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API SPECIFICATION

FOR

WELDED OIL STORAGE TANKS

AMERICAN PETROLEUM INSTITUTE
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Division of Production
Dallas 1, Texas

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Note

This specification was originally adopted as tentative in 1935, and as standard in 1940. Revised editions were issued in 1942, 1944, 1946, 1948, 1950, 1951, 1952, 1954, 1955, and 1957. The present edition supersedes the 14th edition, dated October 1957. It includes changes adopted at the 1957 meeting, as detailed in Circ. PS-1117.

SUGGESTIONS FOR ORDERING

The purchaser should state on his inquiry or purchase order the following:

Specification .... API Std 12C
Number of tanks........
Diameter, ft. ....
Height, ft. ....
Nominal capacity, bbl........
Time of completion........
Freight and hauling........
Erection, location and facilities........ Par. 5.1.2
Tank grade details........ Par. 5.1.1, Appendix B
Plate specifications (bottom, shell, and roof) ....
Bolting .... Par. 2.9

Bottom design:
- Thickness of plates........ Par. 3.2.1
- Size of plates........ Par. 3.2.1
- Joint design .... Par. 3.2.3

Shell design:
- Max. Sp. Gr. of contents........ Par. 3.3.2
- Thickness of plates (each course)........ Par. 3.3.4
- Width of plates........ Par. 3.3.7
- Wind girders .... Sect. 3.4

Roof and roof support design.... Sect. 3.5, Appendix C
Tank appurtenances (type, size, and location) .... Sect. 3.6
Stairways, platforms, and walkways.. Tables 17, 18, 19
Shop Inspection .... Sect. 4.2
Field inspection .... Sect. 5.3
Bottom test .... Par. 5.3.4
Shell Test .... Par. 5.3.6
Roof test .... Par. 5.3.7
Painting requirements .... Par. 5.1.4
Special provisions (permits, fees, liability, etc.)

The purchaser may exercise an option with respect to the following requirements.

Mill test reports........ Par. 4.2.1
Bottom plate arrangement and welding procedure Par.5.2.9,10
Shell plate alignment........ Par. 3.3.8
Top angle orientation........ Par. 3.3.10
Horizontal joint penetration and fusion...... Par. 3.3.12
Roof column .... Par. 3.5.6
Roof slope .... Par. 3.5.7
Shell manhole design........ Fig. 7
Shell nozzle design........ Fig. 8,9
Cleanout fitting support........ Par. 3.6.9, Fig. 11
Roof nozzle flange design........ Fig. 13, 14
Drawoff elbow design........ Fig. 15, 16
Welding procedure qualification test reports .... Par. 7.1.5
Welder or welding operator qualification test reports .... Par. 7.1.5, 7.3.23
Welding procedure specification........ Sect. 7.4

The following requirements are subject to agreement between the purchaser and the manufacturer.

Shell joint tests........ Part 6
- Shell plate width........ Par. 3.3.7
- Sectioning method .... Sect. 6.1
- Closure of openings........ Par. 6.1.19
- Segment ownership .... Par. 6.1.27
- Radiographic method .... Sect. 6.2
- Film ownership .... Par. 6.2.17

API SPECIFICATION FOR WELDED STORAGE TANKS

Foreword

a. This specification is under the jurisdiction of the API Committee on Standardization of Tanks for Oil Storage.

b. Provisions for welding and details pertaining thereto, as given herein, were prepared in cooperation with the American Welding Society, these including definitions of welding and welded joints, and fabrication thereof; materials suitable for welding, including electrodes; qualification of welding procedures and welders; and inspection requirements for field welding.

c. This specification is not intended to cover storage tanks which are to be erected in areas subject to regulations which are more stringent than this specification. In such cases this specification should be followed insofar as it does not conflict with the local requirements.

d. Other specifications under the jurisdiction of the Committee on Standardization of Tanks for Oil Storage include the following:

Std 12A: Specification for Oil-Storage Tanks with Riveted Shells.
Covers material, design, fabrication, and erection requirements for vertical, cylindrical, aboveground steel tanks with riveted shells in nominal capacities of 240 to 255,000 bbl. (in standard sizes) for oil storage.

Std 12G: Specification for Aluminum-Alloy Welded Storage Tanks.
Covers material, design, fabrication, erection, and testing requirements for vertical, cylindrical, above-ground, closed and open-top, welded aluminum-alloy storage tanks in various sizes and capacities.

RP 12H: Recommended Practice for Installation of New Bottoms in Old Storage Tanks.
Covers method of replacing bottoms in old riveted or welded storage tanks with new bottom of concrete or steel.

e. Related specifications under the jurisdiction of the Committee on Lease Production Vessels include the following:

Std 12B: Specification for Bolted Production Tanks.
Covers material, design, and erection requirements for vertical, cylindrical, above-ground, bolted, steel, production tanks in nominal capacities of 100 to 10,000 bbl. (in standard sizes) for oil-field service. It also includes appurtenance requirements.

Std 12D: Specification for Large Welded Production Tanks.
Covers material, design, fabrication, and erection requirements for vertical, cylindrical, aboveground, closed-top, welded, steel, production tanks in capacities of 500 to 3,000 bbl. (in standard sizes) for oil-field service. It also includes appurtenance requirements.

Std 12E: Specification for Wooden Production Tanks.
Covers material, design, fabrication, and erection requirements for vertical, cylindical, abovegound, closed-top, wooden, production tanks in nominal capacities of 130 to 1500 bbl. (in standard sizes) for oil-field service.

Std 12F: Specification for Small Welded Production Tanks.
Covers material, design, and construction requirements for vertical, cylindrical, above-ground, shop-welded, steel production tanks in nominal capacities of 90 to 400 bbl. (in standard sizes up to a maximum diameter of 12 ft.) for oil-field service.

f. Related standards and recommended practices issued by other Institute divisions, include the following:

Std 620: Recommended Rules for the Design and Construction of Large, Welded, Low-Pressure Storage Tanks.
Covers storage tanks for operation at internal pressures of 0.5 psig up to but not exceeding 15 psig.

RP 2000: Guide for Tank Venting.
Covers recommended practices for venting aboveground petroleum storage tanks designed to operate at or near atmospheric pressure. Recommended practices for testing venting devices are included.

Accident Prevention Manual No. 1, Cleaning Petroleum Storage Tanks:

Section A: Crude Oil and Unfinished Products Tanks.

Section B: Gasoline Tanks.

Inspection of Atmospheric and Low-Pressure Storage Tanks (Chapter XIII of Guide for Inspection of Refinery Equipment).
Contains a description of the design and construction of atmospheric and low-pressure storage tanks for crude, intermediate, and refined products, gas, chemicals and water; reasons for inspection and causes of deterioration; recommendations on frequency and time of inspection; procedures and tools required for inspection of tanks in service and out of service and of auxiliary equipment, including testing tanks and determining limits; methods of repairs; and recommendations concerning inspection records and reports.

1. SCOPE

1.1 This specification covers material, design, fabrication, erection, and testing requirements for vertical, cylindrical, above-ground, closed and open-top, welded steel storage tanks in various sizes and capacities, for internal pressures approximating atmospheric pressures.

1.2 This specification is designed to provide the oil industry with tanks of adequate safety and reasonable economy, for use in the storage of petroleum and its products and those other liquid products commonly handled and stored by the various branches of the industry. It does not present, nor is it contemplated to establish, a fixed series of allowable tank sizes; but rather it is intended to permit the selection by the purchaser of whatever size of tank may be required to best meet his particular needs.

1.3 Appendix A to this specification presents for ready reference design data relating to tanks which may be built under this specification. The data presented therein are for convenience and are not mandatory.

1.4 Nothing contained in this specification is to be construed as granting any right, by implication or otherwise, for manufacture, sale, or use in connection with any method, apparatus, or product covered by letters patent, nor as insuring anyone against liability for infringement of letters patent.

1.5 **Compliance.** The manufacturer is responsible for complying with all of the provisions of this specification. The purchaser may make any investigation necessary to satisfy himself of compliance by the manufacturer, and may reject any material that does not comply with this specification. It is urged that the purchaser avail himself of this right and furnish his own inspection independently of any supervisory inspection furnished by the manufacturer, and that the purchaser inspector follow closely all of the details of field construction and testing herein specified, which affect the integrity and safety of the completed structure.

2. MATERIAL

Plates

2.1 Plates shall conform to the latest revision of ASTM[1] A 7 (open-hearth or electric-furnace process only), A 283 grade C, or A 283 grade D, except that all plates in thickness greater than ¾ in. shall conform to A 283 grade C. Copper-bearing steel shall be used if so specified on the purchase order.

