168	64400	96800	128000	160000	192000	223000	255000

(1) Detail drawings are not available for tanks with 100" courses. Use of these sizes of tanks is classed as a "Permissible Alternate", subject to agreement between supplier and purchaser. See Par. 14, 16, and 42, and Appendix "C". Joint details shall be in accord with Tables 8 and 9 herein. See footnote to Par. (e) of Foreword.

PART I.

DESIGN SPECIFICATION

SECTION 1.

MATERIAL

Plates:

1. Plates shall conform to ASTM** A 7 or A 10. Open hearth steel only shall be used.

2. Copper-bearing steel may be used for roof plates if so specified by the purchaser.

3. Plate specification by weight is recommended, and plates purchased on weight specifications shall individually comply with the normal tolerances as they appear in this specification. The plate thicknesses, or weights, as stipulated herein are minimum; heavier material may be required on the order at option of the purchaser. Where plates are referred to by thickness in the specification, or on the drawings, the thickness shall be considered as nominal only.

Structural Steel:

4. Structural steel shall conform to ASTM** A 7.

Castings:

5. Steel castings shall conform at least to ASTM A 27, Grade A 3.

Rivets:

6. Rivets for hot driving shall conform to either ASTM A 141**, or ASTM A 31**, or ASME Boiler Code***.

7. Rivets for cold driving shall conform to ASTM A 31, soft annealed.

8. If copper-bearing steel is specified for the roof plates, the rivets shall contain the same percentage of copper.

SPECIAL NOTE: Attention is called to the fact that the minimum ultimate tensile strength requirements for steels meeting ASTM Specification A 7 was raised from 55,000 lb. per sq. in. in the 1933 issue to 60,000 lb. per sq. in. in the 1934 and subsequent issues. However, the consensus of the members of the API Tank Committee is that no attempt should be made to take advantage of the increased strength of these steels until further experience is had with them. Accordingly, the allowable stresses given in Paragraph 13 are unchanged from previous editions of this Standard.

**ASTM Specifications referred to herein may be secured from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. (See Special Note.)

***ASME Boiler Code referred to herein may be secured from the American Society of Mechanical Engineers, 29 West 39th St., New York City.

The principal provisions of these specifications are included in Appendix A, Tables 10 and 11.

SECTION 2.

SHELL DESIGN

Loads and Working Stresses:
(See Appendix "A" for sample computations.)

9. Stresses are to be computed on the assumption that the tank is filled level full of water at 60 degrees Fahr.,* and the tension in each ring is to be computed 12 inches above the bottom gauge line of the ring in question.

10. In computing net section of plate, rivet holes when punched $\frac{1}{16}$ inch over nominal diameter for hot driven rivets, are to be assumed $\frac{1}{8}$ inch larger than nominal diameter of the rivet; when punched $\frac{1}{32}$ inch over nominal diameter for cold driven rivets, holes are to be assumed $\frac{1}{16}$ inch larger than nominal diameter of rivet. When drilled, or when subpunched and reamed, holes are to be assumed $\frac{1}{16}$ inch larger in diameter than nominal diameter of rivet.

The net section of rivet to be used for computing shear values shall be, in the case of hot driven rivets, nominal diameter plus $\frac{1}{16}$ inch; in case of cold driven, nominal diameter plus $\frac{1}{32}$ inch.

11. All openings over 4 inches in diameter in the shell of the tank shall be reinforced. This reinforcement may be the flange of the fitting used, or an additional ring of metal, or both flange and ring.

12. The amount of reinforcement shall be computed as described in Appendix A of this specification.

13. The following maximum allowable working stresses shall be used in design:

Maximum tensile stress in net section of plate:
21,000 lb. per sq. in.

Maximum shear in net section of rivet:
16,000 lb. per sq. in.

*Water at 60° Fahr. weighs 62.37 lb. per cubic foot; see Merriman's Civil Engineers Pocket Book, (John Wiley & Sons, New York).

Maximum bearing stress on plates or rivets:

35,000 lb. per sq. in. when rivets are in double shear.

32,000 lb. per sq. in. when rivets are in single shear.

Sizes of Plate and Tank:

14. Tank shall be designed so that the diameter is a multiple of six feet, using shell plates having a minimum net length (total length minus lap) of 6 pi feet (6 times 3.1416). The number of plates in each course shall not exceed the diameter of the tank divided by 6, and may be reduced from this number by agreement between purchaser and supplier. The minimum overall width of shell plates shall be 72 inches. Plates 100 inches wide, for tanks 36 feet and over in diameter, may be used by agreement between purchaser and manufacturer. Existing API standard drawings, which provide for eight courses using plate width of 72 inches, call for plate lengths of 6 pi feet. If longer plates are specified without change of width, vertical joint details shall be the same as for the standard plate length. Where 100-inch plates are used, or 72-inch plates are used for 9th and 10th courses or for 168-ft. diameter tanks, joint details shall conform to details given in Tables 6-A, 6-B, 7, 8, and 9.

When longer sheets are specified, or when 100-inch sheets are specified, or when 72-inch sheets are specified for 168-ft. diameter tanks or for 9th and 10th courses, it shall be considered as a "permissible alternate" to API Standard Riveted Tanks, subject to agreement between manufacturer and purchaser, and provision to use the API monogram on such tanks will be permitted, but such tanks may not be marked with the monogram until the manufacturer has furnished complete details of design, nor until such details have been approved by the purchaser; Appendices B and C are revised accordingly as given hereinafter.

15. The minimum thickness of shell plates shall be ¼ inch in tanks over 48 feet in diameter; and shall be $\frac{1}{4}$ inch in tanks 48 feet or less in diameter.

Note Paragraph 3.

Arrangement of Members:

16. Tanks shall be designed with vertical rings so that all plates will be truly rectangular. Rings shall be arranged with relation to each other to permit the use of the same roof structure and riveted bottom details (except bottom angle) for all heights of tanks of one diameter.

NOTE: Available drawings for tanks 36' to 144' diameter inclusive are for plate widths of 72 inches, and employ the following arrangement of courses:

In tanks 6 rings high or less each ring is inside the one beneath it; in 7-ring tanks the second ring is outside the first and each ring above the second is inside the one beneath it; and in 8-ring tanks the second ring is inside the first, the third ring outside the second, and each ring above the third inside the one beneath it.

For tanks having 9 or 10 courses 72 inches wide, the first course shall be arranged as follows (See Note 4 to Table 1):

For 9 rings, the first ring shall be inside the second, and the second and higher rings shall be identical with a complete 8-ring tank.

For 10 rings, the first ring shall be outside the second, and the second and higher rings shall be identical with a complete 9-ring tank.

For tanks using 100-inch plates, arrangement of courses shall be as given above for 6, 7, and 8 course tanks.

17. The top angle shall ordinarily be placed on the inside of the shell; but may be placed on the outside if specifically so ordered by the purchaser.*

18. The bottom angle shall be inside the shell, unless ordered by the purchaser to be placed outside*.

Riveting:

19. The following combinations of rivet sizes and plate thicknesses are suggested:

$\frac{3}{16}$" Plate	$\frac{7}{16}$" Rivets
¼" Plate	$\frac{5}{8}$" Rivets
$\frac{5}{16}$" Plate	$\frac{5}{8}$" Rivets
$\frac{3}{8}$" Plate	¾" Rivets
$\frac{7}{16}$" Plate	¾" Rivets
½" to and incl. $\frac{5}{8}$" Plate	$\frac{7}{8}$" Rivets
Over $\frac{5}{8}$" and incl. ¾" Plate	1" Rivets
Over ¾" and incl. $\frac{7}{8}$" Plate	1⅛" Rivets
Over $\frac{7}{8}$" Plate	1¼" Rivets

20. In roundabout seams the same size of rivet shall be used as used in the vertical joint of the ring above.

21. Unless otherwise limited by considerations of stress, the minimum distance between centers of rivet holes shall be 3 times the nominal diameter of the rivet, and the maximum distance shall be 7 times the thickness of the plate, plus the nominal diameter of the rivet.

22. Where the net gage width of a course is not equal to a whole number of major pitches for the

*The drawings for sizes 36' to 144' inclusive, show bottom and roof plate layouts for riveted construction, with bottom and top angle inside. If riveted roof or bottom with angle outside is specified, then a different layout of sketch plates must be provided, showing the required extra lengths, and altered layout of circumference rivet circle. If welded roof or bottom is specified, layout will be similar to design shown for riveted, but laps at joints will be less, and sketch plates will ordinarily be cut to fit in the field. Longer sheets will be required for some of the sketch plates.

joint selected, the minor pitches at the plate edges shall be adjusted as shown in Fig. 1 herein. (This applies to 100-inch plates, and to 72-inch plates when used for 9th and 10th courses or for 168-ft. diameter tanks).

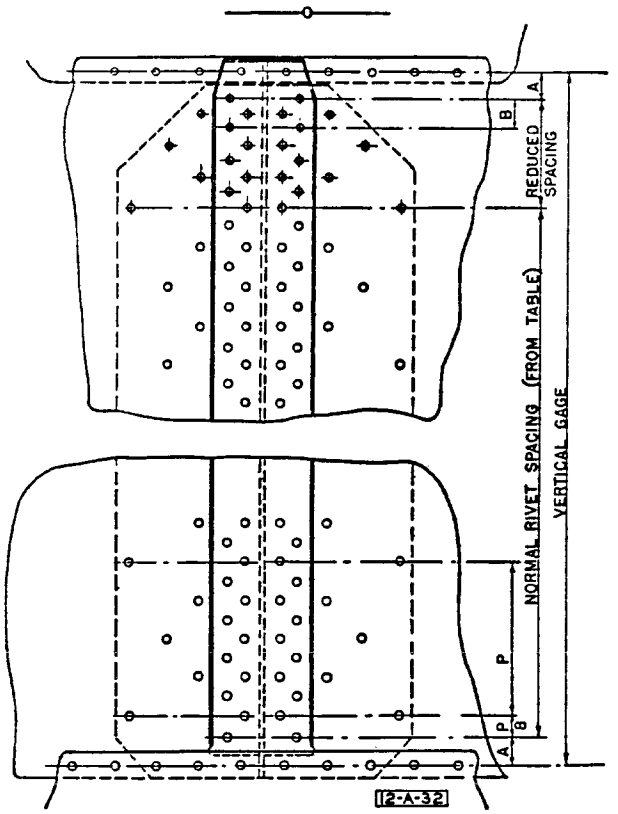

FIG. 1
EXAMPLE OF END ADJUSTMENT PITCHES

NOTES:
Dimension A may vary from two rivet edge distances (plus clearance if applicable) to maximum caulking pitch.
Dimension B may vary from three rivet diameters to the maximum caulking pitch. The number of minor pitches at reduced spacing is variable, but cannot exceed the number in one major pitch. Reduced spacing may be applied at the top of the course only.
Dimensions A and B should be selected to give reduced spacing which is as close as possible to the normal spacing for the course.

23. For tanks 144 feet in diameter or less, using eight 72-inch courses, or less, the distance from center lines of rivets to the edges of plates and the allowance for bevel shearing or planing shall be as shown in Table 3. The distance between gauge lines of roundabout joints shall be exactly as found by deducting from "W", dimension "C" for edges to be caulked and dimension "A" for edges not to be caulked.

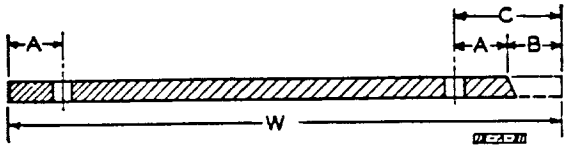

FIG. 2

TABLE 3—EDGE DISTANCES
See Fig. 2
(See Par. 47 and 48)
(All Dimensions in Inches)

Plate Thickness	Rivet Diameter	(See Sketch Above) A	B	C
3/16	7/16	3/4	1/4	1
1/4	7/16	3/4	3/8	1-1/8
1/4	5/8	15/16	3/8	1-5/16
5/16	5/8	15/16	7/16	1-3/8
11/32	5/8	15/16	1/2	1-7/16
11/32	3/4	1-1/8	1/2	1-5/8
3/8	5/8	15/16	9/16	1-1/2
3/8	3/4	1-1/8	9/16	1-11/16
13/32	5/8	15/16	9/16	1-1/2
13/32	3/4	1-1/8	9/16	1-11/16
7/16	5/8	15/16	5/8	1-9/16
7/16	3/4	1-1/8	5/8	1-3/4
15/32	3/4	1-1/8	5/8	1-3/4
15/32	7/8	1-5/16	5/8	1-15/16
1/2	3/4	1-1/8	3/4	1-7/8
1/2	7/8	1-5/16	3/4	2-1/16
9/16	3/4	1-1/8	3/4	1-7/8
9/16	7/8	1-5/16	3/4	2-1/16
5/8	7/8	1-5/16	13/16	2-1/8
11/16	7/8	1-5/16	13/16	2-1/8
11/16	1	1-1/2	13/16	2-5/16
3/4	7/8	1-5/16	7/8	2-3/16
25/32	1	1-1/2	7/8	2-3/8
25/32	1-1/8	1-11/16	7/8	2-9/16
7/8	1-1/8	1-11/16	7/8	2-9/16
15/16	1-1/4	1-7/8	1	2-7/8
1	1-1/4	1-7/8	1	2-7/8
1-1/16	1-1/4	1-7/8	1	2-7/8

24. For tanks using 100-inch plates, or using 72-inch plates for 9th and 10th courses, or for 168-foot diameter tanks, the allowances for edge preparation are not specified but shall be held to a practical minimum.

25. For tanks 144 feet in diameter or less, using eight 72-inch courses, or less, the distance between the center lines of any two adjacent rows of rivets or the "back pitch," measured at right angles to the direction of the joint, shall be determined in accordance with Paragraphs A-4, A-5, and A-6, Appendix A. (These requirements correspond to Par. P-182, ASME Boiler Construction Code, edition of 1940.)

26. For tanks using 100-inch plates, or using 72-inch plates for 9th and 10th courses, or for 168-foot diameter tanks, the distance between the center line of any two adjacent rows of rivets, or the "back pitch", measured at right angles to the direction of the joint, shall be determined in accordance with Par. A-7 and A-8, Appendix "A".

SECTION 3.

ROOF DESIGN

27. Conical steel roof and supporting structure shall be designed to carry a live load of 25 lbs. per sq. ft. in addition to the dead load, and the supporting structure shall be designed in accordance with the unit stresses given in Par. 31.

28. Structural channels shall be used for roof columns, except that steel pipe or other structural shapes of equivalent column strength may be used by agreement between manufacturer and purchaser.† The slope of the roof shall be ¾ inch in 12 inches, or other value as ordered by the purchaser, except that the slope of the self-supporting roof of the 12-foot tank shall be 2 inches in 12 inches‡.

29. Roof plates shall be $\frac{3}{16}$ inch thick**, not less than 72 inches wide, and shall have the same approximate length as $\frac{3}{16}$-inch shell plates. Plates 100 inches wide may be used by agreement between purchaser and manufacturer. They may be either riveted or welded; if riveted, rivets shall be $\frac{1}{2}$ inch @ 1½ inches pitch.

See "Permissible Variation" (C-4) in Appendix C.

30. Rafters shall be placed so that spacing in the outer row shall not be greater than 2 pi feet (2 x 3.1416); spacing on inner rows shall not be greater than 5½ feet. In earthquake territory, ¾-inch diameter tie rods shall be placed between rafters in the outer ring of rafters as indicated in Fig. 3. These tie rods may be omitted if I or H sections are used in rafters§.

31. Allowable Stresses: All parts of the structure shall be so proportioned that the sum of the maximum static stresses in pounds per square inch shall not exceed the following:*

Tension

Rolled Steel, on net section 18,000

On the area of the nominal diameter of rivets 13,500

Compression

Rolled Steel, on short lengths or where lateral deflection is prevented 18,000

On gross section of columns ..... $\dfrac{18{,}000}{1 + \dfrac{L^2}{18{,}000\ r^2}}$

With a maximum of 15,000

in which "L" is the unbraced length of the column, and "r" is the corresponding least radius of gyration of the section, both in inches.

For main compression members, the ratio L/r shall not exceed 180

For bracing and other secondary members, the ratio L/r shall not exceed 200

Bending

On extreme fibers of rolled sections, and built-up sections, net section, if lateral deflection is prevented 18,000

When the unsupported length "L" exceeds 15 x "b", the width of the compression flange, the stress in pounds per square inch in the latter shall not exceed ..... $\dfrac{20{,}000}{1 + \dfrac{L^2}{2{,}000\ b^2}}$

The laterally unsupported length of beams and girders shall not exceed 40 x "b" the width of the compression flange.

The above restrictions limiting beams to lengths with an L/b ratio not greater than 40, and to stress not greater than permitted by the formula for L/b ratios greater than 15, do not apply to rafters, which are in contact with the steel roof plating, it being assumed that under full load conditions, friction between the roof sheets and the rafters will provide adequate lateral support to the compression flange of the rafters.

On extreme fibers of pins, when the forces are assumed as acting at the center of gravity of the pieces 27,000

Shearing

On Pins 13,500

On Power-driven Rivets 13,500

On turned bolts in reamed holes with a clearance of not more than 1/50th of an inch 13,500

On Hand-driven Rivets 10,000

On Unfinished Bolts 10,000

On the gross area of the webs of beams and girders, where "h", (the clear distance between web flanges in inches) is not more than 60 x "t" (the thickness of the web in inches), or when the web is adequately stiffened 12,000

On the gross area of the webs of beams and girders, if the web is not stiffened where "h" is more than 60 x "t" the greatest average shear per sq. inch, V/A, shall not exceed ..... $\dfrac{18{,}000}{1 + \dfrac{h^2}{7{,}200\ t^2}}$

in which V is the total shear, and A is gross area of web in sq. inches.