NOTE 1: *As alternatives, plates conforming to ASTM A 131 grades A, B, and C; A 201 grades A and B; A 284 grade B; and A 373 are acceptable (without restriction as to thickness except as imposed in A 131 and A 373), and may be specified when the purchaser considers the severity of the service conditions warrants the use of these premium materials.*

NOTE 2: *The manufacturer shall state in his proposal the plate specification which he intends to use.*

2.2 Plate specification on an edge-thickness basis is required[2] for all shell plates the thicknesses of which are determined by design computations. Shell plates for which minimum thicknesses have been fixed for practical reasons, and which will not under-run the theoretical required thickness by more than 0.01 in., also roof and bottom plates, may be specified on a weight basis. The plate thicknesses or weights, as stipulated herein are minima; thicker or heavier material may be required on the order at the option of the purchaser.

2.3 **Sheets.** Sheets shall conform to the latest revision of ASTM A 245, grade C, open-hearth process only. Copper-bearing steel shall be used if so specified on the purchase order. Sheets may be ordered on a weight or thickness basis, at the option of the tank manufacturer.

2.4 **Welding Electrodes.** Manual arc-welding electrodes shall conform to the latest revision of ASTM A 233: Specifications for Mild Steel Arc-Welding Electrodes of the E-60 Series of Classification, suitable for the electric-current characteristics, the position of welding, and other conditions of intended use.

2.5 **Structural Shapes.** Structural shapes shall conform to the latest revision of ASTM A 7 (open-hearth or electric-furnace process only). Copper-bearing steel shall be used if so specified on the purchase order.

2.6 **Castings.** Castings shall conform to the latest revision of ASTM A 27, grade 60-30, fully annealed.

2.7 **Piping.** Except as otherwise specified herein, pipe and pipe couplings shall conform to the latest revision of API Std 5L. By agreement between the purchaser and the manufacturer, couplings for threaded connections may be supplied without recesses. When so supplied, the couplings in all other respects shall conform to API Std 5L. Pipe used for structural purposes shall conform to API Std 5L grade B or API Std 5LX, with respect to physical properties of the material.

2.8 **Flanges.** Hub slip-on welding and welding-neck flanges shall conform to the material requirements for forged carbon-steel flanges as specified in ASA B16.5. Plate-ring flanges shall conform to the requirements of Par. 2.1, within the thickness limits controlled therein, or to ASTM A 201, grade A for all thicknesses.

2.9 **Bolting.** Bolting shall conform to the latest revision of ASTM A 307.

NOTE: *Purchasers should specify on their orders the desired shape of bolt heads and nuts, also whether regular or heavy dimensions are desired.*

[1] ASTM specifications referred to herein may be secured from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

[2] Plates may be purchased on the weight basis in compliance with this requirement, provided they are ordered sufficiently heavier than the nominal weight corresponding to the specified minimum thickness to insure that plates furnished by the mill will not underrun the theoretical thickness by more than 0.01 in.

3. DESIGN

3.1 JOINT DESIGN

3.1.1 Definitions. The following definitions shall apply to tank joint designs.

a. Double-Welded Butt Joint: A joint between two abutting parts lying in approximately the same plane and welded from both sides.

b. Single-Welded Butt Joint with Backing: A joint between two abutting parts lying in approximately the same plane, welded from one side only using a strip, bar, or other suitable backing material.

c. Double-Welded Lap Joint: A joint between two overlapping members, in which the overlapped edges of both members are welded with fillet welds.

d. Single-Welded Lap Joint: A joint between two overlapping members, in which the overlapped edge of one member is welded with a fillet weld.

e. Butt Weld: A weld placed in a groove between two abutting members. Grooves may be square, V (single or double), or U (single or double), and may be either single or double beveled.

f. Fillet Weld: A weld of approximately triangular cross-section joining two surfaces approximately at right angles to each other, as in a lap joint, tee joint, or corner joint.

g. Full-Fillet Weld: A fillet weld whose size is equal to the thickness of the thinner member joined.

h. Tack Weld: A weld made to hold parts of a weldment in proper alignment until the final welds are made.

3.1.2 Size of Weld. The size of a weld shall be based on the following dimensions:

a. Groove Weld: The joint penetration (depth of chamfering plus the root penetration when specified).

b. Fillet Weld: For equal-leg fillet welds, the leg length of the largest isosceles right triangle which can be inscribed within the fillet-weld cross section. For unequal-leg fillet welds, the leg lengths of the largest right triangle which can be inscribed within the fillet-weld cross section.

3.1.3 Joint Restrictions. The following restrictions on type and size of joints or welds shall apply:

a. Tack welds may not be considered as having any strength value in the finished structure.

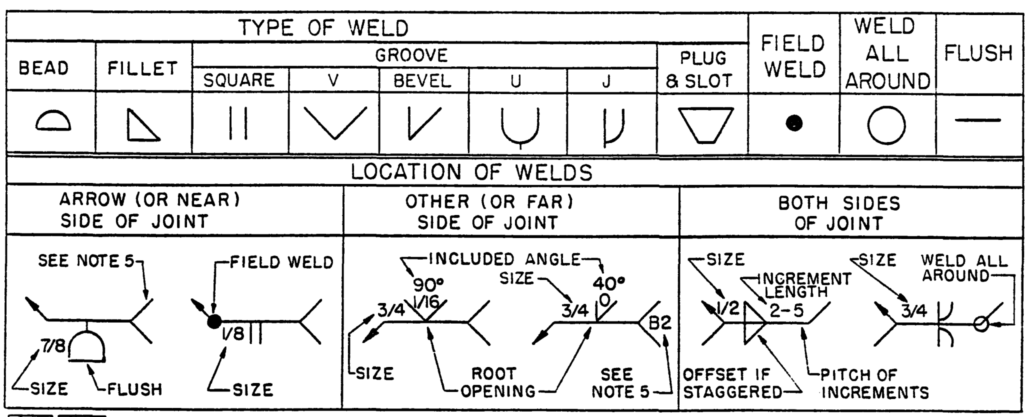
b. The minimum size of fillet welds shall be as follows: plates $\frac{3}{16}$ in. thick, full-fillet welds; plates over $\frac{3}{16}$ in. thick, not less than one-third the thickness of the thinner plate at the joint, with a minimum of $\frac{3}{16}$ in.

c. Single-welded lap joints are permissible only on bottom plates and roof plates.

d. Lap-welded joints, as tack welded, shall be lapped not less than five times the nominal thickness of the thinner plate joined, but in the case of double-welded lap joints need not exceed 2 in. and in the case of single-welded lap joints need not exceed 1 in.

3.1.4 Welding Symbols. Welding symbols used on drawings shall be those of the American Welding Society, as given in Fig. 1.

3.1.5 Typical Joints. Typical tank joints are shown in Fig. 2, 3, and 4.



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1. The side of the joint to which the arrow points is the arrow side and the opposite side of the joint is the other side.
2. Arrow-side and other-side welds are same size unless otherwise shown.
3. Symbols apply between abrupt changes in the direction of welding or to the extent of hatching or dimension lines, except where the all-around symbol is used.
4. All welds are continuous and of user's standard proportions, unless otherwise shown.
5. Tail of arrow used for specification process, or other reference. (Tail may be omitted when reference not used.)
6. When a bevel- or J-groove weld symbol is used, the arrow shall point with a definite break toward the member which is to be chamfered. (In cases where the member to be chamfered is obvious, the break in the arrow may be omitted.)
7. Dimensions of weld sizes, increment lengths, and spacing, in inches.
8. For more detailed instruction in the use of these symbols refer to Standard Welding Symbols, published by American Welding Society.

FIG. 1
WELDING SYMBOLS

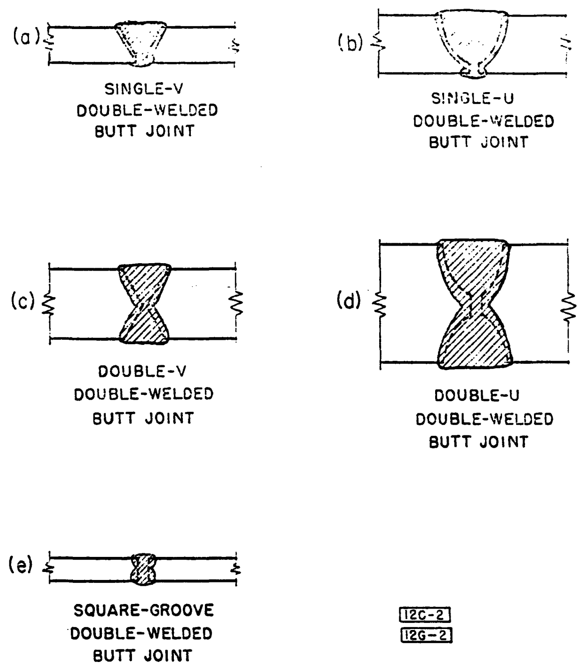


FIG. 2
TYPICAL VERTICAL JOINTS IN SHELL[1]

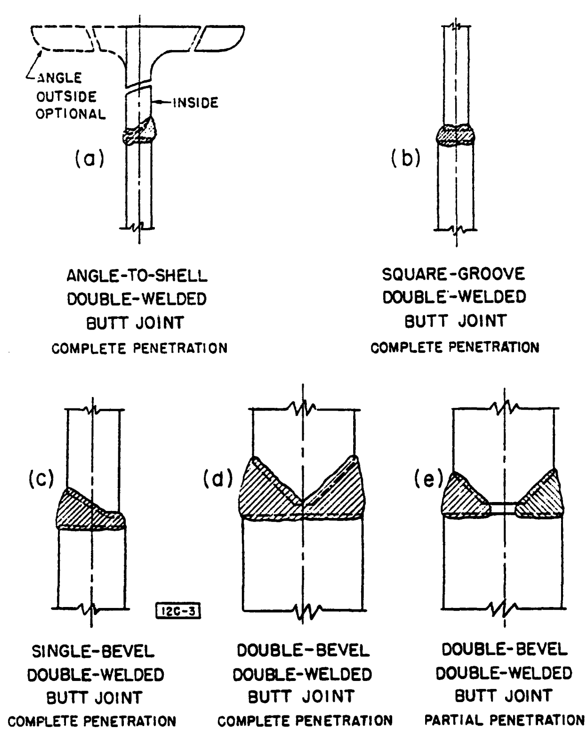
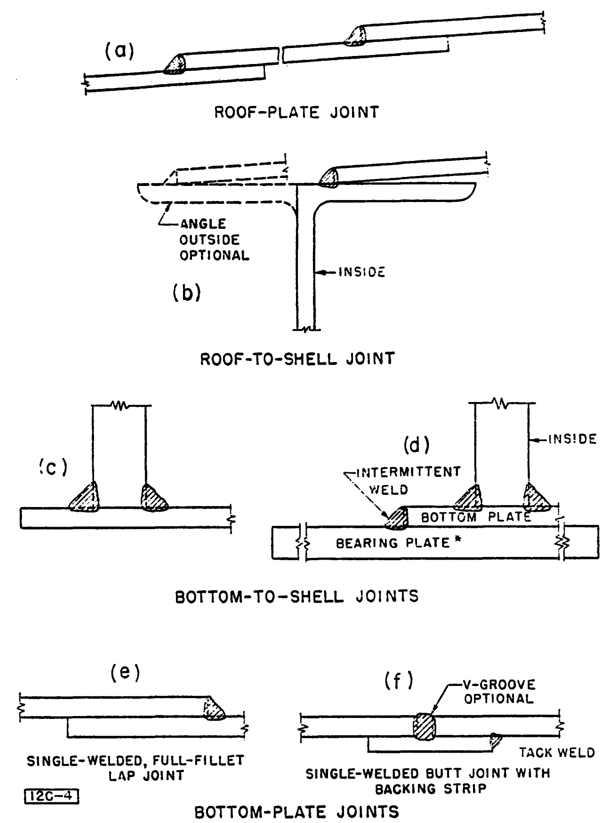


FIG. 3
TYPICAL HORIZONTAL JOINTS IN SHELL[2]



***See Appendix B for recommendations on bearing plates.**

FIG. 4
TYPICAL ROOF AND BOTTOM JOINTS[3]

[1]See Par. 3.3.11 for specific requirements on vertical shell joints.

[2]See Par. 3.3.12 for specific requirements on horizontal shell joints.

[3]See Par. 3.2.3 for specific requirements on bottom-plate joints; Par. 3.2.4 for specific requirements on bottom-to-shell joints; Par. 3.5.3 for specific requirements on roof plate joints; and Par. 3.5.4 on roof-to-top angle joints.

3.2 BOTTOM DESIGN

NOTE: *Storage tanks, particularly in the larger sizes, impose appreciable bearing loads on the subgrade and it is recommended that consideration be given to providing suitable foundations to prevent uneven settlement with attendant distortion and possible failure of the tank. Details of recommended foundations are given in Appendix B herein.*

Plate Sizes

3.2.1 All bottom plates shall have a minimum nominal thickness of ¼ in. (10.2 per sq. ft. See Par. 2.2). All rectangular plates shall preferably have a minimum width of 72 in. All sketch plates (bottom plates upon which the shell rests) which have one end rectangular, shall also preferably have a minimum width of 72 in. for the rectangular end.

3.2.2. Bottom plates shall be ordered of sufficient size so that when trimmed at least one-inch width will project beyond the outside edge of the weld attaching the bottom to the shell plate.

Design

3.2.3 Bottoms shall be built to one of two alternative methods of construction:

a. Lap-welded bottom plates shall be reasonably rectangular and square-edged. Three-plate laps in tank bottoms shall not be closer than 12 in. from each other and also from the tank shell. Bottom plates need be welded on the top side only, with a continuous full-fillet weld on all seams. The plates under the bottom ring shell connection shall have the outer ends of the joints fitted and lap welded to form a smooth bearing for the shell plates as shown in Fig. 5.

b. Butt-welded bottom plates shall have the parallel edges prepared for butt welding with either square or V grooves. If square, the root opening shall be not less than ¼ in. The butt welds shall be made by applying a backing strip ⅛ in. thick or heavier by tack welding to the under side of the plate. A metal spacer shall be used, if necessary, to maintain the root opening between the adjoining plate edges. The manufacturer may submit other methods of butt welding the bottom for the purchaser's approval. Three-plate joints in tank bottoms shall not be closer than 12 in. from each other and also from the tank shell.

3.2.4 The attachment between the bottom edges of the lowest course shell plate and the bottom plate shall be a continuous fillet weld laid on each side of the shell plate. The size of such welds shall be not greater than ½ in., and neither less than the nominal thickness of the bottom plates or shell plates (whichever is smaller) nor less than the following values.

Maximum Thickness of Shell Plate, in.	Size of Fillet Weld, in.
$\frac{3}{16}$	$\frac{3}{16}$
Over $\frac{3}{16}$ to ¾	¼
Over ¾ to 1¼	$\frac{5}{16}$
Over 1¼ to 1½	⅜

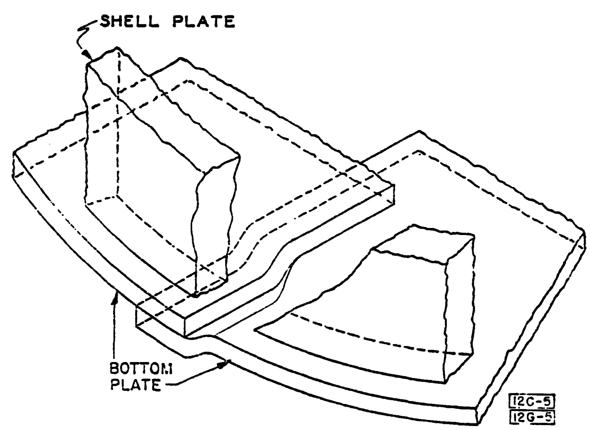


FIG. 5
METHOD OF PREPARING LAP-WELDED BOTTOM PLATES UNDER TANK SHELL
See Par. 3.2.3a.

3.3 SHELL DESIGN

See Appendix A for typical tank sizes and shell plate thicknesses

3.3.1 Working Stresses. The following maximum allowable working stresses shall be used in design:

a. The maximum tensile stress before applying the factor for efficiency of joint shall be 21,000 lb. per sq. in.

b. The strength of fillet welds for structural attachment shall be computed as 13,600 lb. per sq. in. of cross section measured in the throat of the weld for transverse welds, and 75 per cent of this value for longitudinal welds. The throat of a fillet weld shall be assumed as 0.707 times the shorter leg of the fillet weld.

Loads

3.3.2 Stresses shall be computed on the assumption that the tank is filled with water at 60 deg. F.[1] or the liquid to be stored, if heavier than water. The tension in each ring shall be computed 12 in. above the centerline of the lower horizontal joint of the course in question. In computing these stresses, the tank diameter shall be taken as the nominal[2] diameter of the bottom course.

3.3.3 Isolated radial loads on tank shells, such as caused by heavy loads from platforms and elevated walkways between tanks, shall be distributed by rolled structural sections, plate ribs, or built-up members, preferably in a horizontal position.

Sizes and Thicknesses of Shell Plates

3.3.4 The minimum thicknesses of shell plates shall be computed from the stress on the vertical joints using a joint efficiency factor of 0.85.

NOTE: *The following formula may be used in calculating the minimum thickness of shell plate:*

$$t = 0.0001456 \times D \times (H\text{-}1) \times S$$

Wherein:

t=minimum thickness, in inches

D=nominal inside diameter of tank, in feet[2]

H=height, in feet, from the bottom of the course under consideration to the top of the top angle or to the bottom of any overflow which limits the tank filling height.