**Note Paragraph 2.

†The detail drawings show channel columns; if pipe or other structural shapes are used, revised details of roof columns shall be provided by the manufacturer.

‡The drawings for sizes 36' to 144', inclusive, show roof plate layouts and roof support details for plates 72" wide, with a slope of ¾ inch in 12 inches. If a different slope or plate width is to be used, revised details of roof plates and supports shall be provided by the manufacturer.

§Drawings now call for channel section for rafters. I and H sections may be used as an alternate in earthquake territory by agreement between the purchaser and manufacturer.

*These requirements are based on the 1934 issue of the American Institute of Steel Construction "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings", with certain changes made in recognition of the difference in load conditions between buildings and tank structures.

Bearing

	Double Shear	Single Shear
Pins	30,000	24,000
Power-driven Rivets	30,000	24,000
Turned bolts in reamed holes	30,000	24,000
Hand-driven Rivets	20,000	16,000
Unfinished bolts	20,000	16,000

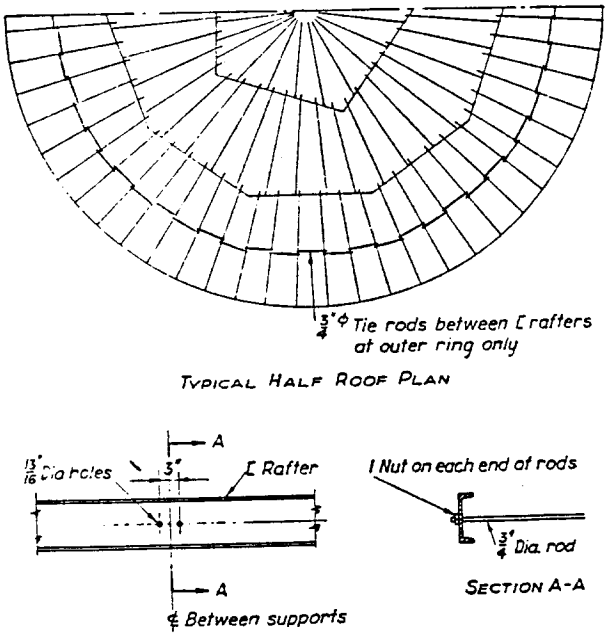

FIG. 3
TIE RODS FOR RAFTERS

SECTION 4.
BOTTOM DESIGN

Plate Sizes:

32. The minimum width of bottom plates shall be 72 inches; plates of 100-inch width may be used by agreement between purchaser and manufacturer. Bottom plate joints may be either riveted or welded.

33. All rectangular bottom plates shall be ¼-inch thick and shall have the same approximate lengths as ¼-inch shell plates. Bottom sketch plates in tanks 48 feet in diameter and less shall be ¼-inch thick, and in tanks over 48 feet in diameter shall be ⅜-inch thick.

Rivets:

34. For tanks with riveted bottoms the rivets shall be ⅝ inch in diameter. The pitch of rivets shall conform to the requirements in Paragraph 21.

Welded Construction:

35. Tanks with welded bottoms may be supplied only upon agreement between the purchaser and the manufacturer. When so supplied the API monogram may be affixed to such tank indicating that otherwise the tank is manufactured in accordance with this specification, provided that the manufacturer shall stamp the letter "X" as a prefix to his certificate-of-authority number on the API name plate.§ Such welded bottoms, including the joint between shell and bottom, shall be in accordance with API Std. 12-C: "Specification on All-welded Oil Storage Tanks."

§See Par. C-5 of Appendix "C".

SECTION 5.

MARKING

36. Tanks with riveted shells manufactured in accordance with this specification shall be identified by authorized manufacturers† by a special nameplate, detailed in Fig. 4, bearing the API monogram. Size of monogram on name plate shall be ½ inch high, substantially as shown. Authority to use the monogram will be granted to any manufacturer, in accordance with the rules and regulations laid down in Appendix "G".

37. The API monogram shall not be used on tanks which do not meet this specification.

38. Name plates for riveted tanks shall be fastened by tack welding or brazing to the tank shell plate or manhole reinforcing plate immediately above the manhole.

39. Where a manufacturer's shop practice is such that minor variations from the standard designs will enable him to fabricate tanks more economically, it shall not be considered a violation of the authority to use the API monogram, provided that such variations in no way conflict with essential requirements of this specification, and provided further that such variations are approved by the API Committee on the Standardization of Steel Tanks for Oil Storage. After approval of such variations they shall be published and included in Appendix C of these specifications as "permissible variations". When any permissible variation is used, the manufacturer shall notify the purchaser in advance and shall stamp the letter "X" as a prefix to his certificate-of-authority number on the name plate.

40. Each licensee shall report yearly to the Institute, on forms provided, regarding his use of the monogram. Failure to so report is cause for cancellation of authority to use it. When a licensee makes material in accordance with this specification and fails to use the monogram thereon as stipulated herein, his certificate shall be cancelled. It will be necessary to make another application in order to be reinstated.*

41. The use of the letters "API" or reference to API specifications by any licensee, to describe material which does not completely comply with this specification, is prohibited and shall be sufficient cause for cancellation of authority to use the API monogram hereunder.

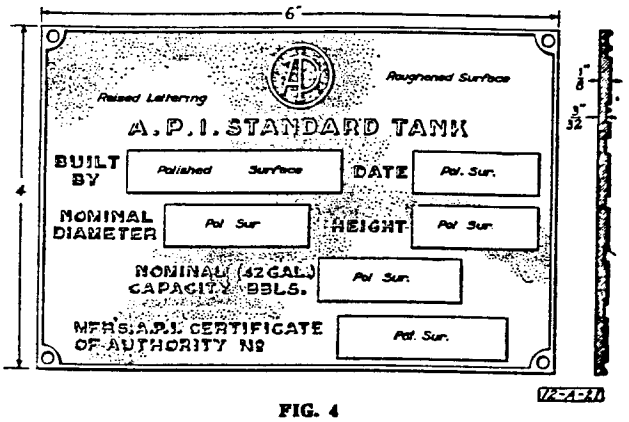

FIG. 4

API NAME PLATE

Name plates may be purchased anywhere at the manufacturer's option. If desired, the builder's name may be cast directly into plate instead of stamping it on polished surface after "built by" as shown in Figure 4.

†See Appendix "F" for list of licensees.

*Adopted May, 1940, by the Institute's Central Committee on Standardization of Oil Field Equipment.

PART II.

FABRICATION SPECIFICATION

Workmanship:

42. All work of fabricating API Standard Tanks shall be done in accordance with the plans accompanying this specification, except as provided in Appendix C: "Permissible Variations", or in the case of tanks for which drawings have not been published, shall be the equivalent, and similar in details of fabrication, to those shown in the drawings for the standard tank nearest to the size being planned. The workmanship and finish shall be first class in every respect, subject to the closest inspection by manufacturer's inspector, whether or not purchaser waives any part of the inspection.

43. Straightening of material shall be done before being laid out or worked on in any way and by methods which will not injure it. Heating or hammering will not be permitted, except when heated to a forging temperature.

44. Laying out shall be done by experienced workmen only. Rivet holes shall be accurately spaced so that they come opposite each other in adjoining parts. If upon assembling, holes do not match within $\frac{1}{16}$ inch, the plate or plates containing such unfair holes may be rejected at the option of the purchaser.

Rivet Holes:

45. All plates (except bottom or roof plates when a welded bottom or roof is ordered) shall be punched before being bevel-sheared, planed or rolled. All punched and reamed holes shall be clean-cut without torn or ragged edges. The diameter of the punch shall be the same as the nominal diameter of the hole. The diameter of the die shall not be less than $\frac{1}{32}$ inch nor more than $\frac{1}{16}$ inch larger than the diameter of the punch.

46. Where rivets are to be driven hot, finished diameter of the holes shall be $\frac{1}{16}$ inch larger than nominal diameter of rivet; where rivets are to be driven cold, finished diameter of holes shall be $\frac{1}{32}$ inch larger than nominal diameter of rivet. In plates $\frac{5}{8}$ inch thick and under, holes may be either punched to finished diameter, sub-punched and reamed to finished diameter, or drilled. In plates over $\frac{5}{8}$-inch thick, rivet holes shall either be drilled full size, or sub-punched at least $\frac{1}{8}$-inch less than finished diameter and reamed.

Finishing of Plate Edges:

47. Edges of plates shall be trued for caulking either by shearing, machining, or cut with a machine-operated gas torch. Plates $\frac{1}{2}$ inch and less in thickness shall be beveled. Plates over $\frac{1}{2}$ inch in thickness may be either beveled or squared. When beveled, the angle of bevel shall be not less than 65 degrees nor more than 75 degrees.

48. Shearing, machining, or flame cutting shall be done neatly and accurately. The distance from center lines of rivets to the edges of plates and the allowance for trueing shall be as provided in Par. 23 and 24. A tolerance of plus or minus $\frac{1}{8}$ inch will be permitted in edge distance after trueing.

49. Plates to be scarfed may be heated to a cherry red color.

Rolling:

50. After plates are punched and sheared they shall when necessary be shaped to the proper curve by cold rolling. Plates $\frac{1}{16}$ inch thick and less than $\frac{5}{8}$ inch thick shall be rolled to the specified radius for tanks 30 feet or less in diameter; plates $\frac{5}{8}$ inch thick and less than $\frac{1}{2}$ inch thick shall be rolled to the specified radius for tanks 60 feet and less in diameter; plates $\frac{1}{2}$ inch and less than $\frac{5}{8}$ inch thick shall be rolled for tanks 120 feet and less in diameter and plates $\frac{5}{8}$ inch and heavier shall be rolled for all sizes of tanks.

Marking:

51. All plates and roof members shall be marked as shown on the drawings.

Shipping:

52. Plates and tank material shall be loaded on cars in such a manner as to insure delivery without damage.

53. Bolts, nuts, rivets, railing connections, nipples and small details shall be boxed, crated, or put in kegs or bags for shipment.

Inspection:

54. An inspector representing the purchaser shall at all times have free entry to all parts of the manufacturer's works while work under the contract is being performed. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification, and shall furnish free of cost any samples or specimens of materials for the purpose of testing. Inspection shall be made at the place of manufacture prior to shipment unless otherwise specified. The manufacturer shall give the purchaser ample notice as to when he will start fabrication so that the inspector may be on hand when required.

55. Shop inspection shall not release the manufacturer from replacing any defective material which may be discovered in the field.

56. Any material or workmanship which in any way fails to meet the requirements of this specification will be rejected by the inspector and must not be used under the contract. Material which shows injurious defects subsequent to its acceptance at the manufacturing works will be rejected and the manufacturer will be notified to this effect, and required to furnish new material.

Adjustments:

57. The responsibility for policing compliance under this specification rests primarily with the purchaser. He is expected to make any investigation necessary to satisfy himself of compliance and in the event of apparent non-compliance, to confer with the manufacturer to determine the facts and fix the responsibility.

58. If agreement cannot be reached on the merits of any complaint, either party should refer the matter formally to the Institute by forwarding a complete record of the case to the Secretary of the Central Committee on Standardization who shall refer it to the Engineer's Subcommittee of the Standardization Committee responsible for the specification under which the material is supplied. It shall be the duty of the Engineers' Subcommittee to investigate the merits of the complaints on the evidence submitted. The evidence should be complete, including engineering or test reports, and correspondence bearing on the complaint in question. The ruling of the Engineers' Subcommittee shall be forwarded by the Secretary to the parties involved.

59. In case of dissatisfaction with the ruling of the Engineers' Subcommittee, either party may appeal to the Central Committee on Standardization which shall act as a final board of review and its decision in the matter shall be considered final insofar as compliance with this specification is concerned.

PART III.

ERECTION SPECIFICATION

General:

60. The manufacturer shall furnish all labor, tools, false work, scaffolding, and other equipment necessary for the erection of tanks complete and ready for use.

Assembling:

61. Plates shall be carefully and accurately "laid up", and shall then be firmly drawn together with common machine bolts or wedge bolts before riveting is commenced, placing bolts in at least one out of every five holes.

62. No paint or foreign material shall be used between surfaces in contact, except asbestos caulking strip at end of each bottom seam on riveted bottom, as shown on detailed drawings.

63. To insure full rivet sections, equal to computed area, all holes in vertical shell seams shall be reamed after bolting up, using a reamer $\frac{1}{16}$ inch greater in diameter than nominal diameter of rivet for hot driven rivets and $\frac{3}{32}$ inch greater than nominal diameter for cold driven rivets. Holes properly punched and matched will not require the removal of any metal by the reamer, but the tool must be inserted in each hole as a gauge. Where tolerances of $\frac{1}{16}$ inch for unmatched rivet holes required by Paragraph 44 are exceeded, the plate or plates containing the unmatched holes may be rejected at the option of the purchaser.

64. Burrs and fins on punched holes shall, if necessary, be removed in the field by a tool, countersinking not more than $\frac{1}{16}$ inch.

65. All field joints in shell, bottom and roof of tank shall be riveted unless welding is specified for bottom or roof plates or for top and bottom angles. All field joints in the roof supporting structure shall be bolted except that the column bases shall be riveted to the columns.

66. The size and pitch of the rivets shall be as specified on the drawings, and/or shown in Tables 4, 5, 6-A, 6-B, 7, 8, and 9. They shall be driven by pneumatic or hydraulic tools wherever possible.

67. Rivets $\frac{5}{8}$ inch in diameter and under may be driven cold or hot, except that bottom rivets must be driven hot, unless special conditions make cold driving necessary. All rivets over $\frac{5}{8}$ inch diameter shall be driven hot.

68. Hot rivets shall be driven with either steeple head or button head snaps having dimensions as shown in Fig. 5.

69. Shell rivets, when driven cold may be driven with either steeple or Liverpool snaps, and the dimensions of the latter shall be as shown in Figure 5. Bottom rivets, if driven cold, may be driven with Liverpool or double-radius snaps, as shown in Fig. 5.

70. Tolerances in snap dimensions shown in figures shall be $\frac{1}{32}$ inch plus or minus; tolerances in finished rivet heads shall be plus $\frac{1}{16}$ inch over dimensions shown.

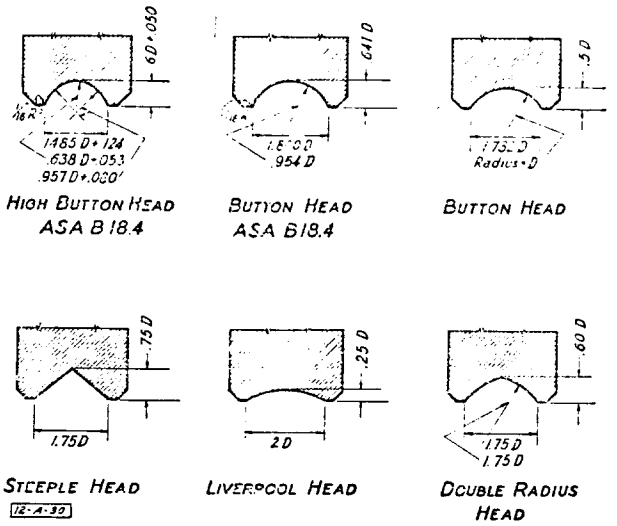

FIG. 5
RIVET SNAPS
"D"=nominal diameter of rivet.

71. Heads shall be as nearly as possible concentric with the rivet body. All rivets shall be driven from the outside of the tank, except that bottom rivets may be driven from the inside. Any burned, loose or defective rivets shall be cut out and redriven. No foreign substance shall be used in the joints except as noted in Par. 62.

Caulking:

72. Riveted seams shall be made tight by caulking. Roof and shell shall be caulked on outside, bottom on inside. The shell and bottom shall be caulked to bottom angle from the outside. The caulking tools and methods used shall be such that the underlying sheet is not damaged, and the edge of the top sheet not turned under. A round-nosed tool shall be used to upset the metal. This operation shall be followed with a fine square tool. Split caulking on plates over $\frac{1}{2}$ inch thick shall be acceptable. All shell openings shall be caulked outside. The work must be done by experienced men only.

73. The opening between ends of plates and outside butt-strap in butt joints shall be stopped by means of a wedge, or by welding, as specified in the order. In locations subject to earthquakes, the opening may be welded over or if a wedge is used, it is recommended that it be welded over.

74. Inside butt-straps will not ordinarily be caulked; but if specially required by purchaser (in tanks where frequent changes of stock and cleaning are anticipated) this shall be done, and stoppers placed in openings between shell sheets and inside butt-straps as above.

75. Holes punched for erection purposes shall be closed tight, either by welding up, by driving in a "burr" and welding over, both inside and out, or by filling with a driven rivet.

Testing and Lowering of Bottom:

76. The bottom and lower part of the first course of tank, when riveted bottoms are specified, shall be riveted and caulked while supported above the grade. Where a welded bottom is specified the bottom shall be welded on the tank grade and one or more shell courses riveted up before the bottom is tested.

77. Where water is available, the tightness of a riveted bottom shall be tested with 6 inches of water before being lowered to foundation; bottom shall be entirely tight to the satisfaction of the purchaser's inspector before lowering.

78. If water is not available, for a tank with riveted bottom, tightness shall be tested by pumping oil, which shall be supplied by the purchaser, underneath bottom, maintaining a head of 6 inches of oil by holding that depth around the edge inside a temporary dam; bottom shall be made entirely tight, to the satisfaction of the purchaser's inspector. The oil line for testing may be either temporarily installed by running it through the manhole to a temporary flange connection at the center of the tank or permanently buried in the grade beneath the tank.