S=Specific gravity of liquid to be stored but in no case less than 1.0.

3.3.5 In no case shall the nominal thickness of shell plates (including shell extensions for floating roofs) be less than the following:

Nominal Tank[2] Diameter, ft.	Nominal Thickness, in.
Smaller than 50	3/16
50 to, but not including, 120	1/4
120 to 200, incl.	5/16
Over 200	3/8

[1]Water at 60 deg. F. weighs 62.37 lb. per cu. ft.

[2]Nominal tank diameter shall be the center line diameter of the shell plates, unless otherwise specified by the purchaser.

3.3.6 The maximum nominal thickness of tank shell plates shall be 1½ in.

3.3.7 The width of shell plates shall be as agreed upon between the purchaser and the manufacturer, but preferably should not be less than 72 in. Plates which are to be butt welded shall be properly squared.

Arrangement of Members

3.3.8 The tank shell shall be designed to have all courses truly vertical. Unless otherwise specified, abutting shell plates at horizontal joints shall have a common vertical centerline. Within any three consecutive courses, vertical joints shall not be in alignment but shall be offset from each other a minimum distance of *5t*, *t* being the plate thickness of the thicker course at the point of offset, except that this requirement need not apply to courses for which the plate thickness is established in accordance with Par. 3.3.5.

3.3.9 The wide face of unsymmetrical V- or U-butt joints may be on the outside or the inside of the tank shell, at the option of the manufacturer.

3.3.10 Except as specified for open-top tanks in Par. 3.4.6, tank shells shall be supplied with top angles of not less than the following sizes: tanks 35 ft. and smaller in diameter — 2½ x 2½ x ¼ in.; tanks over 35 ft. through 60 ft. in diameter — 2½ x 2½ x 5/16 in.; tanks larger than 60 ft. in diameter—3 x 3 x ⅜ in. The outstanding leg of the top angle may extend inside or outside the tank shell at the purchaser's option.

3.3.11 Vertical Joints. Vertical joints shall be double welded butt joints with complete penetration and complete fusion. The suitability of plate preparation and welding procedure shall be determined in accordance with Sect. 7.2, Welding Procedure Qualification.

3.3.12 Horizontal Joints. Horizontal joints shall be double-welded butt joints and shall have complete fusion with the base metal over the required depth of weld. The suitability of plate preparation and welding procedure shall be determined in accordance with Sect. 7.2: Welding Procedure Qualification. Horizontal joints shall have complete penetration and complete fusion for a distance of 3 in. on each side of all vertical joint junctions. The remainder of the joint shall conform to the applicable requirements as follows:

a. Single-beveled butt joints, including the top angle-to-shell joints, shall have complete penetration and complete fusion.

b. Square-groove and double-beveled joints, if the thickness of either plate is ⅜ in. or less, shall have complete penetration and complete fusion.

c. Square-groove and double-beveled joints, if the thicknesses of both plates are greater than ⅜ in., shall have at least ⅔ penetration. Any lack of penetration or fusion plus any undercutting (see Par. 5.2.4 regarding undercutting) shall not exceed ⅓ of the thickness of the thinner plate; and the zone lacking penetration or fusion shall be located substantially at the center of the thinner plate.

Shell Openings

NOTE: *The following requirements on shell openings are intended to restrict the use of appurtenances to those providing for attachment to the shell by welding. The only exceptions are bolted door sheets. The design requirements for these are given in Sect. 3.6.*

3.3.13 Openings in tank shells larger than required to accommodate a 2-in. standard-weight coupling shall be reinforced. The minimum cross-sectional area of the reinforcement shall not be less than the product of the vertical diameter of the hole cut in the tank shell and the shell-plate thickness required by Par. 3.3.4. The cross-sectional area of the reinforcement shall be measured vertically, coincident with the diameter of the opening.

3.3.14 All effective reinforcements shall be made within a distance, above or below the centerline of the shell opening, equal to the vertical dimension of the hole in the tank shell plate. The reinforcement may be provided by any one or by any combination of the following:

a. The attachment flange of the fitting.

b. The reinforcing plate.

c. The portion of the neck of the fitting which may be considered as reinforcement according to Par. 3.3.15.

d. Any excess shell plate thickness beyond that required by Par. 3.3.4, within a vertical distance both above and below the centerline of the hole in the shell, equal to the vertical dimension of the hole in the tank shell plate.

3.3.15 The following portions of the neck of a fitting may be considered a part of the area of reinforcement:

a. That portion extending outwardly from the outside surface of the tank shell plate for a distance equal to four times the neck wall thickness or, if the neck wall thickness is reduced within this distance, to the point of transition.

b. That portion lying within the shell-plate thickness.

c. That portion extending inwardly from the inside surface of the tank shell plate for a distance as specified in Subpar. a.

3.3.16 The aggregate strength of the weld attaching a fitting to the shell plate or to an intervening reinforcing plate, or to both, shall equal at least the proportion of the forces, passing through the entire reinforcement, which is computed to pass through the fitting considered.

3.3.17 The aggregate strength of the welding attaching any intervening reinforcing plate to the shell plate shall at least equal the proportion of the forces, passing through the entire reinforcement, which is computed to pass through the reinforcing plate considered.

3.3.18 The attachment welding to the shell, along the outer periphery of the flanged fitting or reinforcing plate, shall be considered effective only for the parts lying outside of the area bounded by vertical lines drawn tangent to the shell opening. The outer peripheral welding, however, shall be applied completely around the reinforcement. All the inner peripheral welding shall be considered effective. The strength of the effective attachment welding shall be considered as its shear resistance at the stress values given for fillet welds in Par. 3.3.1b. The outer peripheral weld shall be of a size equal to the thickness of the shell plate or reinforcing plate, whichever is thinner except that, when low-type nozzles are used with the reinforcing plate extending to the tank bottom (see Fig. 8), the size of that portion of the peripheral weld which attaches the reinforcing plate to the bottom plate shall conform to Par. 3.2.4. The inner peripheral welding shall be large enough to sustain the remainder of the loading.

3.3.19 When two or more openings are located so close that their normal reinforcing-plate edges are closer than ten times the thickness of the thicker reinforcing plate, with a minimum of 6 in., they shall be treated and reinforced as follows:

a. All such openings shall be included in a single reinforcing plate, which shall be proportioned for the largest opening in the group.

b. If the normal reinforcing plates for the smaller openings in the group, considered separately, would fall within the area limits of the solid portion of a normal plate for the largest opening, the smaller openings may be included in a normal plate for the largest opening without increase in size of that plate; provided, however, that if any opening intersects the vertical centerline of another, the total width of the final reinforcing plate along the vertical centerline of either opening shall not be less than the sum of the widths of the normal plates for the openings involved.

c. If the normal reinforcing plates for the smaller openings, considered separately, would not fall within the area limits of the solid portion of a normal plate for the largest opening, the group reinforcing-plate size and shape shall be such as to include the outer limits of the normal reinforcing plates for all of the openings in the group. Change of size from the outer limits of the normal plate for the largest opening to the outer limits of that for the smaller opening farthest therefrom shall be by uniform straight taper unless the normal plate for any intermediate opening would extend beyond the limits so fixed, in which case uniform straight tapers shall join the outer limits of the several normal plates. Provisions of Subpar. b. with respect to openings on the same or adjacent vertical centerlines shall also apply in this case.

Flush-Type Cleanout Fitting

NOTE: *Because of the restraint imposed by the tank bottom and the geometry of the reinforcement, cleanout fittings having the bottom member flush with the tank bottom require special consideration as provided in the following requirements. For selected sizes of fittings, dimensional details are covered by Par. 3.6.3. See Par. 3.6.1 for restrictions on designs of cleanout fittings.*

3.3.20 Cleanout fittings of the flush type shall conform to the following requirements:

a. The opening shall be rectangular, except that the upper corners of the opening shall have a radius at least equal to one third the greatest height of the clear opening. The width or height of the clear opening shall not exceed 48 in.

b. The reinforced opening shall be completely preassembled into a first-ring shell plate.

c. If any plate in the unit has a thickness greater than ⅝ in., the completed unit, including shell plate, shall be thermally stress relieved at a temperature of 1100 to 1200 deg. F. for 1 hr. per inch of thickness.

3.3.21 The cross-sectional area of the shell reinforcement over the top of the opening shall not be less than $\frac{K_1 ht}{2}$

Wherein:

K_1 = the area coefficient as given on Fig. 6, Detail A.

h = the greatest vertical height of the clear opening, in inches.

t = the shell-plate thickness, in inches, required by Par. 3.3.4.

3.3.22 In no case shall the thickness of the shell reinforcing plate be less than the product of coefficient K_2 as given on Fig. 6. Detail B, and the shell-plate thickness required by Par. 3.3.4.

3.3.23 The reinforcement in the plane of the shell shall be provided within a height L above the bottom of the opening. L shall not exceed $1.5h$ except that $L-h$ shall not be less than $\frac{h}{2K_2}$, nor less than 6 in. in case of small openings. Where the latter exception results in a height L greater than $1.5h$, only that portion of the reinforcement within a height of $1.5h$ shall be considered effective in satisfying the provisions of Par. 3.3.21.

3.3.24 The reinforcement required by Par. 3.3.21 may be provided by any one or by any combination of the following:

a. The shell reinforcing plate.

b. Any excess shell-plate thickness beyond that required by Par. 3.3.4.

c. That portion of the neck plate equal to the thickness of the reinforcing plate.

3.3.25 The width of the tank-bottom reinforcing plate at the centerline of the opening shall be 10 in. plus the combined thickness of the shell and shell reinforcing plates. The minimum thickness of the bottom reinforcing plate, t_b, in inches, shall be determined as follows:

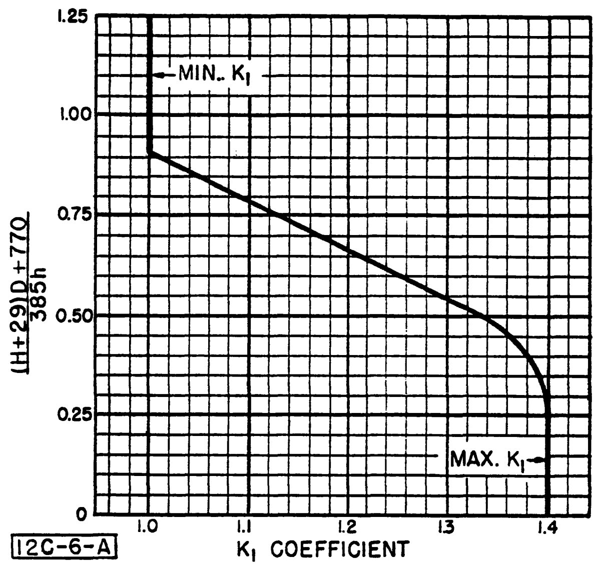
$$t_b = \frac{h^2}{14{,}000} + \frac{b}{310}\sqrt{H}$$

Wherein:

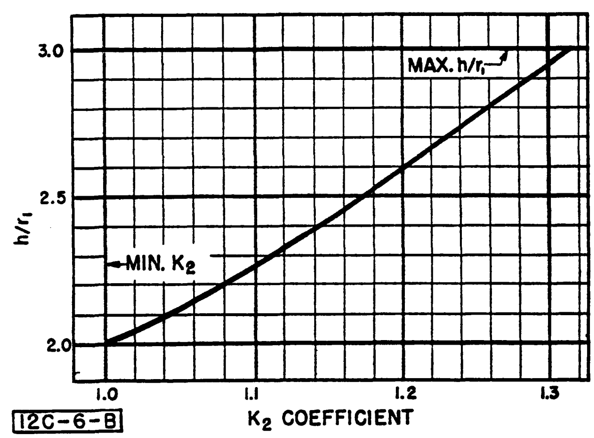
b = horizontal width of clear opening, in inches.

H = height of tank shell, in feet.

h = the greatest vertical height of the clear opening, in inches.



DETAIL A
K_1 COEFFICIENT FOR DETERMINING MINIMUM SHELL REINFORCEMENT AREA AT TOP OF OPENING
See Par. 3.3.21



DETAIL B
K_2 COEFFICIENT FOR DETERMINING MINIMUM SHELL REINFORCEMENT PLATE THICKNESS
See Par. 3.3.22

Wherein:

h = greatest vertical height of clear opening, in inches.

r_1 = upper corner radius of clear opening, in inches.

H = height of tank, in feet.

D = inside diameter of tank, in feet.

FIG. 6
DESIGN FACTORS FOR FLUSH-TYPE CLEANOUT FITTINGS

The following requirements on bolted door sheets are based on specific design requirements as follows:

Bolted Door Sheets

3.3.26 The minimum net cross-sectional area of the door plates, excluding the tapered ends, shall not be less than the product of the shell plate thickness and the vertical height of the cut out in the shell plus twice the bolt-hole diameter:

$$t_D\ (h_D - N_1\ d) = t_s\ (h_c + 2d)$$

3.3.27 The shear stress in the gross section of the bolts shall not exceed 16,000 lb. per sq. in.

3.3.28 The bearing stress on bolts and bolt holes shall not exceed 32,000 lb. per sq. in. and the fit of the turned bolt in the reamed hole shall conform to the standards of the American Institute of Steel Construction.

3.3.29 The strength of the bolted connection shall be at least 90 per cent of the strength of the unbolted shell plate. For shear loading on the flush-type door sheet:

$$N \times a \times 16{,}000 = t_s\ (h_c + 2.5d + f) \times 21{,}000 + 0.90$$

For shear loading on the raised type door sheet:

$$N \times a \times 16{,}000 = t_s\ (h_c + 4d) \times 21{,}000 \times 0.90$$

3.3.30 The distance between centers of bolt holes shall not be less than 3 times the bolt diameter, and the bolt hole spacing at the sealing edge of the plate not exceed 7 times the sum of the minimum door-sheet thickness plus the nominal bolt diameter plus the washer thickness (if washers are used).

3.3.31 The tensile stress in the net section of the door plate at the first row of bolt holes next to the shell plate cutout, shall not exceed 21,000 lb. per sq. in, and at subsequent rows shall not exceed 21,000 lb. per sq. in. after allowance is made for the total shearing value or bearing value (whichever is less) of the bolts in the preceding row or rows.

3.3.32 For flush-type bolted door sheets:

a. The girder shall be designed to withstand a bending moment which would result if the ends of the girder were on hard ground and the center unsupported.

b. The load on the girder shall be equal to the weight of a column of water with the following dimensions: a, 0.03 times the tank radius, in feet; b, width of shell cutout plus two feet; c, the tank height, in feet.

c. The design length of the girder shall be equal to the width of the shell cutout plus two feet.

In the preceding equations:

t_s = thickness of shell plate, in inches.

t_D = thickness of door plate, in inches.

h_D = height of door plate in inches.

h_c = Height of shell cutout, in inches.

d = diameter of bolts and bolt holes in inches.

a = cross-sectional area of bolts, in square inches.

N = number of bolts required in each end section of door plate.

N_1 = number of bolts in first row of bolts next to the shell cutout.

NOTE: *When the difference in diameter of the bolt and bolt holes, because of wear, approximates 0.020 in., it is recommended that the holes be re-reamed and fitted wth oversize milled-body bolts. However, the holes should not be reamed to the extent that the efficiency of the bolted connection becomes less than 85 per cent. This point is reached when the bolt-hole diameters become ¼ in. larger than the bolt diameters specified in Tables 20 and 21.*

3.4 DESIGN OF WIND GIRDERS FOR OPEN-TOP TANKS

3.4.1 Open-top tanks shall be provided with stiffening rings to maintain roundness when the tank is subjected to wind loads. Stiffening rings shall be located at or near the top of the top course, and preferably on the outside of the tank shell.

3.4.2 The required minimum section modulus of the stiffening ring shall be determined by the equation:

$$Z = 0.0001\, D^2 H_2$$

Wherein:

Z = section modulus, in inches, cubed.
D = nominal diameter of tank, in feet.
H_2 = height of tank shell, in feet, including any "freeboard" provided above the maximum filling height as a guide for a floating roof.

3.4.3 The section modulus of the stiffening ring shall be based upon the properties of the applied members and may include a portion of the tank shell for a distance of 16 plate thicknesses below and, if applicable, above the ring shell attachment. When curb angles are attached to the top edge of the shell ring by butt welding, this distance shall be reduced by the width of the vertical leg of the angle.

NOTE: ***Section moduli values for typical ring members are given in Appendix A.***

3.4.4 Stiffening rings may be made of either structural sections, formed plate sections, or sections built up by welding, or of combinations of such types of sections assembled by welding. The outer periphery of stiffening rings may be circular or polygonal.

3.4.5 The minimum size of angle for use alone, or as a component in a built-up stiffening ring, shall be 2½ x 2½ x ¼ in. The minimum nominal thickness of plate for use in formed or built-up stiffening rings shall be ¼ in.

3.4.6 When stiffening rings are located more than 2 ft. 0 in. below the top of the shell, the tank shall be provided with a 2½ x 2½ x 3/16-in. top curb angle for 3/16-in. shells and a 3 x 3 x ¼-in. angle for shells greater than 3/16-in., or other members of equivalent section modulus.