79. Tanks with welded bottoms shall be tested in accordance with stipulations given in API Std. 12-C.

80. No welding shall be done on any tank unless all lines connecting thereto have been completely blanked off.

81. All reasonable care shall be taken to preserve the prepared grade under the tank, and before the bottom is lowered, where a riveted bottom is specified, the grade shall be re-shaped, if necessary, to the satisfaction of the purchaser's inspector.

Testing Shell and Roof:

82. Upon completion, the entire tank shell shall be tested by filling with oil or water to the level of the top angle. If it is not feasible to fill the tank as indicated, the test may be made by painting all seams on the inside with a highly penetrating oil, such as automobile spring oil, examining the outside of the seams for leakage. All leaks discovered by the above tests shall be stopped.

83. The roof shall be tested by applying an internal air pressure equivalent to not less than ½ inch of water, and applying strong soap solution, or linseed oil, or other suitable material, to all seams. All leaks discovered shall be stopped.

84. Before acceptance, entire tank, when filled with oil, must be tight and free from leaks.

Cleaning Up:

85. Upon completion of the erection the manufacturer will remove or dispose of all rubbish and other unsightly material caused by his operations and will leave the premises in as good a condition as he found them.

Inspection:

86. An inspector representing the purchaser shall at all times have free entry to all parts of the job while work under the contract is being performed. The manufacturer shall afford the inspector, free of cost, reasonable facilities to satisfy him that the work is being done in accordance with this specification.

87. Any material or workmanship which in any way fails to meet the requirements of this specification will be rejected by the inspector and must not be used under the contract. Material or workmanship which shows injurious defects subsequent to its acceptance at the manufacturing works will be rejected and the manufacturer will be notified to this effect, and will be required to furnish new material or correct defective workmanship.

88. The purchaser's inspector shall examine all defects found in welds, and his approval shall be required before they are repaired.

89. Purchaser's inspector may judge quality of welds either by visual inspection, or by chipping off sections of fillet with cold chisel. Re-welding required by latter operation shall be paid for by purchaser unless welds are found to be defective, in which case all defective welding shall be cut out and replaced at expense of the manufacturer.

APPENDIX A

DESIGN DATA

This Appendix contains the following:

Details of design for small tanks,*
Details of design for large tanks,*
Specifications for materials,
Computing reinforcement of shell openings,
Computing back pitch of rivets,
Computing working stresses in butt-strap joints,
Analysis of joints in standard tanks,
Strength of butt joints,
Strength of lap joints.

*See Par. (c) of Foreword.

TABLE 4

DETAILS OF DESIGN FOR SMALL TANKS

72" Plates, 8 Courses or Less†

Detail Drawings not available; see Construction Drawings for 36-ft. diameter tank.

Diameter		12'	18'	24'	30'
Shell Courses	Number of sheets per shell course	2	3	4	5
6 (Top.)	Thickness of Plate	3/16	3/16	3/16	3/16
	Riveting	7/16 L1	7/16 L1	7/16 L1	7/16 L1
	Rivet Pitch	1.5	1.5	1.5	1.5
5	Thickness of Plate	3/16	3/16	3/16	3/16
	Riveting	7/16 L1	7/16 L1	7/16 L1	7/16 L1
	Rivet Pitch	1.5	1.5	1.5	1.5
4	Thickness of Plate	3/16	3/16	3/16	3/16
	Riveting	7/16 L1	7/16 L1	7/16 L1	7/16 L1
	Rivet Pitch	1.5	1.5	1.5	1.5
3	Thickness of Plate	3/16	3/16	3/16	3/16
	Riveting	7/16 L1	7/16 L1	7/16 L1	7/16 L1
	Rivet Pitch	1.5	1.5	1.5	1.5
2	Thickness of Plate	3/16	1/4	1/4	1/4
	Riveting	7/16 L1	5/8 L1	5/8 L1	5/8 L1
	Rivet Pitch	1.5	2.05	2.05	2.05
1 (Bot.)	Thickness of Plate	3/16	1/4	1/4	1/4
	Riveting	7/16 L1	5/8 L1	5/8 L1	5/8 L2
	Rivet Pitch	1.5	2.05	2.05	2.375

Top Angles* 2-1/2"x2-1/2"x1/4"
Bottom Angles* 3"x3"x5/16"
Bottom Rectangular Plates* 1/4"
Bottom Sketch Plates* 1/4"
Bottom Rivets* 5/8"
Roof Supports—All tanks except 12' diameter shall have center column, steel rafters, and standard slope of ¾" in 12". The 12' diameter tank shall have self-supporting roof with slope 2" in 12".
Roof Plates*—Rectangular and sketch—3/16".

*For all diameters given above.

†See Table 14 for shell joint analyses.

TABLE 5

DETAILS OF DESIGN FOR LARGE TANKS

72" Plates, 8 Courses or Less†

See Appendix E for List of Construction Drawings Which Form a Part of This Specification

Diameter		36′	48′	60′	78′	102′	120′	144′
Shell Courses	Number of Sheets Per Shell Course	6	8	10	13	17	20	24
8 (Top)	Thickness of Plate	3/16"	3/16"	1/4"	1/4"	1/4"	1/4"	1/4"
	Riveting	7/16" L1	7/16" L1	5/8" L1	5/8" L1	5/8" L1	5/8" L1	5/8" L1
	Rivet Pitch	1.5"	1.5"	2.05"	2.05"	2.05"	2.05"	2.05"
7	Thickness of Plate	3/16"	3/16"	1/4"	1/4"	1/4"	1/4"	5/16"
	Riveting	7/16" L1	7/16" L1	5/8" L1	5/8" L1	5/8" L2	5/8" L2	5/8" L2
	Rivet Pitch	1.5"	1.5"	2.05"	2.05"	2.375"	2.375"	2.565"*
6	Thickness of Plate	3/16"	1/4"	1/4"	1/4"	5/16"	11/32"	13/32"
	Riveting	7/16" L1	5/8" L1	5/8" L2	5/8" L2	5/8" L2	5/8" L3	3/4" L3
	Rivet Pitch	1.5"	2.05"	2.375"	2.375"	2.565"*	3.0"	3.59"
5	Thickness of Plate	1/4"	1/4"	1/4"	5/16"	13/32"	7/16"	15/32"
	Riveting	5/8" L1	5/8" L2	5/8" L2	5/8" L2	3/4" L3	3/4" L4	3/4" B3
	Rivet Pitch	2.05"	2.375"	2.375"	2.565"*	3.59"	3.8125"	7.1562"
	Thickness of Butt Straps: Inside							5/16"
	Thickness of Butt Straps: Outside							13/32"
4	Thickness of Plate	1/4"	1/4"	5/16"	3/8"	15/32"	15/32"	9/16"
	Riveting	5/8" L2	5/8" L2	5/8" L2	3/4" L3	3/4" L4	3/4" B4	7/8" B4
	Rivet Pitch	2.375"	2.375"	2.565"*	3.375"	4.0"	14.3125"	16.5"
	Thickness of Butt Straps: Inside						11/32"	13/32"
	Thickness of Butt Straps: Outside						13/32"	15/32"
3	Thickness of Plate	1/4"	5/16"	11/32"	7/16"	1/2"	9/16"	11/16"
	Riveting	5/8" L2	5/8" L2	5/8" L3	3/4" L3	7/8" B4	7/8" B4	1" B4
	Rivet Pitch	2.375"	2.565"*	3.00"	3.59"	16.5"	16.5"	18.42"
	Thickness of Butt Straps: Inside					3/8"	13/32"	1/2"
	Thickness of Butt Straps: Outside					15/32"	15/32"	17/32"
2	Thickness of Plate	5/16"	11/32"	13/32"	15/32"	9/16"	5/8"	25/32"
	Riveting	5/8" L2	5/8" L3	3/4" L3	3/4" B3	7/8" B4	7/8" B5	1 1/8" B4
	Rivet Pitch	2.565"*	3.00"	3.59"	7.1562"	16.5"	16.625"	20.75"
	Thickness of Butt Straps: Inside				5/16"	13/32"	15/32"	5/8"
	Thickness of Butt Straps: Outside				13/32"	15/32"	15/32"	5/8"
1 (Bot.)	Thickness of Plate	5/16"	3/8"	15/32"	1/2"	5/8"	3/4"	7/8"
	Riveting	5/8" L2	3/4" L3	3/4" L3	7/8" B4	7/8" B5	1" B4	1 1/8" B5
	Rivet Pitch	2.565"*	3.375"	3.4"	16.5"	16.625"	18.42"	22.00"
	Thickness of Butt Straps: Inside				3/8"	13/32"	9/16"	5/8"
	Thickness of Butt Straps: Outside				15/32"	13/32"	9/16"	11/16"
Top Angles		2 1/2 x 2 1/2 x 5/16	2 1/2 x 2 1/2 x 5/16	2 1/2 x 2 1/2 x 5/16	3x3x3/8	3x3x3/8	3x3x3/8	3x3x3/8
Bottom Angles		3x3x3/8	3x3x5/8	3x3x3/8	4x4x1/2	4x4x5/8	4x4x5/8	4x4x5/8
Bottom Rectangular Plates		1/4"	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"
Bottom Sketch Plates		1/4"	1/4"	5/16"	5/16"	5/16"	5/16"	5/16"
Bottom Rivets		5/8"	5/8"	5/8"	5/8"	5/8"	5/8"	5/8"

*Pitch when rivets are driven cold 2.375".

†See Tables 6-A and 6-B for 9th and 10th courses; see Table 7 for 168′ dia. tanks.

TABLE 6-A
DESIGN DETAILS FOR LARGE TANKS: 36', 48' AND 60'
72" Plates, 9th and 10th Courses*

Ring Number	Tank Diameter	36'	48'	60'
3	Mean Diameter, Feet	36.0780'	48.0885'	60.1068'
	Design Head, Feet	45.79'	45.68'	45.47'
	Plate Load, Lb. per Lin. In.	4289	5708	7096
	Plate and Rivets	5/16" Pl, 5/8" R	3/8" Pl, 3/4" R	11/32" Pl, 3/4" R
	Joint and Pitch	L2 at 2.565" H L2 at 2.375" C	L3 at 3.375"	L3 at 3.40"
	Outside Strap	———	———	———
	Inside Strap	———	———	———
	Girth Rivets	5/8"	3/4"	3/4"
	Vertical Gage	5' 9 1/8"	5' 8 3/4"	5' 8 3/4"
2	Mean Diameter, Feet	36.0233'	48.0234'	60.0313'
	Design Head, Feet	51.55'	51.41'	51.20'
	Plate Load, Lb. per Lin. In.	4876	6416	7988
	Plate and Rivets	11/32" Pl, 5/8" R	11/32" Pl, 3/4" R	7/16" Pl, 3/4" R
	Joint and Pitch	L2 at 2.40" H	L3 at 3.59"	B4 at 14.08"
	Plate and Rivets	5/16" Pl, 5/8" R		
	Joint and Pitch	L3 at 2.81" C		
	Outside Strap	———	———	13/32"
	Inside Strap	———	———	5/16"
	Girth Rivets	5/8"	3/4"	3/4"
	Girth Rivets	5/8"	3/4"	3/4"
	Vertical Gage	5' 9 1/8"	5' 8 3/4"	5' 8 3/4"
1	Mean Diameter, Feet	36.0806'	48.0885'	60.1068'
	Design Head, Feet	57.31'	57.14'	56.93'
	Plate Load, Lb. per Lin. In.	5374	7141	8893
	Plate and Rivets	11/32" Pl, 5/8" R	3/8" Pl, 3/4" R	11/32" Pl, 3/4" R
	Joint and Pitch	L3 at 3.00" H L3 at 3.00" C	B4 at 14.08"	B4 at 14.08"
	Outside Strap	———	13/32"	13/32"
	Inside Strap	———	9/32"	11/32"
	Girth Rivets	5/8"	3/4"	3/4"
	Bottom Angle	3"x3"x3/8"	3"x3"x3/8"	3"x3"x3/8"

*See Table 5 for courses 1 to 8 incl. See Tables 7, 8, and 9 for 168' dia. tanks.

NOTES: Ring No. 3=bottom course of present 8 ring tanks.
Assumed net width of each course=nominal width (72") less 1/2" on each edge for resquaring or beveling. See Par. 24.
Designs are for drilled holes in shell plates and butt straps.
Lap joints taken from Table 15.

TABLE 6-B

DESIGN DETAILS FOR LARGE TANKS: 78', 102', 120' AND 144'

72" Plates, 9th and 10th Courses*

Ring Number	Tank Diameter	78'	102'	120'	144'
3	Mean Diameter, Feet	78.1198'	102.1459'	120.1667'	144.2031'
	Design Head, Feet	45.37'	45.22'	45.18'	44.98'
	Plate Load, Lb. per Lin. In.	9205	12000	14095	16846
	Plate and Rivets	½" P1, ⅞" R	⅝" P1, ⅞" R	¾" P1, 1" R	⅞" P1, 1⅛" R
	Joint and Pitch	B4 at 16.50"	B5 at 16.625"	B4 at 18.42"	B5 at 22.00"
	Outside Strap	15/32"	15/32"	9/16"	11/16"
	Inside Strap	⅜"	15/32"	9/16"	5/8"
	Girth Rivets	⅞"	⅞"	1"	1⅛"
2	Vertical Gage	5' 8⅜"	5' 8 3/16"	5' 7 13/16"	5' 7 7/16"
	Mean Diameter, Feet	78.0339'	102.0365'	120.0365'	144.0495'
	Design Head, Feet	51.07'	50.90'	50.83'	50.60'
	Plate Load, Lb. per Lin. In.	10357	13497	15856	18942
	Plate and Rivets	17/32" P1, ⅞" R	11/16" P1, 1" R	13/16" P1, 1⅛" R	21/32" P1, 1¼" R
	Joint and Pitch	$B5_{20}$ at 16.56"	$B5_{20}$ at 18.77"	$B5_{20}$ at 20.98"	B6 at 24.72"
	Outside Strap	15/32"	17/32"	19/32"	23/32"
	Inside Strap	13/32"	17/32"	5/8"	¾"
	Girth Rivets	⅞"	1"	1⅛"	1¼"
1	Girth Rivets	⅞"	1"	1⅛"	1¼"
	Vertical Gage	5' 8⅜"	5' 7 13/16"	5' 7 7/16"	5' 7¼"
	Mean Diameter, Feet	78.1227'	102.1589'	120.1797'	144.2214'
	Design Head, Feet	56.77'	56.55'	56.45'	56.20'
	Plate Load, Lb. per Lin. In.	11526	15013	17630	21064
	Plate and Rivets	13/32" P1, ⅞" R	25/32" P1, 1⅛" R	29/32" P1, 1¼" R	1 3/32" P1, 1¼" R
	Joint and Pitch	$B5_{20}$ at 16.56"	$B5_{20}$ at 20.98"	B6 at 25.375"	B6 at 22.05"
	Outside Strap	15/32"	19/32"	¾"	5/8"
	Inside Strap	7/16"	15/32"	23/32"	⅞"
	Girth Rivets	⅞"	1⅛"	1¼"	1¼"
	Bottom Angle	4"x4"x⅝"	4"x4"x⅝"	5"x5"x¾"	5"x5"x¾"

*See Table 5 for courses 1 to 8 incl. See Tables 7, 8, and 9 for 168' dia. tanks.

NOTES: Ring No. 3 = bottom course of present 8 ring tanks.

Assumed net width of each course = nominal width (72") less ½" on each edge for resquaring or beveling. See Par. 24.

Designs are for drilled holes in shell plates and butt straps.

Lap joints taken from Table 15.