3.4.7 Rings of such design that liquid may be trapped thereon shall be provided with adequate drain holes.

3.4.8 Stiffening rings or portions thereof which are regularly used as a walkway, shall have a width of not less than 24 in. clear of the projecting curb angle on the top of the tank shell, shall be located preferably 3 ft. 6 in. below the top of the curb angle, and shall be provided with a standard railing on the unprotected side and at the ends of the section so used.

3.4.9 When a stair opening is installed through a stiffening ring, the section modulus of that portion of the ring outside the opening, and including the transition section, shall conform to the requirements of Par. 3.4.2. The shell adjacent to such opening shall be stiffened with an angle, or bar placed horizontally. The other sides of the opening shall be stiffened with an angle, or bar placed vertically. The cross-sectional area of these rim stiffeners shall be at least equivalent to the cross-sectional area of that portion of shell included in the section modulus calculations of the stiffening ring (Par. 3.4.3). These stiffeners, or additional members, shall furnish a suitable toe board around the opening. The stiffening members shall extend beyond the end of the opening for a distance equal to, or greater than, the minimum depth of the regular ring sections. The end stiffening members shall frame into the side stiffening members and shall be connected to them in such manner as to develop their full strength.

3.4.10 Supports shall be provided for all stiffening rings when the dimension of the horizontal leg or web exceeds 16 times the leg or web thickness. Such supports shall be spaced at intervals as required for the dead load and vertical live load that may be placed upon the ring. However, the spacing shall not exceed 24 times the width of the outside compression flange.

3.4.11 Continuous welds shall be used for all joints which, because of their location, may be subjected to corrosion from entrapped moisture or cause rust markings on the tank shell. Full-penetration butt welds shall be used for joining ring sections.

3.5 ROOF DESIGN

3.5.1 Definitions. The following definition shall apply

a. **Column-Supported Cone Roof.** A column-supported cone roof is a roof formed to approximately the surface of a right cone. The principal support for the roof is provided by internal roof column and rafters.

b. **Self-Supporting Cone Roof.** A self-supporting cone roof is a roof formed to approximately the surface of a right cone. The roof is supported only on its periphery (without supporting columns).

c. **Self-Supporting Dome Roof.** A self-supporting dome roof is a roof formed to approximately a spherical surface and supported only on its periphery (without supporting columns).

d. **Self-Supporting Umbrella Roof.** A self-supporting umbrella roof is a modified dome roof so formed that any horizontal section is a regular polygon with as many sides as there are roof plates.

Column-Supported Cone Roof

3.5.2 Loading. The roof and supporting structure of a column-supported cone roof shall be designed to support a live load of not less than 25 lb. per sq. ft. of projected area, in addition to the dead load.

3.5.3 Thickness. Roof plates shall have a minimum nominal thickness of $\frac{3}{16}$ in. (7.65 lb. per sq. ft.; see Par. 2.2). Roof plates shall be welded on the top side only, with continuous full-fillet welds on all seams.

3.5.4 Attachment. Roof plates shall be attached to the top angle of the tank with a continuous fillet weld on the top side only. The size of the weld shall be $\frac{3}{16}$ in., or smaller if so specified on the purchase order. Roof plates shall not be attached to the rafters.

> NOTE: *These restrictions are intended to provide a frangible joint which will fail preferentially to the tank shell, in case of excessive internal pressure, also to provide flexibility of the tank roof for the same reason.*

3.5.5 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

Welds, on section through weld throat............15,600

Compression

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

Welds, on section through weld throat............18,000

On gross section of columns......

$$\frac{18{,}000}{1 + \dfrac{L^2}{18{,}000\ r^2}}$$

with a maximum of...15,000

Wherein: 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.......................

$$\frac{20{,}000}{1 + \dfrac{L^2}{2{,}000\ b^2}}$$

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

The foregoing 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 flanges of the rafters.

Shearing

On end welds for structural attachment........13,600

On side welds for structural attachment........10,200

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 $60t$ (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 square inch, V/A, shall not exceed...............

$$\frac{18{,}000}{1 + \dfrac{h^2}{7{,}200\ t^2}}$$

Wherein: V is the total shear, and A is gross area of web in square inches.

3.5.6 Roof Columns. Structural shapes or, at the option of the purchaser, steel pipes shall be used for roof columns. Clip guides shall be installed on tank bottoms to prevent lateral movement of column bases. Rafter clips shall be welded to the tank shell; column-base clip guides shall be welded to the tank bottom.. All other structural attachments shall be either bolted, riveted, or welded.

3.5.7 Roof Slope. The slope of column-supported conical roofs shall be ¾ in. in 12 in., or other value as ordered by the purchaser. If the rafters are set directly on chord girders, producing slightly varying rafter slopes, the slope of the flattest rafter shall conform to the specified or ordered roof slope.

3.5.8 Rafters. Rafters shall have a minimum web thickness of 0.17 in. and shall be spaced so that, in the outer ring, their centers shall not be more than 2 pi ft.

(2 times 3.1416) apart, measured along the circumference of the tank. Spacing on inner rings shall not be greater than 5½ ft. In earthquake territory, ¾-in. **diameter tie rods shall be placed between the rafters in the outer ring. These tie rods may be omitted if I or H sections are used as rafters.**

3.5.9 Self-Supporting Cone Roofs. Self-supporting cone roofs shall conform to the following requirements*.

a. Maximum $\theta = 37$ deg. (tangent = 9:12)
b. Minimum $\sin \theta = 0.165$ (slope 2 in. in 12 in.)
c. Minimum $t = \dfrac{D}{400 \sin \theta}$ but not less than $\frac{3}{16}$ in.
d. Maximum $t = \frac{1}{2}$ in.
e. The cross-sectional area of the top angle, in square inches, plus the cross-sectional areas of the shell and roof plates within a distance of 16 times their thicknesses, measured from their most remote point of attachment to the top angle, shall equal or exceed $\dfrac{D^2}{3{,}000 \sin \theta}$.

Wherein:

θ = angle of cone elements with the horizontal, in degrees.

D = nominal diameter of the tank shell, in feet.

t = nominal thickness of the roof plates, in inches.

3.5.10 Self-Supporting Dome and Umbrella Roofs. Self-supporting dome and umbrella roofs shall conform to the following requirements.*

a. R = D (unless otherwise specified by the purchaser)
b. Minimum R = 0.80D
c. Maximum R = 1.2D
d. Minimum $t = \dfrac{R}{200}$ but not less than $\frac{3}{16}$ in.
e. Maximum $t = \frac{1}{2}$ in.
f. The cross-sectional area of the top angle, in square inches, plus the cross-sectional areas of the shell and roof plates, within a distance of 16 times their thicknesses, measured from their most remote point of attachment to the top angle, shall equal or exceed $\dfrac{DR}{1{,}500}$.

Wherein:

R = radius of curvature of the roof, in feet.

D = nominal diameter of the tank shell, in feet.

t = nominal thickness of the roof plates, in inches.

3.5.11 The top angle sections for self-supporting roofs shall be joined by butt welds having complete penetration and fusion. Joint efficiency factors need not be applied in conforming to the requirements of Par. 3.5.9 and 3.5.10.

3.5.12 For self-supporting roofs, whether of the cone, dome, or umbrella types, the edges of the roof plates, at the option of the manufacturer, may be flanged horizontally to rest flat against the top angle to improve welding conditions.

*The formulas applying to self-supporting roofs provide for a live load of 25 lb. per sq. ft.

3.6 TANK APPURTENANCES

General

3.6.1 When appurtenances are installed on tanks conforming to this specification, the use of appurtenances as specified herein is required, except that alternative designs of appurtenances, other than flush-type, cleanout fittings and bolted door sheets, which provide equivalent strength, tightness, and utility, are permissible if so agreed to by the purchaser. Flush-type cleanout fittings and bolted door sheets shall conform to the designs specified in Par. 3.6.8 and 3.6.11, until existing requirements are revised to permit alternative designs as may be shown to be safe by additional field experience or further development work.

3.6.2 Manhole necks, nozzle necks, reinforcing plates, and shell-plate openings, which have either sheared or oxygen-cut surfaces, shall have such surfaces made uniform and smooth, with the corners rounded, except where such surfaces are fully covered by attachment welds.

Shell Manholes

3.6.3 Shell manholes shall conform to Fig. 7 and Tables 1 through 5. Manhole reinforcing plates, and segments thereof if not made in one piece, shall be provided with a ¼-in. diameter tell-tale hole (for the purpose of detecting leakage through the interior welds). Such holes shall be located substantially on the horizontal centerline and shall be left open to the atmosphere.

3.6.4 Manhole frames may be press-formed or of built-up welded construction. The dimensions listed in the tables are given to cover both types of construction. Allowance has been made for thinning of the neck of the formed type in the pressing operation, or for the minimum neck thickness listed for the built-up type.

3.6.5 The maximum diameter of the shell cutout shall be the sum of the inside diameter of the frame plus four times the attachment flange thickness plus one inch. Dimensions are listed in the tables for a pressed frame using a constant-diameter ring die, and for a built-up frame. The latter dimensions apply conservatively to a pressed frame using a constant-diameter plug die.

Shell Nozzles

3.6.6 Shell nozzles shall conform to Fig. 8 and 9, and Tables 6, 7, and 8. Nozzle reinforcing plates, and segments thereof if not made in one piece, shall be provided with a ¼-in. diameter tell-tale hole, located substantially on the horizontal centerline and left open to the atmosphere.

3.6.7 Details and dimensions specified herein are for nozzles installed with their axes perpendicular to the shell plate. Nozzles may be installed at an angle of other than 90 deg. to the shell plate in a horizontal plane, provided the width of the reinforcing plate (dimension *W*, Fig. 8 and Table 6) is increased by the amount that the horizontal chord of the opening cut in the shell plate (dimension D_p, Fig. 8 and Table 7) increases as the opening changes from circular to elliptical in making the angular installation. In addition, nozzles not larger than 3-in. nominal pipe size, for insertion of thermometer wells, sampling connections, or other purposes not involving the attachment of extended piping, may be installed at an angle of 15 deg. or less, off perpendicular in a vertical plane, without modification of the nozzle reinforcing plate.

Flush-Type Cleanout Fittings

3.6.8 Flush-type cleanout fittings shall conform to Par. 3.3.20, Fig. 10 and Tables 9, 10, and 11.

3.6.9 When a flush-type cleanout fitting is installed on a tank resting on an earth grade without concrete or masonry walls under the tank shells, provision shall be made to support the fitting and retain the grade by either of the following methods.

Method A: Install a vertical steel bulkhead plate under the tank, along the contour of the tank shell and symmetrical with the opening as shown in Fig. 11, Method A.

Method B: Install a concrete or masonry retaining wall under the tank, with its outer face conforming to the contour of the tank shell as shown in Fig. 11, Method B.

3.6.10 When a flush-type cleanout fitting is installed on a tank resting on a ring wall, a notch having the dimensions shown in Fig. 11, Method C, shall be provided to accommodate the cleanout fitting.

3.6.11 When a flush-type cleanout fitting is installed on a tank resting on an earth grade inside a foundation retaining wall, a notch shall be provided in the retaining wall to accommodate the fitting and a supplementary inside retaining wall shall be provided to support the fitting and retain the grade. The dimensions shall be as shown in Fig. 11, Method D.

3.6.12 **Bolted Door Sheets.** Flush-type bolted door sheets shall conform to Fig. 19 and Table 20.

3.6.13 When a flush-type bolted door sheet is installed on a tank resting on an earth grade with or without a concrete retaining wall and without a concrete or masonry wall under the tank shell, provision shall be made to support the fitting and retain the grade by the method shown in Fig. 20, Method A.

3.6.14 When a flush-type bolted door sheet is installed on a tank resting on a ring wall, a cutout having the dimensions shown in Fig. 20, Method B shall be provided.

3.6.15 Raised-type bolted door sheets shall conform to Fig. 21 and Table 21.

3.6.16 **Roof Manholes.** Roof manholes shall conform to Fig. 12 and Table 12. Where work is expected to be carried on through the manhole opening during the use of the tank, it is recommended that the roof structure around the manhole be suitably reinforced.

3.6.17 **Roof Nozzles.** Flanged roof nozzles shall conform to Fig. 13 and Table 13. Threaded nozzles shall conform to Fig. 14 and Table 14.

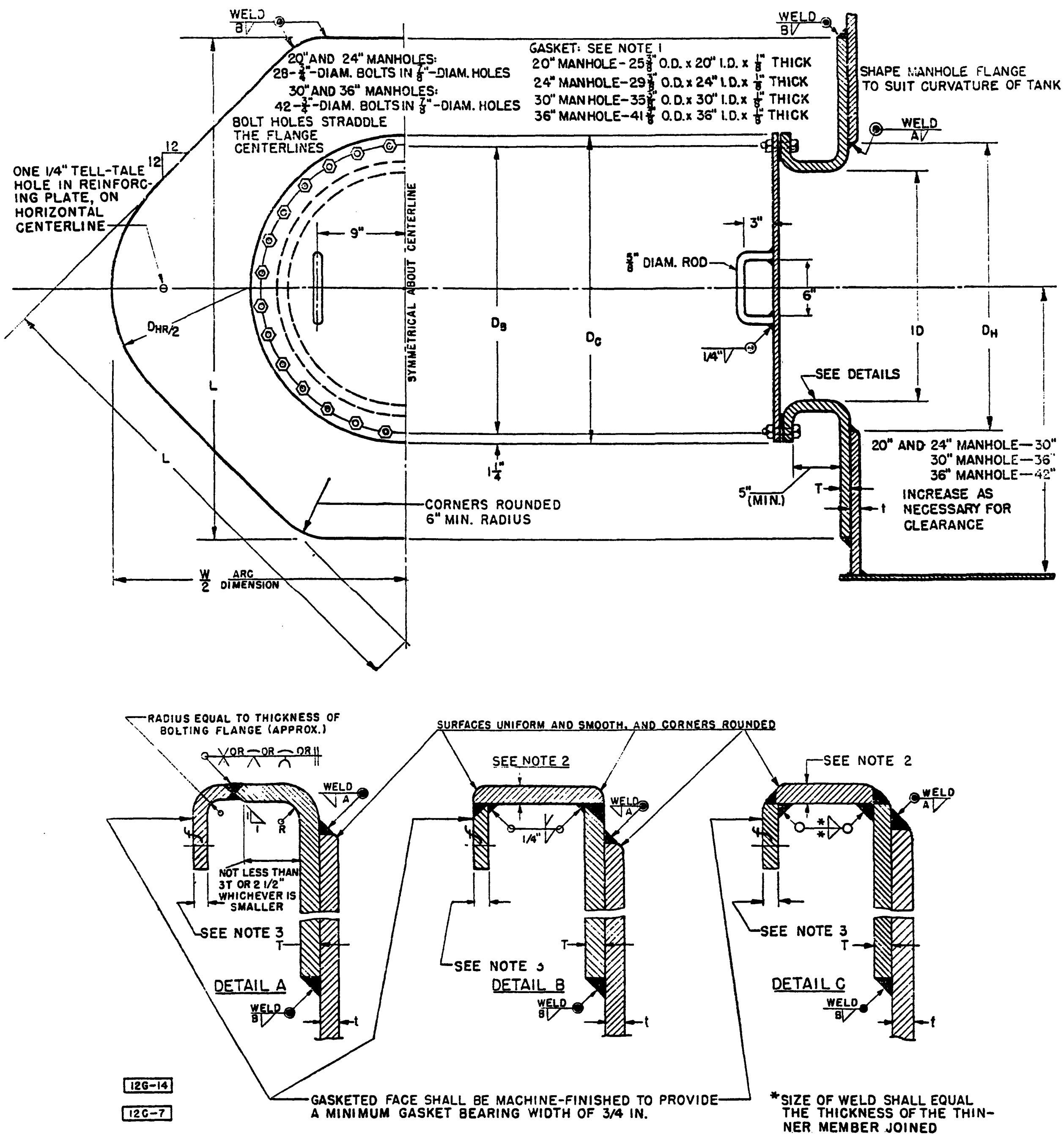
3.6.18 **Water Draw-Off Elbows.** Water draw-off elbows shall conform to Fig. 15 and Table 15. Cast steel fittings conforming to Fig. 16 and Table 16 may be substituted, at purchaser's option, and attached by welding.

3.6.19 **Draw-Off Sumps.** Draw-off sumps shall conform to Fig. 17.

3.6.20 **Scaffold-Cable Support.** Supports for scaffold cables shall conform to Fig. 18.

3.6.21 **Threaded Connections.** Threaded piping connections shall be female, threads to be the API line-pipe thread in accordance with API Std 6A: Threads in Valves, Fittings, and Flanges.

3.6.22 **Platforms, Walkways, and Stairways.** Platforms, walkways, and stairways shall be in accordance with Tables 17, 18, and 19.



ALTERNATIVE DESIGNS OF MANHOLES

NOTE 1: Gasket material shall be long-fiber asbestos sheet, unless otherwise specified.
NOTE 2: See Tables 2 through 5.
NOTE 3: See Table 1.

FIG. 7

SHELL MANHOLE

See Tables 1, 2, 3, 4, and 5

TABLE 1
SHELL MANHOLE COVER PLATE AND BOLTING FLANGE THICKNESS

See Fig. 7. All dimensions in inches except as otherwise stated.