TABLE 7

DETAILS OF DESIGN FOR LARGE TANKS
72″ Plates, All Courses, 168′ Tanks*

Ring Number	Detail	Tank Diameter 168′	Nominal Height (In Feet)
10	Girth Rivets	5/8″	
	Vertical Gage	5′ 9 1/8″	
	Mean Diameter, Feet	167.8229′	
	Design Head, Feet	4.9062′	
	Plate Load, Lb. per Lin. In.	2140	5′ 11″
	Plate and Rivets	1/4″ P1, 5/8″ R	
	Joint and Pitch	L1 at 2.05″ H & C	
	Outside Butt Strap	.....	
	Inside Butt Strap	.....	
9	Girth Rivets	5/8″	
	Vertical Gage	5′ 9 1/8″	
	Mean Diameter, Feet	167.8698′	
	Design Head, Feet	10.6666′	
	Plate Load, Lb. per Lin. In.	4653	11′ 8″
	Plate and Rivets	5/16″ P1, 5/8″ R	
	Joint and Pitch	L3 at 2.81″ H & C	
	Outside Butt Strap	.....	
	Inside Butt Strap	.....	
8	Girth Rivets	5/8″	
	Vertical Gage	5′ 8 15/16″	
	Mean Diameter, Feet	167.9271′	
	Design Head, Feet	16.4114′	
	Plate Load, Lb. per Lin. In.	7162	17′ 5″
	Plate and Rivets	3/8″ P1, 3/4″ R	
	Joint and Pitch	B4 at 14.08″	
	Outside Butt Strap	13/32″	
	Inside Butt Strap	7/32″	
	Girth Rivets	3/4″	
7	Girth Rivets	3/4″	
	Vertical Gage	5′ 8 9/16″	
	Mean Diameter, Feet	168.0000′	
	Design Head, Feet	22.1249′	
	Plate Load, Lb. per Lin. In.	9660	23′ 2″
	Plate and Rivets	1/2″ P1, 7/8″ R	
	Joint and Pitch	$B5_{20}$ at 16.56″	
	Outside Butt Strap	15/32″	
	Inside Butt Strap	3/8″	
6	Girth Rivets	7/8″	
	Vertical Gage	5′ 8 3/8″	
	Mean Diameter, Feet	168.0937′	
	Design Head, Feet	27.8228′	
	Plate Load, Lb. per Lin. In.	12154	28′ 10″
	Plate and Rivets	5/8″ P1, 7/8″ R	
	Joint and Pitch	$B5_{20}$ at 16.56″	
	Outside Butt Strap	15/32″	
	Inside Butt Strap	17/32″	

Ring Number	Detail	Tank Diameter 168′	Nominal Height (In Feet)
	Girth Rivets	7/8″	
5	Vertical Gage	5′ 8 3/16″	
	Mean Diameter, Feet	168.2083′	
	Design Head, Feet	33.5051′	
	Plate Load Lb. per Lin. In.	14646	34′ 6″
	Plate and Rivets	3/4″ P1, 1″ R	
	Joint and Pitch	$B5_{20}$ at 18.77″	
	Outside Butt Strap	17/32″	
	Inside Butt Strap	9/16″	
	Girth Rivets	1″	
4	Vertical Gage	5′ 7 5/8″	
	Mean Diameter, Feet	168.0729′	
	Design Head, Feet	39.1405′	
	Plate Load, Lb. per Lin. In.	17098	40′ 2″
	Plate and Rivets	7/8″ P1, 1 1/4″ R	
	Joint and Pitch	B6 at 25.375″	
	Outside Butt Strap	3/4″	
	Inside Butt Strap	11/16″	
	Girth Rivets	1 1/4″	
3	Girth Rivets	1 1/4″	
	Vertical Gage	5′ 7 1/4″	
	Mean Diameter, Feet	168.2292′	
	Design Head, Feet	44.7447′	
	Plate Load, Lb. per Lin. In.	19562	45′ 9″
	Plate and Rivets	1″ P1, 1 1/4″ R	
	Joint and Pitch	B6 at 23.99′	
	Outside Butt Strap	11/16″	
	Inside Butt Strap	25/32″	
	Girth Rivets	1 1/4″	
2	Vertical Gage	5′ 7 1/4″	
	Mean Diameter, Feet	168.0521′	
	Design Head, Feet	50.3489′	
	Plate Load, Lb. per Lin. In.	21989	51′ 4″
	Plate and Rivets	1 1/8″ P1, 1 1/4″ R	
	Joint and Pitch	B6 at 21.47″	
	Outside Butt Strap	13/32″	
	Inside Butt Strap	29/32″	
	Girth Rivets	1 1/4″	
1	Vertical Gage	5′ 7 1/4″	
	Mean Diameter, Feet	168.2500′	
	Design Head, Feet	55.9531′	
	Plate Load, Lb. per Lin. In.	24465	57′ 0″
	Plate and Rivets	1 1/4″ P1, 1 1/4″ R	
	Joint and Pitch	B6 at 19.45″	
	Outside Butt Strap	15/32″	
	Inside Butt Strap	1 1/32″	
	Girth Rivets	1 1/4″	
	Top Angle	3x3x3/8	
	Bottom Angle	5x5x3/4	

*See Tables 8 and 9 for 100″ Courses.

NOTES: Assumed net width of each course equals nominal width (72″) less 1/2″ on each edge for resquaring or beveling. Designs are for drilled holes in shell plates and butt straps. See Par. 24.
Lap Joints taken from Table 15.

TABLE 8

DETAILS FOR LARGE TANKS

100" Plates, All Courses*

Ring No.	Tank Diameter	36'	48'	60'	78'	102'	120'	144'	168'
8	Girth Rivets	7/16"	7/16"	5/8"	5/8"	5/8"	5/8"	5/8"	5/8"
	Plate Thickness	3/16"	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"	1/4"
	Riveting	7/16", L1	7/16", L1	5/8", L1	5/8", L1	5/8", L1	5/8", L1	5/8", L2	5/8", L2
	Rivet Pitch	1.50"	1.50"	2.05" H&C	2.05" H&C	2.05" H&C	2.05" H&C	2.375" H&C	2.375" H&C
	Thickness of Butt Straps: Inside	———	———	———	———	———	———	———	———
	Thickness of Butt Straps: Outside	———	———	———	———	———	———	———	———
	Girth Rivets	7/16"	7/16"	5/8"	5/8"	5/8"	5/8"	5/8"	5/8"
7	Plate Thickness	3/16"	3/16"	1/4"	1/4"	9/32"	5/16"	3/8"	3/8"
	Riveting	7/16", L1	7/16", L1	5/8", L1	5/8", L2	5/8", L2	5/8", L3	3/4", L3	3/4", B3
	Rivet Pitch	1.50"	1.50"	2.05" H&C	2.375" H&C	2.59" H&C	2.81" H&C	3.375"	7.04"
	Thickness of Butt Straps: Inside	———	———	———	———	———	———	———	1/4"
	Thickness of Butt Straps: Outside	———	———	———	———	———	———	———	13/32"
	Girth Rivets	7/16"	7/16"	5/8"	5/8"	5/8"	5/8"	3/4"	3/4"
6	Girth Rivets	7/16"	7/16"	5/8"	5/8"	5/8"	5/8"	3/4"	3/4"
	Plate Thickness	1/4"	1/4"	9/32"H, 1/4"C	5/16"	11/32"	11/32"	15/32"	17/32"
	Riveting	5/8", L1	5/8", L2	5/8", L2	5/8", L3	3/4", L3	3/4", B3	3/4", B4	7/8", $B5_{20}$
	Rivet Pitch	2.05" H&C	2.375" H&C	2.59"H,2.375"C	2.81" H&C	3.59"	7.04"	14.08"	16.56"
	Thickness of Butt Straps: Inside	———	———	———	———	———	9/32"	11/32"	13/32"
	Thickness of Butt Straps: Outside	———	———	———	———	———	11/32"	13/32"	15/32"
	Girth Rivets	5/8"	5/8"	5/8"	5/8"	3/4"	3/4"	3/4"	7/8"
5	Plate Thickness	1/4"	9/32"	11/32"	13/32"	7/16"	1/2"	13/32"	29/32"
	Riveting	5/8", L2	5/8", L2	5/8", L2	3/4", L3	3/4", B4	7/8", $B5_{20}$	7/8", $B5_{20}$	1", B4
	Rivet Pitch	2.375" H&C	2.59" H&C	2.40"H,2.09"C	3.59"	14.08"	16.56"	16.56"	18.42"
	Thickness of Butt Straps: Inside	———	———	———	———	5/16"	3/8"	7/16"	1/2"
	Thickness of Butt Straps: Outside	———	———	———	———	13/32"	15/32"	15/32"	17/32"
	Girth Rivets	5/8"	5/8"	5/8"	3/4"	3/4"	7/8"	7/8"	1"
4	Girth Rivets	5/8"	5/8"	5/8"	3/4"	3/4"	7/8"	7/8"	1"
	Plate Thickness	9/32"	11/32"	13/32"	7/16"	17/32"	5/8"	3/4"	7/8"
	Riveting	5/8", L2	5/8", L2	3/4", L3	3/4", B4	7/8", $B5_{20}$	7/8", $B5_{20}$	1", $B5_{20}$	1 1/4", B6
	Rivet Pitch	2.59" H&C	2.40"H,2.09"C	3.59"	14.08"	16.56"	16.56"	18.77"	25.375"
	Thickness of Butt Straps: Inside	———	———	———	5/16"	11/32"	13/32"	7/16"	15/32"
	Thickness of Butt Straps: Outside	———	———	———	13/32"	13/32"	15/32"	17/32"	9/16"
	Girth Rivets	5/8"	5/8"	3/4"	3/4"	7/8"	7/8"	1"	1 1/4"
3	Plate Thickness	5/16"	13/32"	13/32"	1/2"	21/32"	3/4"	29/32"	1 1/16"
	Riveting	5/8", L2	3/4", L3	3/4", B4	7/8", $B5_{20}$	7/8", $B5_{20}$	1", $B5_{20}$	1 1/4", B6	1 1/4", B6
	Rivet Pitch	2.56"H,2.375"C	3.59"	14.08"	16.56"	16.56"	18.77"	25.375"	22.66"
	Thickness of Butt Straps: Inside	———	———	9/32"	5/8"	1/2"	9/16"	23/32"	21/32"
	Thickness of Butt Straps: Outside	———	———	13/32"	11/32"	11/32"	17/32"	3/4"	21/32"
	Girth Rivets	5/8"	3/4"	3/4"	7/8"	7/8"	1"	1 1/4"	1 1/4"
2	Plate Thickness	11/32"	5/8"	15/32"	13/32"	3/4"	7/8"	1 1/16"	1 1/4"
	Riveting	5/8", L3	3/4", B4	3/4", B4	7/8", B4	1", $B5_{20}$	1 1/4", B6	1 1/4", B6	1 1/4", B6
	Rivet Pitch	3.00" H&C	14.08"	14.08"	16.25"	18.77"	25.375"	22.66"	19.45"
	Thickness of Butt Straps: Inside	———	9/32"	11/32"	7/16"	9/16"	11/16"	27/32"	1 1/32"
	Thickness of Butt Straps: Outside	———	13/32"	15/32"	15/32"	17/32"	3/4"	31/32"	33/32"
	Girth Rivets	5/8"	3/4"	3/4"	7/8"	1"	1 1/4"	1 1/4"	1 1/4"
1	Girth Rivets	5/8"	3/4"	3/4"	7/8"	1"	1 1/4"	1 1/4"	1 1/4"
	Plate Thickness	13/32"	7/16"	17/32"	29/32"	7/8"	1"	1 5/32"	1 7/16"
	Riveting	3/4", L3	3/4", B4	7/8", B4	7/8", $B5_{20}$	1 1/4", B6	1 1/4", B6	1 1/4", B6	1 1/4", B6
	Rivet Pitch	3.59"	14.08"	16.25"	16.56"	25.375"	23.99"	19.92"	17.09"
	Thickness of Butt Straps: Inside	———	5/16"	3/8"	1/2"	11/16"	29/32"	1"	1 7/32"
	Thickness of Butt Straps: Outside	———	13/32"	15/32"	15/32"	3/4"	11/16"	9/16"	29/32"
	Girth Rivets	3/4"	3/4"	7/8"	7/8"	1 1/4"	1 1/4"	1 1/4"	1 1/4"
	Top Angle	2 1/2 x 2 1/2 x 5/16	2 1/2 x 2 1/2 x 5/16	2 1/2 x 2 1/2 x 5/16	3x3x3/8	3x3x3/8	3x3x3/8	3x3x3/8	3x3x3/8
	Bottom Angle	3 x3 x3/8	3 x3 x5/8	3 x3 x3/8	4x4x1/2	4x4x5/8	5x5x3/4	5x5x3/4	5x5x3/4

NOTE: Lap joints are taken from Table 15.

*See Table 9 for design data.

TABLE 9

DESIGN DATA FOR LARGE TANKS

100" Plates, All Courses*

Ring No.	Tank Diameter	36'	48'	60'	78'	102'	120'	144'	168'
8	Vertical Gage	8' 1 1/2"	8' 1 1/2"	8' 1 1/3"	8' 1 1/8"	8' 1 1/8"	8' 1 1/8"	8' 1 1/8"	8' 1 1/8"
	Mean Diameter, Feet	35.8800'	47.8696'	59.8489'	77.8437'	101.8281'	119.8177'	143.7917'	167.7703'
	Design Head, Feet	7.2396'	7.2396'	7.2084'	7.2396'	7.2396'	7.2396'	7.2396'	7.2396'
	Plate Load, Lb./In.	675	901	1121	1465	1916	2254	2705	3175
7	Vertical Gage	8' 1 1/2"	8' 1 1/2"	8' 1 1/8"	8' 1 1/8"	8' 1 1/8"	8' 1 1/8"	8' 0 13/16"	8' 0 13/16"
	Mean Diameter, Feet	35.9118'	47.9009'	59.8906'	77.8854'	101.8724'	119.8646'	143.8438'	167.8229'
	Design Head, Feet	15.3646'	15.3646'	15.3022'	15.3334'	15.3334'	15.3334'	15.3177'	15.3177'
	Plate Load, Lb./In.	1434	1913	2382	3104	4059	4776	5726	6681
6	Vertical Gage	8' 1 5/16"	8' 1 5/16"	8' 1 1/8"	8' 1 1/8"	8' 0 13/16"	8' 0 13/16"	8' 0 3/4"	8' 0 9/16"
	Mean Diameter, Feet	35.9478'	47.9374'	59.9323'	77.9323'	101.9297'	119.9245'	143.9141'	167.8984'
	Design Head, Feet	23.4740'	23.4740'	23.3959'	23.4271'	23.4115'	23.4115'	23.3802'	23.3646'
	Plate Load, Lb./In.	2193	2924	3644	4745	6201	7296	8744	10195
5	Vertical Gage	8' 1 1/8"	8' 1 1/8"	8' 1 1/8"	8' 0 13/16"	8' 0 3/4"	8' 0 9/16"	8' 0 9/16"	8' 0 3/8"
	Mean Diameter, Feet	35.9895'	47.9817'	59.9818'	77.9922'	102.0000'	120.0000'	144.0026'	168.0026'
	Design Head, Feet	31.5678'	31.5678'	31.4897'	31.5052'	31.4740'	31.4584'	31.4271'	31.3802'
	Plate Load, Lb./In.	2952	3936	4909	6386	8348	9810	11761	13701
4	Vertical Gage	8' 1 1/8"	8' 1 1/8"	8' 0 13/16"	8' 0 3/4"	8' 0 9/16"	8' 0 3/8"	8' 0 3/8"	7' 11 5/8"
	Mean Diameter Feet	36.0338'	48.0338'	60.0443'	78.0625'	102.0807'	120.0937'	144.1146'	168.1354'
	Design Head, Feet	39.6615'	39.6615'	39.5678'	39.5667'	39.5209'	39.4897'	39.4427'	39.3490'
	Plate Load, Lb./In.	3714	4951	6174	8027	10484	12324	14772	17198
3	Vertical Gage	8' 1 1/8"	8' 0 13/16"	8' 0 3/4"	8' 0 9/16"	8' 0 3/8"	8' 0 3/8"	7' 11 5/8"	7' 11 1/4"
	Mean Diameter Feet	36.0833'	48.0963'	60.1120'	78.1406'	102.1797'	120.2083'	144.2526'	168.2969'
	Design Head, Feet	47.7553'	47.7396'	47.6303'	47.6146'	47.5521'	47.5053'	47.4115'	47.2865'
	Plate Load, Lb./In.	4478	5967	7441	9669	12627	14840	17778	20681
2	Vertical Gage	8' 1 1/8"	8' 0 3/4"	8' 0 3/4"	8' 0 3/8"	8' 0 3/8"	7' 11 5/8"	7' 11 1/4"	7' 11 1/4"
	Mean Diameter, Feet	36.0286'	48.0312'	60.0391'	78.0495'	102.0625'	120.0729'	144.0885'	168.1042'
	Design Head, Feet	55.8490'	55.8021'	55.6928'	55.6458'	55.5677'	55.4741'	55.3490'	55.2240'
	Plate Load, Lb./In.	5229	6965	8690	11287	14739	17310	20725	24125
1	Vertical Gage	8' 0 15/16"	8' 0 3/4"	8' 0 9/16"	8' 0 3/8"	7' 11 5/8"	7' 11 1/4"	7' 11 1/4"	7' 11 1/4"
	Mean Diameter, Feet	36.0911'	48.0989'	60.1224'	78.1537'	102.1979'	120.2292'	144.2786'	168.3282'
	Design Head, Feet	63.9271'	63.8646'	63.7396'	63.6770'	63.5365'	63.4116'	63.2865'	63.1615'
	Plate Load, Lb./In.	5996	7982	9959	12933	16874	19813	23729	27630

*See Table 8 for other details.

NOTES: Assumed net width of each course equals nominal width (100") less 1/2" on each edge for beveling or resquaring. See Par. 24.
Designs are for drilled holes in shell plates and butt straps.

TABLE 10

PRINCIPAL PROVISIONS OF MATERIALS SPECIFICATIONS LISTED IN SECTION I.

For Details See Texts of Specifications Referred To.

Use	Specification	Process of Manufacture	Chemical Properties (1)		PHYSICAL PROPERTIES				
			Phosphorus (Not over)	Sulphur (Not over)	Tensile Strength	Yield Point	Elongation—% In 2"	Elongation—% In 8"	BEND TEST
Plates and Shapes	A 7 ASTM	Open Hearth **Bessemer	Acid —.06* Basic—.04* Bes. —.10*	.05*	60,000-72,000	.5 Tensile Strength Minimum 33,000	22	1,500,000† / Ten. Str.	¾" and under—cold bent 180° around ½" pin. Over ¾" to 1"—cold bent around 1" pin. Over 1"—cold bent around 1½" pin.
Rivets	A 141 ASTM	Open Hearth	.04*	.045*	52,000-62,000	.5 Tensile Strength Minimum 28,000		1,500,000† / Ten. Str.	Cold 180° flat on itself.
Rivets	A 31 ASTM (1) and Boiler Code ASME	Open Hearth	.04	.045	45,000-55,000	.5 Tensile Strength		1,500,000‡ / Ten. Str.	(1) Specimen cold bent 180° flat on itself. (2) Specimen heated to 1200° and quenched in water bent 180° flat on itself. (3) Rivet shank cold bent as above. FLATTENING TEST (4) Rivet head shall flatten while hot to diam. 2½ times shank diam.
Steel Castings	A 27 ASTM (2) Grade A3		.05	.06	60,000 Min.	30,000 Min.	24	———	———

*From ladle analysis made by manufacturer; check analysis from finished material by purchaser may show 25% more.

**Open-hearth steel only allowed for tank plates by API Std 12-A.

†See exceptions listed in particular code.

‡Need not be over 30%.

(1) Manganese 0.30-0.50, ASTM A 31.

(2) Manganese 1.00, ASTM A 27.

TABLE 11—PERMISSIBLE VARIATIONS OF RECTANGULAR PLATES ORDERED TO WEIGHT*

Ordered Weight, Lb. Per Sq. Ft.	Permissible Variations in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Ordered Weights																		Ordered Weight, Lb. Per Sq. Ft.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over.		
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	
Under 5	5	3	5.5	3	6	3	7	3	—	—	—	—	—	—	—	—	—	—	Under 5
5 to 7.5 excl.	4.5	3	5	3	5.5	3	6	3	—	—	—	—	—	—	—	—	—	—	5 to 7.5 excl.
7.5 " 10 "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	—	—	—	—	7.5 " 10 "
10 " 12.5 "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5 "
12.5 " 15 "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15 "
15 " 17.5 "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5 "
17.5 " 20 "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20 "
20 " 25 "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25 "
25 " 30 "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30 "
30 " 40 "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40 "
40 or over	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over

NOTE—The weight per square foot of individual plates shall not vary from the ordered weight by more than 1⅓ times the amount given in this table.

*Copied from ASTM.

(1) METHOD OF COMPUTING REINFORCEMENT FOR OPENINGS IN TANK SHELL:

A-1. In computing the necessary reinforcement of an opening in a tank shell (See Design Specification, Par. 12), the net area of the reinforcement shall bear the same ratio to the area of metal removed from the shell as the strength of the vertical joint in the shell course bears to the strength of the solid plate.

A-2. Sufficient rivets shall be used to transmit to the shell plate by shear the full strength of the reinforcing ring or flange, at a maximum unit shear of 16,000 lb. per sq. in.

A-3. In computing the net reinforcing area of a fitting, such as a boilermaker's flange or manhole flange having a neck, the material in the neck may be considered as part of the flange, for a height, measured from the surface of the reinforced sheet, equal to 4 times the thickness of the material in the neck.

---

(2) METHOD OF COMPUTING BACK PITCH OF RIVETS FOR TANKS 144-FT. IN DIAMETER OR LESS, USING EIGHT OR LESS 72-INCH COURSES:

A-4. If P/d is 4 or less, the minimum value shall be 2d.

A-5. If P/d is over 4, the minimum value shall be:

$$2d+0.1\ (P-4d).$$

where

"P" equals pitch of rivet, in inches, in outer row where a rivet in the inner row comes midway between two rivets in the outer row.

"P" equals pitch of rivets, in inches, in the outer row less pitch of rivets in the inner row where two rivets in the inner row come between two rivets in the outer row.

(It is here assumed that the joints are of usual construction where rivets are symmetrically spaced).

"d" equals diameter, in inches, of the rivet holes.

A-6. The pitch of rivets shall be measured either on the flat plate before rolling, or on the median line after rolling.

---

(3) METHOD OF COMPUTING BACK PITCH OF RIVETS FOR TANKS USING 100-INCH PLATES OR USING 72-INCH PLATES FOR 9TH AND 10TH COURSES OR 168-FT. DIAMETER:

A-7. The distance between the center lines of any two adjacent rows of rivets, except those adjacent to the edge of the outside butt strap*, or the back-pitch, measured at right angles to the direction of the joint, shall not be less than the following:

For joints where one rivet in the inner row is placed midway between two rivets in the outer row,

$$\text{Back-pitch} = 1.75d + 0.185\ (P - 4d)$$ with a minimum of 1.75d.

For joints where two rivets in the inner row are placed midway between two rivets in the outer row,

$$\text{Back-pitch} = 2d + 0.14\ (P - 4d)$$ with a minimum of 2d.

Where P = pitch, in inches, of rivets in the outer row of two.

d = diameter, in inches, of the rivet holes.

A-8. The pitch of rivets shall be measured either on the flat plate before rolling, or on the median line after rolling.

*The back-pitch for the rows adjacent to the edge of the outside butt strap shall be as given in Table 1B, Col. 10.

---

(4) METHOD OF COMPUTING WORKING STRESSES IN RIVETED BUTT-STRAP JOINTS:

A-9. The API method of computing the strength of riveted butt-strap joints differs from the ASME Boiler Construction Code in two particulars: (1) working stresses in the steel are computed instead of efficiency as related to the ultimate strength of the materials and (2) all rivets are assumed to be equally loaded.

A-10. The method is illustrated by the following example, in which the stresses are computed for the second course of the 120-foot diameter API Standard Tank:

A-11. Notation

L = Load on tank shell in pounds per lineal inch of vertical joint = Static head in pounds per square inch times radius of tank in inches.

t = Thickness of shell plate.

i = Thickness of inside butt strap.

o = Thickness of outside butt strap.

P = Pitch of rivets on row having the greatest pitch.

d = Diameter of rivet, computed according to Paragraph 10.

D = Diameter of rivet hole as given in Paragraph 10.

a = Cross-sectional area of rivet, computed according to Paragraph 10.

n = Total number of rivets in single shear in a length of joint equal to "P".

N = Total number of rivets in double shear in a length of joint equal to "P".

Symbols n or N with subscript indicate number of rivets in a given row, counting rows from the center of the joint, in a length of joint, P.

s = Shearing load on each rivet in single shear as given by formula (1).

S = Shearing load on each rivet in double shear = (2s).

f_t = Tensile stress in net section of shell plate, lbs. per sq. in.

f_i = Tensile stress in net section of inside butt strap, lbs. per sq. in.

f_o = Tensile stress in net section of outside butt strap, lbs. per sq. in

f_s = Shearing stress in rivets, lbs. per sq. in.

c = Crushing stress on shell plate for rivets in single shear, lbs. per sq. in.

C = Crushing stress on shell plate for rivets in double shear, lbs. per sq. in.

c_i = Crushing stress on inside butt strap, lbs. per sq. in.

c_o = Crushing stress on outside butt strap, lbs. per sq. in.

A-12. Formulae

(1) $s=\frac{LP}{n+2N}$

(2) $S=2s.$

(3) $f_s=\frac{s}{a}$

(4) f_t in fifth (outer) row of rivets $=\frac{LP}{t\,(P-D)}$

(5) f_t in fourth row of rivets $=\frac{LP-sn_5}{t\,(P-D\,n_4)}$

(6) f_t in third row of rivets $=\frac{LP-s\,(n_5+n_4)}{t\,(P-D\,n_2)}$

(7) f_t in second row of rivets $=\frac{LP-s\,(n_5+n_4+n_2)}{t\,(P-D\,n_2)}$

(8) f_t in first row of rivets, assuming equal spacing in the first and second rows $=\frac{1}{2}$ stress in second row.

(9) $f_i=\frac{s\,(N+n)}{i\,(P-D\,N_1)}$

(10) $f_o=\frac{s\,N}{o\,(P-D\,N_1)}$

(11) $c=\frac{s}{t\,d}$

(12) $C=\frac{S}{t\,d}$

(13) $c_i=\frac{s}{i\,d}$

(14) $c_o=\frac{s}{o\,d}$

A-13. Illustrative example—Design of Course 2 of 120-foot diameter Standard Tank.

L=12326 pounds.	a =0.6903 square inches.
t =0.625 inch.	N =8
i =0.46875 inch.	N_1=4
o =0.46875 inch.	N_2=4
P=16.625 inches.	n =4
d =0.9375 inch.	n_3=2
D=1.0 inch.	n_4=1
	n_5=1

Computation

(1) $s=\frac{12326\times16.625}{4+(2\times8)}=\frac{204920}{20}=10246$ pounds.

(2) $S=2\times10246=20492$ pounds.

(3) $f_s=\frac{s}{a}=\frac{10246}{0.6903}=14842$ lbs. per sq. in.

(4) f_t in fifth row $=\frac{12326\times16.625}{0.625\,(16.625-1)}=20988$ lbs. per sq. in.

(5) f_t in fourth row $=\frac{(12326\times16.625)-(10246\times1)}{0.625\,(16.625-1)}$

$=19935$ lbs. per sq. in.

(6) f_t in third row $=\frac{(12326\times16.625)-10246(1+1)}{0.625\,(16.625-1\times2)}$

$=20177$ lbs. per sq. in.

(7) f_t in second row $=\frac{(12326\times16.625)-10246\,(1+1+2)}{0.625\,(16.625-1\times4)}$

$=20776$ lbs. per sq. in.

(8) f_t in first row $=\frac{20776}{2}=10388$ lbs. per sq. in.

(9) $f_i=\frac{10246\,(8+4)}{0.46875\,(16.625-1\times4)}=20776$ lbs. per sq. in.

(10) $f_o=\frac{10246\times8}{0.46875\,(16.625-1\times4)}=18851$ lbs. per sq. in.

(11) $c=\frac{10246}{0.625\times0.9375}=17486$ lbs. per sq. in.

(12) $C=\frac{20492}{0.625\times0.9375}=34973$ lbs. per sq. in.

(13) $c_i=\frac{10246}{0.46875\times0.9375}=23316$ lbs. per sq. in.

(14) $c_o=\frac{10246}{0.46875\times0.9375}=23316$ lbs. per sq. in.

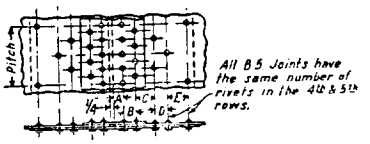

FIG. 6

DISTANCE BETWEEN RIVET ROWS
(See Table 13)

TABLE 12
ANALYSIS OF VERTICAL SHELL JOINTS IN API STANDARD TANKS‡
72" Plates, 8 Courses or Less†
(Dimensions in Inches, except Col. 11)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
				Rivet Areas, Square Inches, In Length of Joint = P									Actual Unit Stresses in Joint as Designed lbs. per sq. in.		
													On Rivets		
Thickness of Plate	Dia. of Rivet	Type of Joint	Rivet "P" Pitch	Shear	Compression	Net Section of Plate, sq. in., In Length of Joint = P	Maximum Allowable Load (L) per Lineal Inch of Joint	Tank Dia. and Ring No.	Actual Load (L) On Shell per Lineal Inch of Joint	Depth in Feet To Design Point	Pressure, lbs. per sq. in.	Actual Load On Shell In Length of Joint = P	Shear	Comp.	Tension In Shell
5/16	7/8	L1	1.5	0.1964	0.094	0.176	2000	36/8	465	4.99	2.16	697	3548	7414	3960
5/16	7/8	L1	1.5	0.1964	0.094	0.176	2000	48/8	620	4.99	2.16	930	4735	9893	5284
1/4	5/8	L1	2.05H	0.3712	0.172	0.325	2683	60/8	768	4.93	2.14	1574	4240	9151	4843
1/4	5/8	L1	2.05C	0.3382	0.164	0.333	2561	60/8	768	4.93	2.14	1574	4654	9597	4727
1/4	5/8	L1	2.05H	0.3712	0.172	0.325	2683	78/8	1004	4.96	2.15	2058	5544	11965	6332
1/4	5/8	L1	2.05C	0.3382	0.164	0.333	2561	78/8	1004	4.96	2.15	2058	6085	12549	6180
5/16	7/8	L1	1.5	0.1964	0.094	0.176	2000	36/7	1013	10.86	4.70	1520	7739	16170	8636
1/4	5/8	L1	2.05H	0.3712	0.172	0.325	2683	102/8	1313	4.96	2.15	2692	7252	15651	8283
1/4	5/8	L1	2.05C	0.3382	0.164	0.333	2561	102/8	1313	4.96	2.15	2692	7960	16415	8084
5/16	7/8	L1	1.5	0.1964	0.094	0.176	2000	48/7	1351	10.86	4.70	2027	10320	21564	11517
1/4	5/8	L1	2.05H	0.3712	0.172	0.325	2683	120/8	1546	4.96	2.15	3169	8537	18424	9751
1/4	5/8	L1	2.05C	0.3382	0.164	0.333	2561	120/8	1546	4.96	2.15	3169	9370	19323	9516
5/16	7/8	L1	1.5	0.1964	0.094	0.176	2000	36/6	1563	16.74	7.25	2345	11940	24946	13323
1/4	5/8	L1	2.05H	0.3712	0.172	0.325	2683	60/7	1671	10.74	4.65	3425	9226	19913	10538
1/4	5/8	L1	2.05C	0.3382	0.164	0.333	2561	60/7	1671	10.74	4.65	3425	10127	20884	10285
1/4	5/8	L1	2.05H	0.3712	0.172	0.325	2683	144/8	1855	4.96	2.15	3803	10245	22110	11704
1/4	5/8	L1	2.05C	0.3382	0.164	0.333	2561	144/8	1855	4.96	2.15	3803	11245	23189	11420
1/4	5/8	L1	2.05H	0.3712	0.172	0.325	2683	48/6	2079	16.70	7.23	4262	11482	24779	13114
1/4	5/8	L1	2.05C	0.3382	0.164	0.333	2561	48/6	2079	16.70	7.23	4262	12602	25988	12799
1/4	5/8	L1	2.05H	0.3712	0.172	0.325	2683	36/5	2111	22.58	9.78	4827	11657	25157	13314
1/4	5/8	L1	2.05C	0.3382	0.164	0.333	2561	36/5	2111	22.58	9.78	4827	12794	26384	12994
1/4	5/8	L1	2.05H	0.3712	0.172	0.325	2683	78/7	2178	10.77	4.66	4465	12028	25959	13738
1/4	5/8	L1	2.05C	0.3382	0.164	0.333	2561	78/7	2178	10.77	4.66	4465	13202	27226	13408
1/4	5/8	L2	2.375H	0.7424	0.344	0.406	3592	60/6	2578	16.55	7.17	6123	8247	17799	15081
1/4	5/8	L2	2.375C	0.6764	0.328	0.414	3661	60/6	2578	16.55	7.17	6123	9052	18668	14790
1/4	5/8	L2	2.375H	0.7424	0.344	0.406	3592	36/4	2658	28.39	12.30	6313	8503	18351	15549
1/4	5/8	L2	2.375C	0.6764	0.328	0.414	3661	36/4	2658	28.39	12.30	6313	9333	19247	15249
1/4	5/8	L2	2.375H	0.7424	0.344	0.406	3592	48/5	2806	22.51	9.75	6664	8976	19373	16413
1/4	5/8	L2	2.375C	0.6764	0.328	0.414	3661	48/5	2806	22.51	9.75	6664	9852	20317	16097
1/4	5/8	L2	2.375H	0.7424	0.344	0.406	3592	102/7	2848	10.77	4.66	6764	9111	19662	16660
1/4	5/8	L2	2.375C	0.6764	0.328	0.414	3661	102/7	2848	10.77	4.66	6764	10000	20621	16338
1/4	5/8	L2	2.375H	0.7424	0.344	0.406	3592	36/3	3201	34.17	14.80	7602	10239	22098	18724
1/4	5/8	L2	2.375C	0.6764	0.328	0.414	3661	36/3	3201	34.17	14.80	7602	11239	23177	18362
1/4	5/8	L2	2.375H	0.7424	0.344	0.406	3592	120/7	3351	10.77	4.66	7959	10720	23136	19603
1/4	5/8	L2	2.375C	0.6764	0.328	0.414	3661	120/7	3351	10.77	4.66	7959	11766	24265	19223
1/4	5/8	L2	2.375H	0.7424	0.344	0.406	3592	78/6	3357	16.58	7.18	7973	10739	23177	19638
1/4	5/8	L2	2.375C	0.6764	0.328	0.414	3661	78/6	3357	16.58	7.18	7973	11787	24307	19258
1/4	5/8	L2	2.375H	0.7424	0.344	0.406	3592	60/5	3488	22.36	9.68	8272	11142	24046	20374
1/4	5/8	L2	2.375C	0.6764	0.328	0.414	3661	60/5	3488	22.36	9.68	8272	12229	25219	19981
1/4	5/8	L2	2.375H	0.7424	0.344	0.406	3592	48/4	3535	28.33	12.27	8396	11309	24406	20679
1/4	5/8	L2	2.375C	0.6764	0.328	0.414	3661	48/4	3535	28.33	12.27	8396	12413	25597	20280

TABLE 12 (Cont'd): VERTICAL SHELL JOINTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
				Rivet Areas, Square Inches, in Length of Joint = P									Actual Unit Stresses in Joint as Designed lbs. per sq. in.		
													On Rivets		
Thickness of Plate	Dia. of Rivet	Type of Joint	Rivet Pitch "p"	Shear	Compression	Net Section of Plate, sq. in., in Length of Joint = P	Maximum Allowable Load (L) per Lineal Inch of Joint	Tank Dia. and Ring No.	Actual Load (L) On Shell per Lineal Inch of Joint	Depth in Feet To Design Point	Pressure, lbs. per sq. in.	Actual Load On Shell in Length of Joint = P	Shear	Comp.	Tension in Shell
7/16	5/8	L2	2.565H	0.7424	0.480	0.567	4640	36/2	3743	40.02	17.33	9601	12932	22327	16932
7/16	5/8	L2	2.375C	0.6764	0.410	0.517	4572	36/2	3743	40.02	17.33	8890	18143	21683	17195
7/16	5/8	L2	2.565H	0.7424	0.480	0.567	4640	144/7	4022	10.77	4.66	10316	13895	23990	18194
7/16	5/8	L2	2.375C	0.6764	0.410	0.517	4572	144/7	4022	10.77	4.66	9552	14122	23297	18471
7/16	5/8	L2	2.565H	0.7424	0.480	0.567	4640	48/3	4259	34.10	14.77	10924	14714	25404	19266
7/16	5/8	L2	2.375C	0.6764	0.410	0.517	4572	48/3	4259	34.10	14.77	10115	14954	24671	19565
7/16	5/8	L2	2.565H	0.7424	0.480	0.567	4640	36/1	4289	45.79	19.83	11001	14818	25583	19402
7/16	5/8	L2	2.375C	0.6764	0.410	0.517	4572	36/1	4289	45.79	19.83	10186	15059	24844	19702
7/16	5/8	L2	2.565H	0.7424	0.480	0.567	4640	102/6	4390	16.58	7.18	11260	15167	26186	19858
1/2	5/8	L2	2.375C	0.6764	0.410	0.517	4572	102/6	4390	16.58	7.18	10426	15414	25429	20166
9/16	5/8	L2	2.565H	0.7424	0.480	0.567	4640	60/4	4393	28.17	12.20	11268	15177	26204	19873
9/16	5/8	L2	2.375C	0.6764	0.410	0.517	4572	60/4	4393	28.17	12.20	10433	15424	25446	20180
9/16	5/8	L2	2.565H	0.7424	0.480	0.567	4640	78/5	4537	22.39	9.70	11637	15675	27062	20523
9/16	5/8	L2	2.375C	0.6764	0.410	0.517	4572	78/5	4537	22.39	9.70	10775	15930	26280	20841
11/16	5/8	L3	3.00H	1.114	0.709	0.773	5414	48/2	4982	39.94	17.30	14946	18416	21080	19355
11/16	5/8	L3	3.00C	1.016	0.677	0.784	5411	48/2	4982	39.94	17.30	14946	14711	22077	19064
11/16	5/8	L3	3.00H	1.114	0.709	0.773	5414	120/6	5165	16.57	7.18	15495	13909	21854	20045
11/16	5/8	L3	3.00C	1.016	0.677	0.784	5411	120/6	5165	16.57	7.18	15495	15251	22888	19764
11/16	5/8	L3	3.00H	1.114	0.709	0.773	5414	60/3	5298	33.93	14.70	15894	14267	22417	20561
11/16	5/8	L3	3.00C	1.016	0.677	0.784	5411	60/3	5298	33.93	14.70	15894	15644	23477	20273
5/8	3/4	L3	3.375	1.555	0.914	0.9375	5833	48/1	5703	45.68	19.78	19248	12378	21059	20581
5/8	3/4	L3	3.375	1.555	0.914	0.9375	5833	78/4	5710	28.17	12.20	19271	12392	21084	20555
11/16	3/4	L3	3.59	1.555	0.990	1.103	6452	102/5	5921	22.36	9.68	21256	13669	21471	19271
11/16	3/4	L3	3.59	1.555	0.990	1.103	6452	144/6	6190	16.55	7.17	22222	14291	22446	20146
11/16	3/4	L3	3.59	1.555	0.990	1.103	6452	60/2	6199	39.76	17.22	22254	14311	22478	20175
13/16	3/4	L3	3.59	1.555	1.066	1.188	6945	78/3	6877	33.88	14.68	24688	15876	23159	20881
13/16	3/4	L4	3.8125	2.074	1.422	1.285	7078	120/5	6960	22.35	9.67	26535	12794	18660	20649
11/16	3/4	L3	3.4	1.555	1.142	1.183	7310	60/1	7096	45.47	19.69	24126	15515	21126	20393
11/16	3/4	L4	4.00	2.074	1.523	1.465	7690	102/4	7456	28.12	12.18	29824	14379	19582	20857
11/16	3/4	B3	7.1562	4.67	—	—	8368	78/2	8050	39.69	17.20	57607	12336	33605	20157
11/16	3/4	B3	7.1562	4.67	—	—	8368	144/5	8344	22.31	9.66	59711	12786	34839	20898
11/16	3/4	B4	14.3125	9.35	—	—	8884	120/4	8764	28.11	12.17	125435	12735	34665	20794
1/2	7/8	B4	16.5	13.12	—	—	9446	102/3	8970	33.79	14.64	148005	11280	33237	19942
1/2	7/8	B4	16.5	13.12	—	—	9446	78/1	9205	45.37	19.65	151883	11576	34108	20465
9/16	7/8	B4	16.5	13.12	—	—	10626	102/2	10490	39.57	17.14	173085	13192	34553	20731
9/16	7/8	B4	16.5	13.12	—	—	10626	144/4	10492	28.03	12.14	173118	13195	34553	20731
9/16	7/8	B4	16.5	13.12	—	—	10626	120/3	10528	33.78	14.61	173712	13240	34679	20806
5/8	7/8	B5	16.625	13.81	—	—	12336	102/1	12000	45.22	19.59	199500	14446	34048	20428
5/8	7/8	B5	16.625	13.81	—	—	12336	120/2	12326	39.56	17.12	204920	14839	34973	20983
11/16	1	B4	18.42	16.845	—	—	13189	144/3	12609	33.66	14.58	232258	13788	33467	20080
3/4	1	B4	18.42	16.845	—	—	14387	120/1	14095	45.18	19.56	259630	15418	34295	20578
13/16	1 1/8	B4	20.75	21.043	—	—	15649	144/2	14748	39.41	17.07	306021	14548	34721	20616
*7/8	1 1/4	B5	22.00	23.26	—	—	16914	144/1	16846	44.98	19.48	370612	15933	33969	20554

†This table shows the actual stresses in every joint used in API tanks as designed, computed in accordance with the preceding method.

‡Applies to tanks 86 to 144 ft. in diameter, having 8 or less 72" courses.

*13 Rivets—21 Single Shears.

NOTES TO TABLE 12:

Col. 3: The letter "L" indicates "Lap" joint; the letter "B" indicates "Butt" joint; numerals indicate number of rows of rivets.

Col. 4: Pitch of rivets on row having the greatest pitch; "H" indicates hot driven rivets; "C" indicates cold driven rivets.

Cols. 5 and 6: Rivet areas computed after driving, according to Section II.

Col. 7: Net area of plate in tension, after deducting for rivet holes, according to Paragraph 10.

Col. 9: Ring number based on an 8-ring tank, counting from the bottom.

Col. 11: Depth taken at 12 inches above bottom gage line of given course.

Col. 12: Depth times 62.37, divided by 144.

Col. 13: Col. 10 times "P".

Cols. 14, 15 and 16: Stress produced by actual loads, Col. 13, acting on the areas given in Cols. 5, 6 and 7.

TABLE 11
STRENGTH OF BUTT JOINTS†
72" Plates, 8 Courses or Less*
(Dimensions in Inches)

1	2	3	4	5	6	7	8	9	10	11	12
Thickness of Plate	Dia. of Rivet (Nominal)	Maximum Allowable Load (L) Lbs. per Lineal Inch of Joint	Type of Joint	Rivet Pitch "P"	Strap Thickness		Distance Between Rivet Rows See Fig. 6				
					Inside	Outside	"A"	"B"	"C"	"D"	"E"
7/16" (17.85#)	3/4	6977	B 2	4.458	11/32	7/32	1 1/8	2 7/16	—	—	—
	3/4	7814	B 3	7.165	5/16	11/32	1 1/8	1 11/16	2 7/16	—	—
	3/4	8248	B 4	14.33	5/16	11/32	1 1/4	1 11/16	2 7/16	2 1/16	—
15/32" (19.13#)	3/4	8370	B 3	7.167	5/16	11/32	1 1/8	1 11/16	2 7/16	—	—
	3/4	8885	B 4	14.335	11/32	11/32	1 1/8	1 11/16	2 7/16	2 1/16	—
1/2" (20.40#)	3/4	8928	B 3	7.17	5/16	11/32	1 1/8	1 11/16	2 7/16	—	—
	3/4	9424	B 4	14.33	11/32	11/32	1 1/4	1 11/16	2 7/16	2 1/16	—
	7/8	8949	B 3	8.25	5/16	11/32	1 5/16	2	2 3/4	—	—
	7/8	9446	B 4	16.5	11/32	11/32	1 5/16	2	2 3/4	2 7/16	—
	7/8	9871	B 5	16.62	3/8	11/32	1 5/16	2	2 3/4	2 7/16	3 1/4
17/32" (21.68#)	7/8	9507	B 3	8.25	11/32	11/32	1 5/16	2	2 3/4	—	—
	7/8	10035	B 4	16.5	3/8	11/32	1 5/16	2	2 3/4	2 7/16	—
	7/8	10487	B 5	16.62	11/32	11/32	1 5/16	2	2 3/4	2 7/16	3 1/4
9/16" (22.95#)	7/8	10066	B 3	8.25	3/8	11/32	1 5/16	2	2 3/4	—	—
	7/8	10626	B 4	16.5	11/32	11/32	1 5/16	2	2 3/4	2 7/16	—
	7/8	11105	B 5	16.62	7/16	11/32	1 5/16	2	2 3/4	2 7/16	3 1/4
19/32" (24.23#)	7/8	10627	B 3	8.25	3/8	11/32	1 5/16	2	2 3/4	—	—
	7/8	11217	B 4	16.5	7/16	11/32	1 5/16	2	2 3/4	2 7/16	—
	7/8	11722	B 5	16.62	11/32	11/32	1 5/16	2	2 3/4	2 7/16	3 1/4
5/8" (25.50#)	7/8	11186	B 3	8.25	11/32	11/32	1 5/16	2	2 3/4	—	—
	7/8	11807	B 4	16.5	7/16	11/32	1 5/16	2	2 3/4	2 7/16	—
	7/8	12336	B 5	16.625	11/32	11/32	1 5/16	2	2 3/4	2 7/16	3 1/4
	1	11206	B 3	9.334	11/32	11/32	1 1/2	2 1/4	3 1/4	—	—
	1	11822	B 4	18.667	7/16	11/32	1 1/2	2 1/4	3 1/4	2 3/4	—
	1	12343	B 5	18.83	11/32	11/32	1 1/2	2 7/16	3 1/4	2 3/4	3 11/16
21/32" (26.78#)	7/8	11927	B 3	8.125	7/16	11/32	1 5/16	2	2 3/4	—	—
	7/8	12589	B 4	16.25	11/32	11/32	1 5/16	2	2 3/4	2 7/16	—
	7/8	13004	B 5	16.56	1/2	11/32	1 5/16	2 7/16	2 3/4	2 7/16	3 1/4
	1	11926	B 3	9.21	7/16	11/32	1 1/2	2 1/4	3 1/4	—	—
	1	12589	B 4	18.42	11/32	11/32	1 1/2	2 1/4	3 1/4	2 3/4	—
	1	13002	B 5	18.77	1/2	11/32	1 1/2	2 7/16	3 1/4	2 3/4	3 11/16
11/16" (28.05#)	1	12495	B 3	9.21	7/16	11/32	1 1/2	2 1/4	3 1/4	—	—
	1	13189	B 4	18.42	1/2	11/32	1 1/2	2 1/4	3 1/4	2 3/4	—
	1	13622	B 5	18.77	11/32	11/32	1 1/2	2 7/16	3 1/4	2 3/4	3 11/16
23/32" (29.33#)	1	13062	B 3	9.21	11/32	11/32	1 1/2	2 1/4	3 1/4	—	—
	1	13787	B 4	18.42	11/32	11/32	1 1/2	2 1/4	3 1/4	2 3/4	—
	1	14240	B 5	18.77	7/16	11/32	1 1/2	2 7/16	3 1/4	2 3/4	3 11/16
3/4" (30.60#)	1	13630	B 3	9.21	1/2	11/32	1 1/2	2 1/4	3 1/4	—	—
	1	14387	B 4	18.42	11/32	11/32	1 1/2	2 1/4	3 1/4	2 3/4	—
	1	14860	B 5	18.77	7/16	11/32	1 1/2	2 7/16	3 1/4	2 3/4	3 11/16
25/32" (31.88#)	1	14119	B 3	9.04	1/2	11/32	1 1/2	2 1/4	3 1/4	—	—
	1	14904	B 4	18.08	7/16	11/32	1 1/2	2 1/4	3 1/4	2 3/4	—
	1	15462	B 5	18.35	11/32	11/32	1 1/2	2 7/16	3 1/4	2 3/4	3 11/16
	1 1/8	14198	B 3	10.29	1/2	11/32	1 11/16	2 1/2	3 7/16	—	—
	1 1/8	14987	B 4	20.58	7/16	11/32	1 11/16	2 1/2	3 7/16	3 1/16	—
	1 1/8	15478	B 5	20.98	11/32	11/32	1 11/16	2 7/16	3 7/16	3 1/16	4 1/16
13/16" (33.15#)	1 1/8	14766	B 3	10.29	11/32	11/32	1 11/16	2 1/2	3 7/16	—	—
	1 1/8	15587	B 4	20.58	11/32	11/32	1 11/16	2 1/2	3 7/16	3 1/16	—
	1 1/8	16098	B 5	20.98	5/16	11/32	1 11/16	2 7/16	3 7/16	3 1/16	4 1/16
27/32" (34.43#)	1 1/8	15834	B 3	10.29	7/16	11/32	1 11/16	2 1/2	3 7/16	—	—
	1 1/8	16185	B 4	20.58	11/32	11/32	1 11/16	2 1/2	3 7/16	3 1/16	—
	1 1/8	16715	B 5	20.98	5/16	11/32	1 11/16	2 7/16	3 7/16	3 1/16	4 1/16
7/8" (35.70#)	1 1/8	15802	B 3	10.09	7/16	11/32	1 11/16	2 1/2	3 7/16	—	—
	1 1/8	16685	B 4	20.18	5/16	11/32	1 11/16	2 1/2	3 7/16	3	—
	1 1/8	17313	B 5	20.47	11/32	11/32	1 11/16	2 7/16	3 7/16	3 1/16	4 1/16

†This table shows the maximum strength obtainable from butt joints in plates of the thicknesses shown, using various sizes and numbers of rows of rivets, without exceeding the stresses allowable under the API Specification.

*Applies to tanks 86 to 144 feet in diameter, having 8 or less 72" courses.

Col. 1: Values in parentheses are weights of plates, lbs. per sq. ft.

Col. 3: These figures show the maximum load the joints will carry without exceeding the allowable working stresses given in Section II.

Col. 4: The letter "B" indicates "Butt" joint; the numeral indicates number of rivet rows.

Col. 5: Pitch of rivets on row having the greatest pitch.

Cols. 8 to 12 incl.: These dimensions correspond to those shown on drawings. In a few cases these have for practical considerations been made a few hundredths of an inch less than minima computed by formula in Paragraph A-5.

TABLE 14
ANALYSIS OF VERTICAL SHELL JOINTS IN THE LIMITING COURSES OF API STANDARD 12', 18', 24' AND 30' DIA. TANKS†
72" Plates, 8 Courses or Less
(Dimensions as given are in inches except where otherwise noted)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
				Rivet Areas, Square Inches, In Length of Joint "P"									Actual Unit Stresses in Joint as Designed lbs. per sq. in.		
													On Rivets		
Thickness of Plate	Dia. of Rivet	Type of Joint	Rivet Pitch "p"	Shear	Bearing	Net Section of Plate, sq. ins., in Length of Joint "p"	Maximum Allowable Load per Lineal Inch of Joint	Tank Dia. and Ring No.	Actual Load on Shell per Lineal Inch of Joint	Depth in Feet to Design Point	Pressure, lbs. per sq. in.	Actual Load on Shell in Length of Joint "p"	Shear	Bearing	Tension in Shell
3/16	7/8	L-1	1.5H	0.1964	0.094	0.176	2005	12/1	1071	34.34	14.87	1607	8182	17096	9181
3/16	7/8	L-1	1.5C	0.1726	0.088	0.182	1840	12/1	1071	34.34	14.87	1607	9311	18261	8830
1/4	5/8	L-1	2.05H	0.3712	0.172	0.325	2685	18/1	1601	34.21	14.82	3282	8842	19081	10098
1/4	5/8	L-1	2.05C	0.3382	0.164	0.333	2560	18/1	1601	34.21	14.82	3282	9704	20012	9856
3/16	7/8	L-1	1.5H	0.1964	0.094	0.176	2005	30/3	1762	22.61	9.79	2643	13457	28117	15017
3/16	7/8	L-1	1.5C	0.1726	0.088	0.182	1841	30/3	1762	22.61	9.79	2643	15313	30084	14522
1/4	5/8	L-1	2.05H	0.3712	0.172	0.325	2685	24/1	2134	34.21	14.82	4375	11786	25436	13462
1/4	5/8	L-1	2.05C	0.3382	0.164	0.333	2560	24/1	2134	34.21	14.82	4375	12936	26677	13138
1/4	5/8	L-1	2.05H	0.3712	0.172	0.325	2685	30/2	2216	28.43	12.31	4543	12239	26413	13978
1/4	5/8	L-1	2.05C	0.3382	0.164	0.333	2560	30/2	2216	28.43	12.31	4543	13433	27701	13643
1/4	5/8	L-2	2.375H	0.7424	0.344	0.406	3590	30/1	2668	34.21	14.82	6337	8536	18422	15608
1/4	5/8	L-2	2.375C	0.6764	0.328	0.414	3660	30/1	2668	34.21	14.82	6337	9369	19320	15307

†This table shows the actual stresses in the vertical shell joints of the particular courses which govern the design of API small tanks.

Col. No. 3—The letter "L" indicates "Lap" joint; numerals indicate number of rows of rivets.

Col. No. 4—"H" indicates hot driven rivets; "C" indicates cold driven rivets.

Col. Nos. 5 and 6—Rivet areas computed after driving in accordance with Section 2, Par. 10. Diameter of rivet in bearing after driving assumed the same as for shear.

Col. No. 7—Net area of plate in tension, after deducting for rivet holes in accordance with Section 2, Par. 10, based on punched holes.

Col. No. 8—Figures show the maximum load in pounds that the joints will carry without exceeding the allowable working stresses given in Section 2, Par. 13.

Col. No. 9—Ring number based on a 6-ring tank, counting from the bottom.

Col. No. 10—Col. 12 times radius of tank in inches.

Col. No. 11—Depth computed in accordance with Section 2, Par. 9 and 23.

Col. No. 12—Col. 11 times 62.37, divided by 144.

Col. No. 13—Col. 10 times rivet pitch "P."

Col. Nos. 14, 15 and 16—Stresses produced by actual loads, Col. 13, acting on the areas given in Cols. 5, 6 and 7.

TABLE 15
STRENGTH OF LAP JOINTS†
72" Plates, 8 Courses or Less
(Dimensions in Inches)

1 Thickness of Plate	2 Dia. of Rivet	3 Maximum Allowable Load (L) Lbs. per Lineal Inch	4 Type of Joint	5 Rivet Pitch "p"	6 Back Pitch	7 Edge Distance	8 Remarks
7/16 (7.65#)	7/8	2000	L 1 C	1.5	—	5/8"	
1/4 (10.2#)	5/8	2688	L 1 H	2.05	—	1 1/16"	Min. P.
	5/8	2561	L 1 C	2.05	—	1 1/16"	Min. P.
	5/8	3592	L 2 H	2.375	1 1/2	1 1/16"	Max. P.
	5/8	3661	L 2 C	2.375	1 1/2	1 1/16"	Max. P.
29/64 (11.47#)	5/8	4196	L 2 H	2.593	1 1/2	1 1/16"	Max. P.
	5/8	4172	L 2 C	2.593	1 1/2	1 1/16"	Max. P.
1/2 (12.75#)	5/8	4640	L 2 H	2.565	1 1/2	1 1/16"	
	5/8	4556	L 2 C	2.375	1 1/2	1 1/16"	
	5/8	4572	L 2 C	2.867	1 1/2	1 1/16"	
	5/8	4812	L 3 H	2.81	1 1/2	1 1/16"	Max. P.
	5/8	4890	L 3 C	2.81	1 1/2	1 1/16"	Max. P.
11/32 (14.03#)	5/8	4949	L 2 H	2.4	1 1/2	1 1/16"	
	5/8	5168	L 2 C	2.093	1 1/2	1 1/16"	
	5/8	5414	L 3 H	3.00	1 1/2	1 1/16"	
	5/8	5411	L 3 C	3.00	1 1/2	1 1/16"	
	3/4	5220	L 2	3.16	1 3/4	1 1/4"	Max. P.
9/32 (15.3#)	3/4	5568	L 2	2.98	1 3/4	1 1/4"	
	3/4	5883	L 3	3.375	1 3/4	1 1/4"	Max. P.
17/32 (16.58#)	3/4	5868	L 2	2.83	1 3/4	1 1/4"	
	3/4	6452	L 3	3.59	1 3/4	1 1/4"	Max. P.
9/16 (17.85#)	3/4	6191	L 2	2.68	1 3/4	1 1/4"	
	3/4	6945	L 3	3.58	1 3/4	1 1/4"	
	3/4	7078	L 4	3.81	1 3/4	1 1/4"	Max. P.
19/32 (19.13#)	3/4	6481	L 2	2.56	1 3/4	1 1/4"	
	3/4	7310	L 3	3.4	1 3/4	1 1/4"	
	3/4	7706	L 4	4.08	1 3/4	1 1/4"	Max. P.
1/2 (20.4#)	3/4	6745	L 2	2.46	1 3/4	1 1/4"	
	3/4	7658	L 3	3.25	1 3/4	1 1/4"	
	3/4	8214	L 4	4.04	1 3/4	1 1/4"	
	7/8	7126	L 2	3.1	2	1 1/4"	
	7/8	7963	L 3	4.16	2	1 1/4"	
	7/8	8100	L 4	4.875	2	1 1/4"	Max. P.

†This table shows the maximum strength obtainable from lap joints in plates of the thicknesses shown, using various sizes and numbers of rows of rivets, without exceeding the stresses allowable under API Specification.

Col. 3: These figures show the maximum load the joints will carry without exceeding the allowable working stresses given in Section II.

Col. 4: The letter "L" indicates "Lap" joint; "C" indicates cold driven rivets; "H" indicates hot driven rivets.

Col. 5: Pitch of rivets on row having the greatest pitch.

TABLE 16

ALLOWABLE UNIT PLATE LOADS [1]

100" Plates, and 72" Plates for 9th and 10th Courses or 168' Diameter

1	2	3	4	5	6
Joint	Nominal Rivet Diameter	Plate Thickness t	Efficiency	Unit Load	Pitch
B-3	3/4"	3/8"	.86538	6815	7.0417
B-4	3/4"	3/8"	.91346	7193	14.0833
B-3	3/4"	13/32"	.86538	7388	7.0417
B-4	3/4"	13/32"	.91346	7793	14.0833
B-3	3/4"	7/16"	.86538	7951	7.0417
B-4	3/4"	7/16"	.91346	8398	14.0833
B-3	3/4"	15/32"	.86538	8519	7.0417
B-4	3/4"	15/32"	.91346	8992	14.0833
B-3	3/4"	1/2"	.86538	9087	7.0417
B-4	3/4"	1/2"	.91346	9591	14.0833
B-3	7/8"	17/32"	.86538	9654	8.1250
B-5$_{21}$	7/8"	1/2"	.93750	9844	17.5000
B-5$_{20}$	7/8"	1/2"	.94340	9906	16.5625
B-4	7/8"	17/32"	.91346	10191	16.2500
B-3	7/8"	9/16"	.86538	10223	8.1250
B-5$_{21}$	7/8"	17/32"	.93750	10459	17.5000
B-5$_{20}$	7/8"	17/32"	.94340	10525	16.5625
B-3	7/8"	18/32"	.86538	10790	8.1250
B-4	7/8"	9/16"	.91346	10791	16.2500
B-5$_{21}$	7/8"	9/16"	.93750	11075	17.5000
B-5$_{20}$	7/8"	9/16"	.94340	11144	16.5625
B-3	7/8"	5/8"	.86538	11358	8.1250
B-4	7/8"	19/32"	.91346	11390	16.2500
B-5$_{21}$	7/8"	19/32"	.93750	11690	17.5000
B-5$_{20}$	7/8"	19/32"	.94340	11763	16.5625
B-4	7/8"	5/8"	.91346	11989	16.2500
B-5$_{21}$	7/8"	5/8"	.93750	12307	17.5000
B-5$_{20}$	7/8"	5/8"	.94340	12382	16.5625
B-4	7/8"	21/32"	.91346	12588	16.2500
B-5$_{21}$	7/8"	21/32"	.93750	12920	17.5000
B-5$_{20}$	7/8"	21/32"	.94340	13001	16.5625
B-4	1"	11/16"	.91346	13188	18.4167
B-5$_{21}$	1"	11/16"	.93750	13536	19.8333
B-5$_{20}$	1"	11/16"	.94340	13620	18.7708
B-4	1"	23/32"	.91346	13788	18.4167
B-5$_{21}$	1"	23/32"	.93750	14151	19.8333
B-5$_{20}$	1"	23/32"	.94340	14239	18.7708
B-4	1"	3/4"	.91346	14387	18.4167
B-5$_{21}$	1"	3/4"	.93750	14766	19.8333
B-5$_{20}$	1"	3/4"	.94340	14859	18.7708
B-6	1 1/8"	3/4"	.94828	14935	22.9583
B-4	1 1/8"	25/32"	.91346	14986	20.5833
B-5$_{21}$	1 1/8"	25/32"	.93750	15381	22.1667
B-5$_{20}$	1 1/8"	25/32"	.94340	15478	20.9792
B-6	1 1/8"	25/32"	.94828	15557	22.9583
B-4	1 1/8"	13/16"	.91346	15586	20.5833
B-5$_{21}$	1 1/8"	13/16"	.93750	15997	22.1667
B-5$_{20}$	1 1/8"	13/16"	.94340	16097	20.9792
B-6	1 1/8"	13/16"	.94828	16180	22.9583
B-4	1 1/8"	27/32"	.91346	16186	20.5833
B-5$_{21}$	1 1/8"	27/32"	.93750	16612	22.1667
B-5$_{20}$	1 1/8"	27/32"	.94340	16716	20.9792
B-6	1 1/8"	27/32"	.94828	16802	22.9583
B-6	1 1/4"	7/8"	.94828	17425	25.3750
B-6	1 1/4"	28/32"	.94828	18047	25.3750
B-6	1 1/4"	15/16"	.94828	18670	25.3750
B-6	1 1/4"	31/32"	.94691	19264	24.7217
B-6	1 1/4"	1"	.94529	19851	23.9902
B-6	1 1/4"	1 1/32"	.94368	20436	23.3030
B-6	1 1/4"	1 1/16"	.94207	21020	22.6562
B-6	1 1/4"	1 3/32"	.94047	21602	22.0464
B-6	1 1/4"	1 1/8"	.93887	22181	21.4705
B-6	1 1/4"	1 5/32"	.93728	22758	20.9256
B-6	1 1/4"	1 3/16"	.93569	23334	20.4095
B-6	1 1/4"	1 7/32"	.93411	23908	19.9198
B-6	1 1/4"	1 1/4"	.93254	24479	19.4547
B-6	1 1/4"	1 9/32"	.93096	25049	19.0122
B-6	1 1/4"	1 5/16"	.92940	25617	18.5907
B-6	1 1/4"	1 11/32"	.92784	26183	18.1889
B-6	1 1/4"	1 3/8"	.92629	26747	17.8054
B-6	1 1/4"	1 13/32"	.92474	27309	17.4389
B-6	1 1/4"	1 7/16"	.92319	27869	17.0883
B-6	1 1/4"	1 15/32"	.92165	28428	16.7526
B-6	1 1/4"	1 1/2"	.92012	28984	16.4310

[1]This table shows the maximum strength obtainable from butt joints in plates of the thicknesses shown, for drilled holes and the rivet pitches adopted for this group of tanks, without exceeding the stresses allowable under the API specification. Allowable unit plate load= efficiency times 21,000 t.

APPENDIX B

INQUIRY OR ORDER FORM

For Standard API Tanks With Riveted Shells

1. Tank(s) Required:
.....Tank(s).....ft. Diameter,.....rings high,
(.....bbl. capacity)
(42 gal.)
(furnished and erected complete ready to receive oil)
(knocked down f. o. b. cars at.....)
(erected only at.....)
(Strike out lines not applicable)
according to the American Petroleum Institute's "Standard No. 12-A: SPECIFICATION FOR STANDARD TANKS W I T H RIVETED SHELLS", and the attached detailed drawings, Nos.....issue of .....erection specifications, and the schedule of details, exceptions and appurtenances herein.

2. **Place of Erection:**
Tank(s) are to be erected on the premises of the .....
located .....
.....

3. **Time of Completion:**
Sufficient men and equipment shall be provided to complete the tank(s) in accordance with the following schedule:
.....
.....
.....

4. **Freight and Hauling:**
The manufacturer shall deliver all material, tools, and equipment f. o. b. cars at.....station on.....Railroad, and shall pay freight on return of said tools, equipment and excess material from said station.
.....shall unload said materials,
(Manufacturer or Purchaser)
tools and equipment, haul to erection site and unload within.....ft. of tank grade; and shall, on completion of work, replace tools, equipment and excess material aboard cars. Erection point.....miles over.....surfaced road from above Railroad station.
(Data need be furnished only if manufacturer does hauling.)
If hauling is done by the purchaser, the manufacturer shall advise purchaser in writing at least one week in advance of date of arrival of first material at Railroad Station, and rates in tons per day at which material must be hauled.

5. **Field Facilities:**
(a) Electric Power supply will.....be available
(not)
at.....,
(Location with respect to erection site)
.....phase, ...volts, ...cycles; tank manufacturer to arrange for service and pay for all power used.

(b) Industrial water supply will be available from ..... at
(Description of Source)
.....
(Location with respect to tank site)
Water used in construction and testing shall be paid for by....., and
(Manufacturer or Purchaser)
disposed of by.....
(Manufacturer or Purchaser)

(c) Compressed Air can.....be supplied by purchaser at.....*(not)*, at.....lb.
(Location)
pressure,.....cu. ft./min. max. delivery, at .....¢/cu. ft.

(d) Camp:
Site shall be provided by.....
(Manufacturer or Purchaser)
Camp Buildings and equipment shall be provided by.....
(Manufacturer or Purchaser)

(e) Sanitary facilities, including closets, plumbing, sewers, etc., shall be provided by.....
(Manufacturer or Purchaser)

(f) Drinking water shall be provided by.....
(Manufacturer or Purchaser)

(NOTE: *If any of the above are to be provided by manufacturer give pertinent data for estimating costs.)*
.....
.....
.....

6. **Tank Grade:**
shall be built by.....
(Manufacturer or Purchaser)
(If by manufacturer specify details of grades required, accompanied by drawings if necessary.)
.....
.....
(If by purchaser, manufacturer shall advise purchaser in writing as to when he will require each grade.)
If the tank is to be built inside of a wall which is already completed and obstructs free access to the grade, the purchaser shall furnish the manufacturer complete details from which the manufacturer can compute the additional costs of doing work in such a location.

7. **Details of Construction:**
Instructions regarding options in specifications and drawings.

(a) Number of shell plates per course shall be.....
(d/6 max. is Std.)

(b) Width of shell plates.....
(72" or 100")

(c) Roof Plate width shall be.....
(72" or 100")

(d) Roof slope shall be.....
(.....inch in 12 inches)

(e) Roof Plates shall be.....
(Riveted or welded)

(f) Roof columns shall be.....
(Channel or other shapes)

(g) Rafter ties shall be.....
(Used or not used)

(h) Top Angle shall be*.....
(In or out)

(i) Bottom plate width shall be.....
(72" or 108")

(j) Bottom Plates shall be*.....
(Riveted or welded)

(k) Bottom Angle shall be*.....
(In or out)

(l) Joints in top and bottom angle shall be.....
.....
(Riveted or welded)
⅝-inch rivets in shell shall be driven.....
.....
(Hot, cold or optional)

(m) Opening between plates in butt joints shall be stopped by.....
(Means of a wedge—or by welding)

(n) Inside butt straps shall be.....
(Caulked or not caulked)

(o) Painting of under side of bottom shall be done by .....
(Manufacturer or Purchaser)
Paint to be provided by.....
(Manufacturer or Purchaser)
(If by manufacturer specify kind of paint and method of application.)
.....
.....
.....
.....

(p) Painting of shell and roof shall be done by .....
(Manufacturer or Purchaser)
Paint to be provided by.....
(Manufacturer or Purchaser)
(If by manufacturer specify kind of paint, method of cleaning surface, and method of application.)
.....
.....
.....

8. **Materials to be Furnished With Knockdown Tanks:**

Erection bolts and washers shall be furnished by.....
(Manufacturer or Purchaser)
The manufacturer shall furnish.....% excess rivets to allow for wastage.
(Usually 5% for cold rivets, 10% for hot rivets and 15% for special rivets of which only a few are required.)
.....
.....
.....

9. **Exceptions:**

(Specify here any details desired which do not conform to API Specifications and Drawings, such as open tank with wind girder for floating roof; special roof such as water seal, breather, umbrella or floating; cold riveting of bottom on account of fire hazards in congested location; etc. Attach special drawings when necessary.)

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

10. **Appurtenances:**

(See Fig. 7 and Table 17.)

11. **General:**

Manufacturer shall furnish all necessary materials, tools, equipment, power, labor, etc., for the erection and testing of the above tanks, except as above provided.

12. **Fire Protection:**

The manufacturer shall communicate with the superintendent in charge of the property on which the tanks are to be built and shall conform to all the regulations in force thereon that are intended to prevent the spread of fire.

13. **Special Provisions:**

Insert here special provisions relative to terms of payment and amount withheld; Employers' Liability, Compensation, and Insurance; Public Liability; Permits; Municipal Fees, and Deposits; Conditions of Acceptance; and Extra Work.

Signed .....
(Purchaser)

By .....
(Purchaser's Agent)

Date.....

ACCEPTED:

Signed .....
(Manufacturer)

By .....
(Manufacturer's Agent)

Date .....

*Top or bottom angle outside, or welded bottom, will require different sketch plates from those shown in the standard drawings.

TABLE 17

APPURTENANCES to go on (each of) these tanks are as follows: See Fig. 7.

	ITEM	REQUIRED No.	REQUIRED Size	REQUIRED Location †	Furnish By*	Install By*	Type or Drwg. No.	REMARKS	Notes on Ordering
Oil Connections	Shell Connection(s) for Oil Inlet and Outlet Lines								(Specify size of oil connections required and height above bottom. A. P. I. Dwg. A-3.)
	Swing Pipe(s)								(Indicate type of swing joint, end fitting, cable attachment, bottom bumper; counter balance or pontoons, etc.)
	Cable Sheave(s)								(Indicate size of cable, whether gas-tight stuffing box desired, etc.)
	Winch(es)								(Indicate type and lifting capacity.)
	Internal Flap Valve(s)								(Sometimes used as emergency shut-off when swing pipe not installed.)
Water Draw System	Water Draw-Off Connection(s)								(Specify size required. A. P. I. Dwg. A-6.)
	Catch Basin(s)								(If desired show sketch of size, sewer connection [if wanted], etc.)
	Safety Shut Off(s)								(Indicate if plug or other emergency internal closure for water-draw desired.)
	Clean-out Opening(s)								(Where heavy B. S accumulation is expected, cleanout opening[s] larger than water-draw is sometimes required.)
Misc.	Shell Manhole(s)								(Specify size required. A. P. I. Dwg. A-1 or A-2.)
	Heating Coil Connection(s)								(Indicate size and location of steam and drain line connections to shell or bottom.)
Roof Openings	Manhole(s)								(Indicate size and type required. A. P. I. Dwg. A-5.)
	Lighting Hatch(es)								(Sometimes desired to admit light for cleaning and repairs; indicate size, type, etc., wanted if any.)
	Vent Outlet Nipple(s)								(Indicate type desired. A. P. I. Dwg. A-4.)
	Vent Protection								(Indicate whether hood, breather valve, flame arrester, etc., wanted.)
	Gauge & Thief Hatch(es)								(Indicate type of cover wanted, etc.)
	Housing for Gauge Hatches								(Sometimes installed where weather conditions require.)
	Gauging Equipment								(Show type required.)
	Foam Boxes								(Show size and type required.)
	Steam Smothering Connections								(Indicate whether nozzle into vapor space or jet protection at vent opening desired.)
	Staging Clip								(Sometimes installed for securing painters' staging.)
Stairs, Etc.	Stair(s) or Ladder(s)								(Indicate type of stair required. A. P. I. Dwg. A-7 or A-8.)
	Walk(s)								(Show location and construction wanted.)
	Railing(s)								(Show location and construction wanted.)
	Miscellaneous								

†Use attached Chart (Fig. 7) for indicating location of appurtenances.
*Use S to denote Manufacturer. Use P to denote Purchaser.

LOCATION OF APPURTENANCES

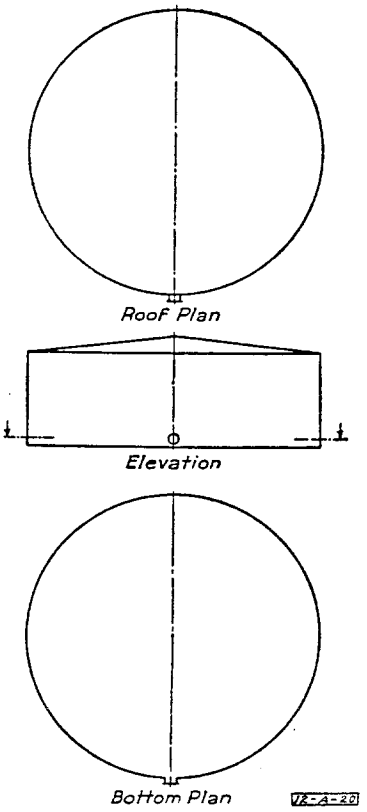

FIG. 7

For guidance of manufacturer indicate desired position of shell manhole with respect to compass direction or with respect to other structures.

APPENDIX C
PERMISSIBLE VARIATIONS

The following permissible variations have been authorized to accommodate special equipment and machinery already installed and in use by certain manufacturers at the time this specification was adopted and to permit without sacrifice of safety alternate details of construction preferred by certain users as meeting their established standard practices. These variations may be used by any licensee provided that he notify in advance all purchasers of his tanks that he is using such variations and provided further that he shall prefix an "X" to the number of his monogram authorization which he stamps on the name plate of the tank in which variation has been used.

C-1: Alternate Rivet Spacing:
Uniform spacing between top and bottom gauge lines of rivets in vertical lap joints, to accommodate special automatic punches, is permitted according to the Schedule in Table 18.

C-2. Pitch of Roundabout Seams:
Pitch of roundabout seams may vary by not more than 10 per cent to such spacing as will permit simultaneous multiple punching of both sides with the machinery now in use.

C-3. Location of Top Angle:
Top angle may be placed on outside of tank shell, as noted in Paragraph 17.

C-4. Rivet Pitch in Bottom and Roof Plates:
Pitch of rivets in seams of bottom and roof plates, excepting the circumferential pitch, may vary from that shown on the Construction Drawings (Note Appendix "E") to such spacing as will permit multiple punching with machinery now in use, provided that this spacing shall comply with Paragraph 21.

C-5. Welded Construction:
Tanks may be constructed with welded bottoms upon agreement between the purchaser and the manufacturer as provided in Par. 35.

C-6. Location of Bottom Angle.
Bottom angle may be placed on outside of tank shell, as noted in Paragraph 18.

C-7. Roof Pitch.
The slope of the roof for all except the 12-foot tank may be other than ¾ inch in 12 inches, as noted in Paragraph 28.

C-8. Roof Columns.
Roof columns may be other than channel shapes, as provided in Paragraph 28.

C-9. Shell Plate Lengths
Shell plates longer than 6 pi feet may be used as provided in Par. 14.

C-10. Shell Plate Widths
Shell plates 72 inches or 100 inches wide may be used as provided in Par. 14.

C-11. Roof Plate Widths
Roof plates 72 inches or 100 inches wide may be used as provided in Par. 29.

C-12. Bottom Plate Widths
Bottom plates 72 inches or 100 inches wide may be used as provided in Par. 32.

C-13. Ninth and Tenth Courses
Tanks with 9 and 10 courses may be used as provided in Par. 14 and 16.

TABLE 18
ALTERNATIVE RIVET SPACING†
Dimensions in Inches

COURSE		TANK DIAMETERS (FEET)						
		36	48	60	78	102	120	144
7	Hot Driven Rivets					2.325	2.325	2.581
	Cold Driven Rivets					2.325	2.325	2.403
6	Hot Driven Rivets			2.325	2.325	2.5811	3.0271	3.4688
	Cold Driven Rivets			2.325	2.325	2.403	3.0271	
5	Hot Driven Rivets		2.325	2.325	2.581	3.4688	3.6481	
	Cold Driven Rivets		2.325	2.325	2.403			
4	Hot Driven Rivets	2.325	2.325	2.581	3.3035	3.9297		
	Cold Driven Rivets	2.325	2.325	2.403				
	Hot Driven Rivets	2.3125**	2.3125**	2.5648**	3.2768**	4.0294**		
	Cold Driven Rivets	2.3125**		2.3879**				
3	Hot Driven Rivets	2.3125	2.5648	3.0054	3.6053			
	Cold Driven Rivets	2.3125	2.3878	3.0054				
2	Hot Driven Rivets	2.5972	2.9219	3.4968				
	Cold Driven Rivets	2.4181	2.9219					
	Hot Driven Rivets	2.581*	3.0271*	3.4688*				
	Cold Driven Rivets	2.403*						
1	Hot Driven Rivets	2.5648	3.2768	3.425				
	Cold Driven Rivets	2.3879						

*Applies only to bottom ring of 7-ring tank.
**Applies only to bottom ring of 5-ring tank.
†These values apply to tanks with 72" plates only, and not to 100" plates.

APPENDIX D

RECOMMENDED PRACTICE

(Adopted Nov., 1938)

Provision should be made to guard against loss of contents of the tank in event of fire, earthquake, settlement, or other mishap. Illustrative methods for guarding against such loss of contents are:

a. The use of internal valves which will automatically close in event of fire.

b. The use of steel-body valves next to tank nozzles and drain connections.

c. The provision of flexibility in piping connections to permit movement due to settlement or earthquake.

d. The location of a roof manhole over bottom drawoff connections where internal valves are not used.

e. The use of swing lines which may be raised above the maximum liquid level.

f. Tank runways which extend from one part of a tank to any part of an adjacent tank or to ground or other structure shall be so supported as to permit free relative movement of the structures joined by the runway.*

*NOTE: *This may be accomplished by firm attachment of the runway to one tank, but with a slip joint at the point of contact between the runway and the other tank; this is to permit either tank to settle or be disrupted by an explosion without endangering the other.*

APPENDIX E

CONSTRUCTION DRAWINGS

Construction Drawings (bound separately) can be supplied for tanks listed in Table 4 in two forms:

(a)* Blueprints (paper) (25½"x33"), price $25.00 per set (7 tanks).

(b)* Vandyke negatives (25½"x33"), price $100.00 per set (7 tanks).

Drawing Number	Subject
120-1	Erection Diagram: Shell Bottom and Supports.
120-2	Erection Diagram: Shell Plates and Supports.
120-3	Bottom Plate Details.
120-4	Shell Details.
120-5	Column Details.
120-6	Girder Rafter Details.
120-7	Roof Details.
120-8	Rivet List (Printed).

In addition to these tank designs, drawings are also available for the following appurtenances:

Dwg. No.	Item	Size Drawings	Price, Each: Blue Prints	Price, Each: Vandykes
A-1.	20" Shell Manhole	25½"x33"	$ .60	$2.25
A-2.	24" Shell Manhole	25½"x33"	.60	2.25
A-3.	Shell Nozzles	17 "x22"	.50	2.00
A-4.	Roof Nozzles	8½"x11"	.25	1.00
A-5.	Roof Manhole	8½"x11"	.25	1.00
A-6.	Water Drain Elbow	17 "x22"	.50	2.00
A-7.	Details and Arrangement of Circumferential Stairway	25½"x33"	.60	2.25
A-8.	Arrangement Outlines for Straight Stairways	25½"x33"	.60	2.25
	Per Set, Total		$3.90	$15.00

*The complete set of drawings for each tank diameter is numbered one to eight inclusive, prefaced by a number indicating the size of tank, thus 120-1, 120-2, etc., etc. However, Drawing No. 8 is in all cases the Rivet List and these lists have been set up in type. One rivet list for each size tank will accompany all detail drawings for that size tank, whether blueprints or vandykes. Additional copies of any Rivet List can be obtained at 15c each. The following shows the subject matter of typical drawings (120-ft. diameter):

All the above described prints can be obtained on application to the API Division of Production, Dallas, Texas.

REGISTRATION OF API TANK DRAWINGS IN CALIFORNIA

The laws of the State of California provide that drawings for structures to be built in the State must be signed by a registered engineer.

A set of these specifications and the drawings accompanying them were therefore filed in February, 1931, with the California Board of Registration for Civil Engineers, properly sealed by G. O. Wilson, then National Chairman of the API Committee on the Standardization of Steel Tanks for Oil Storage, who is a registered Civil Engineer under the California Engineers' Registration Act.

With this sealed set of specifications in their file, the California Board of Registration advises that these tank designs are automatically considered as having been approved and sealed by a California Registered Civil Engineer, and that individual sealing of drawings used for construction of tanks in California will not be required.

APPENDIX G
USE OF MONOGRAM

The foregoing specifications are for the use of all manufacturers desiring to use them.

Manufacturers desiring to warrant that articles manufactured or sold by them conform with these specifications may under certain conditions obtain the license to use the Official API monogram.

The following resolutions adopted by the Board of Directors of the American Petroleum Institute on Oct. 20, 1924, embody the purpose and the conditions under which such official monogram may be used.

WHEREAS, There has been a movement in the petroleum industry to simplify, standardize and improve oil country drilling equipment and methods; and

WHEREAS, The co-operation of the American Petroleum Institute was sought in order that there might be a national forum for the discussion, consideration and adoption or rejection of such proposed standards; and

WHEREAS, It appears desirable that the American Petroleum Institute adopt an official monogram to be used for identifying materials that comply with such standards or specifications (where such specifications or standards call for the use of such monogram) that may hereafter be adopted by the Board of Directors of the American Petroleum Institute; and

WHEREAS, It also appears desirable that the use of such monogram be encouraged wherever and whenever possible to inform the public that material so marked is manufactured in accordance with such specifications;

NOW THEREFORE, BE IT RESOLVED, That the following monogram is hereby adopted as the official monogram of the American Petroleum Institute; and be it further

RESOLVED, That the words "Official Publication" shall be incorporated with said monogram on all such standards and specifications that may hereafter be adopted and published by the American Petroleum Institute, as follows:

BE IT FURTHER RESOLVED, That the General Secretary or Assistant General Secretary be and they are hereby directed to authorize anyone desiring to do so to use such monogram under the following conditions:

Anyone desiring to use the monogram of the American Petroleum Institute shall apply to the American Petroleum Institute, New York City, using the form shown below, entitled: "Application to use official monogram of the American Petroleum Institute." Upon receipt of this application, properly acknowledged, and accompanied by a statement satisfactory to the Institute of the applicant's qualifications (when applicant is a manufacturer) to comply with the specification stated in the application, the Secretary shall issue a certificate of authority to use the said monogram in the form shown below entitled: "Certificate of Authority to use official monogram of the American Petroleum Institute."

BE IT FURTHER RESOLVED, That the Board of Directors of the American Petroleum Institute reserves the right to modify or change the said monogram and to revoke the right or license to use it on the part of any manufacturer for any reason satisfactory to the Board of Directors.

STATEMENT OF MANUFACTURER'S QUALIFICATIONS TO USE API MONOGRAM

The information requested below must accompany all applications to use the monogram of the American Petroleum Institute on material to be manufactured in accordance with its specifications and intended for sale. All such applicants are subject to investigation before licenses are granted. Applications may be rejected if information supplied does not warrant the issuing of the license.

(NOTE: If applicant has previously qualified as a licensee on material where serial number gages are required, and certificates are desired for numbering additional gages, this statement is not necessary. It is also not necessary when applications are required for serial numbers of gages by users or consumers who desire to purchase gages for their own use or to control material not intended for sale.)

Material Covered: _____
(Give title and number of API specification covering the material on which applicant desires to use monogram.)

1. Name: _____
(of applicant)
2. Location of principal office and factory: _____
(City, State, or Country)
3. Class of ownership: _____
(Corporation, partnership or individual)
4. Capital invested: _____
5. When organized: _____
(Year)
6. Is the applicant actually manufacturing this material now? _____
("Yes" or "No")
7. State the length of time applicant has made the material and supplied it to the oil industry: _____
(Years and Months)
8. Approximately what proportion is this material to the average yearly output of all material made by applicant? _____
9. Give the names and addresses of five representative users of this equipment in the oil industry to whom applicant has sold this material:

NAME	COMPANY	ADDRESS

10. If applicant has not supplied this or similar material to the oil industry, state here the industries or other uses for which such material has been supplied:
11. Is the applicant thoroughly familiar with all stipulations given in the API specification covering the material?
12. Does the applicant now possess the necessary equipment and personnel for conducting any tests required in the API specification covering this material? _____
13. Does the applicant now possess such Master gages as may be required by the API specification covering this material? _____
14. Have these gages been certified by an official testing agency? _____
15. If the applicant does not now possess such gages, has he ordered them or does he intend to do so? _____
(When application is accepted, licensee should advise the Institute from whom gages are ordered. The monogram shall not be applied to the product, when gages are stipulated, until the certified gages are in the licensee's possession.)
16. If the applicant is not now manufacturing the material, does he now expect to begin the manufacture of the material? _____
17. If the applicant's present organization has not previously made this material, he shall state here fully his experience, or the experience of the members of his staff, in the manufacture of this material, giving names of organizations previously making this material with which applicant or his staff members have been associated. (Use additional page, if necessary.)
18. Give names of five individuals (including names and addresses of organizations with which connected) who can be used as references regarding applicant's general character, integrity, and reputation. (These references must be responsible business men of the community in which applicant resides, or in which his principal office is located.)

_____
(Signature and title of authorized officer)

_____
(Name of organization, company or individual)

(The above statement to be signed in the name of the applicant by an authorized officer)

***APPLICATION TO USE OFFICIAL MONOGRAM OF THE AMERICAN PETROLEUM INSTITUTE**

The American Petroleum Institute,
New York City*.
Gentlemen:

In consideration of the American Petroleum Institute granting us (me) the right to use the official monogram of the American Petroleum Institute in the manufacturing of_____ we (I) agree that the use of this monogram is a representation that material so marked complies with all of the conditions and specifications contained in the official publication of the Institute entitled _____ including any amendments or modifications that may hereafter be adopted.

We (I) further agree that no material which fails to comply with such specifications shall be so marked.

_____
(Name of Company)

_____
(Authorized Agent or Officer)

COUNTY OF_____

STATE OF_____

Acknowledged and sworn to before me this_____day of_____19____.
Notary Public.

CERTIFICATE OF AUTHORITY TO USE OFFICIAL MONOGRAM OF THE AMERICAN PETROLEUM INSTITUTE

The American Petroleum Institute hereby grants to_____ the right to use the following monogram as specified in official publication of the American Petroleum Institute entitled_____ 

adopted by the Board of Directors, on_____ including any amendments or modifications that may hereafter be adopted, with the understanding that the use of this monogram is a representation that the material so marked complies with the said specification, and provided further, that no material which fails to comply with the said specification shall be so marked.

The American Petroleum Institute reserves the right to revoke this license to use the above monogram for any reason satisfactory to the Board of Directors of the American Petroleum Institute.

Issued at New York_____, 19____
AMERICAN PETROLEUM INSTITUTE.
(SEAL)
_____
Secretary.

*NOTE: TO SAVE TIME, APPLICATIONS TO USE THE API MONOGRAM SHOULD BE MAILED TO THE DIVISION OF PRODUCTION, AMERICAN PETROLEUM INSTITUTE, DALLAS, TEXAS.

CANCELLATION OF LICENSE

For the convenience of licensees, the following gives the causes upon which the right to use the monogram is subject to cancellation:

1. Using the monogram on material that does not meet the specification.
2. Failure to report on use of monogram.
3. Failure to use the monogram on material meeting the specification.
4. Failure to follow marking stipulations.
5. Improper use of the letters "API".
6. Failure to test Master gages, or to report on condition of Master gages.
7. Using the monogram on material controlled by gages which are beyond approved tolerances.
8. Failure to repair gages known to be beyond approved tolerances.
9. For any other reason satisfactory to the Central Committee on Standardization of Oil Field Equipment.

2M—10-51
1M— 3-53
½M— 3-56
½M— 6-57
1M—11-58
5C — 2-69