1	2	3	4	5	6	7	8	9	10
Max. Tank Height, ft.	Equivalent Pressure,* psi.	Minimum Cover Plate Thickness				Minimum Bolting Flange Thickness After Finishing			
		20-in. Manhole	24-in. Manhole	30-in. Manhole	36-in. Manhole	20-in. Manhole	24-in. Manhole	30-in. Manhole	36-in. Manhole
21	9.1	5/16	3/8	7/16	1/2	1/4	1/4	5/16	3/8
27	11.7	3/8	7/16	1/2	9/16	1/4	5/16	3/8	7/16
32	13.9	3/8	7/16	9/16	5/8	1/4	5/16	7/16	1/2
40	17.4	7/16	1/2	5/8	11/16	5/16	3/8	1/2	9/16
45	19.5	1/2	9/16	5/8	3/4	3/8	7/16	1/2	5/8
54	23.4	1/2	9/16	11/16	13/16	3/8	7/16	9/16	11/16
65	28.2	9/16	5/8	3/4	7/8	7/16	1/2	5/8	3/4
75	32.5	5/8	11/16	13/16	15/16	1/2	9/16	11/16	13/16

*Equivalent pressure is based on water loadings.

TABLE 2
20-IN. SHELL MANHOLE

See Fig. 7. All dimensions in inches.

1	2	3	4	5	6	7	8	9	10	11
Shell Thickness and Manhole Attachment Flange Thickness[1] *t and T*	Size of Fillet			Attachment Flange		Frame Using Constant-Diameter Ring Die		Built-Up Frame or Frame Using Constant-Diameter Plug Die		
	Weld *A*	Weld *B*	Approx. Radius *R*	Length of Side *L*	Width *W*	Inside Diam. of Manhole Frame ID_R	Max. Diam. of Hole in Shell[3] D_{HR}	Inside Diam. of Manhole Frame ID_P	Max. Diam. of Hole in Shell D_{HP}	Add Reinforcement if Neck Thickness is Less Than[2]
3/16	3/16	3/16	3/16	46	55	22 5/8	24 1/4	20	21 3/4	
1/4	3/16	1/4	1/4	46	55	22 1/2	24 1/2	20	22	
5/16	3/16	5/16	5/16	45 3/4	54 3/4	22 3/8	24 1/2	20	22 1/4	
3/8	3/16	3/8	3/8	45 1/2	54 1/4	22 1/4	24 3/4	20	22 1/2	
7/16	3/16	7/16	7/16	45 1/4	53 3/4	22 1/8	24 3/4	20	22 3/4	
1/2	3/16	1/2	1/2	45	53 1/2	22	25	20	23	
9/16	1/4	9/16	9/16	44 3/4	53	21 7/8	25	20	23 1/4	
5/8	1/4	5/8	5/8	44 3/4	53	21 3/4	25 1/4	20	23 1/2	
11/16	5/16	11/16	11/16	44 1/2	52 1/2	21 5/8	25 1/4	20	23 3/4	
3/4	5/16	3/4	3/4	44 1/4	52 1/4	21 1/2	25 1/2	20	24	
13/16	3/8	13/16	3/4	44	51 3/4	21 3/8	25 1/2	20	24 1/4	5/16
7/8	3/8	7/8	7/8	44	51 3/4	21 1/4	25 3/4	20	24 1/2	3/8
15/16	7/16	15/16	7/8	44 1/4	52	21 1/8	25 3/4	20	24 3/4	7/16
1	1/2	1	1	44 1/2	52 1/4	21	26	20	25	7/16
1 1/16	1/2	1 1/16	1	44 3/4	52 1/2	20 7/8	26	20	25 1/4	7/16
1 1/8	9/16	1 1/8	1	44 3/4	52 1/2	20 3/4	26 1/4	20	25 1/2	1/2
1 3/16	9/16	1 3/16	1	45	52 3/4	20 5/8	26 1/4	20	25 3/4	9/16
1 1/4	5/8	1 1/4	1	45	52 3/4	20 1/2	26 1/2	20	26	5/8
1 5/16	5/8	1 5/16	1	45 1/4	53	20 3/8	26 1/2	20	26 1/4	5/8
1 3/8	11/16	1 3/8	1	45 1/4	53	20 1/4	26 3/4	20	26 1/2	11/16
1 7/16	11/16	1 7/16	1	45 1/2	53 1/4	20 1/8	26 3/4	20	26 3/4	11/16
1 1/2	3/4	1 1/2	1	45 1/2	53 1/4	20	27	20	27	3/4

Diameter of bolt circle D_B=26 1/4 in.   Diameter of cover plate D_O=28 3/4 in.

[1]If a thicker shell plate is used than is required for the hydrostatic loading (Sect. 3.3, Shell Design), the excess shell-plate thickness, within a vertical distance, both above and below the centerline of the hole in the tank shell plate, equal to the vertical dimension of the hole in the tank shell plate, may be considered as reinforcement, and the thickness *T* of the manhole attachment flange may be decreased accordingly. In such cases, the reinforcement and the attachment welding shall conform to the design limits specified in Sect. 3.3, for reinforcement of shell openings.

[2]The minimum neck thickness shall be the thickness of the shell plate, or the allowable finished thickness of the bolting flange (see Table 1), whichever is the thinner, but in no case shall the neck in a built-up manhole be thinner than the thicknesses given in Col. 11. If the neck thickness on a built-up manhole is greater than the required minimum, the manhole attachment flange may be decreased accordingly within the limits specified in Sect. 3.3, Shell Design.

[3]Hole in shell may be made oval, with horizontal major diameter of 29 in. where necessary for removal of rigid scaffold brackets.

TABLE 3
24-IN. SHELL MANHOLE

See Fig. 7. All dimensions in inches.

1	2	3	4	5	6	7	8	9	10	11
	Size of Fillet			Attachment Flange		Frame Using Constant-Diameter Ring Die		Built-Up Frame or Frame Using Constant-Diameter Plug Die		
Shell Thickness and Manhole Attachment Flange Thickness[1] *t and T*	Weld *A*	Weld *B*	Approx. Radius *R*	Length of Side *L*	Width *W*	Inside Diam. of Manhole Frame ID_R	Max. Diam. of Hole in Shell D_{HR}	Inside Diam. of Manhole Frame ID_P	Max. Diam. of Hole in Shell D_{HP}	Add Reinforcement if Neck Thickness is Less Than[2]
3/16	3/16	3/16	3/16	54	65	26 5/8	28 1/4	24	25 3/4	
1/4	3/16	1/4	1/4	54	64 3/4	26 1/2	28 1/2	24	26	
5/16	3/16	5/16	5/16	53 3/4	64 1/2	26 3/8	28 1/2	24	26 1/4	
3/8	3/16	3/8	3/8	53 1/2	64	26 1/4	28 3/4	24	26 1/2	
7/16	3/16	7/16	7/16	53 1/2	64	26 1/8	28 3/4	24	26 3/4	
1/2	3/16	1/2	1/2	53 1/4	63 1/2	26	29	24	27	
9/16	3/16	9/16	9/16	53	63	25 7/8	29	24	27 1/4	
5/8	1/4	5/8	5/8	52 3/4	62 3/4	25 3/4	29 1/4	24	27 1/2	
11/16	1/4	11/16	11/16	52 1/2	62 1/4	25 5/8	29 1/4	24	27 3/4	
3/4	5/16	3/4	3/4	52 1/2	62 1/4	25 1/2	29 1/2	24	28	
13/16	5/16	13/16	3/4	52 1/4	61 3/4	25 3/8	29 1/2	24	28 1/4	
7/8	3/8	7/8	7/8	52 1/4	61 3/4	25 1/4	29 3/4	24	28 1/2	5/16
15/16	3/8	15/16	7/8	52 1/4	61 3/4	25 1/8	29 3/4	24	28 3/4	7/16
1	7/16	1	1	52 3/4	62 1/4	25	30	24	29	7/16
1 1/16	7/16	1 1/16	1	52 3/4	62 1/4	24 7/8	30	24	29 1/4	7/16
1 1/8	1/2	1 1/8	1	53	62 1/2	24 3/4	30 1/4	24	29 1/2	1/2
1 3/16	1/2	1 3/16	1	53	62 1/2	24 5/8	30 1/4	24	29 3/4	9/16
1 1/4	1/2	1 1/4	1	53 1/4	62 3/4	24 1/2	30 1/2	24	30	9/16
1 5/16	9/16	1 5/16	1	53 1/4	62 3/4	24 3/8	30 1/2	24	30 1/4	5/8
1 3/8	9/16	1 3/8	1	53 1/2	63	24 1/4	30 3/4	24	30 1/2	5/8
1 7/16	5/8	1 7/16	1	53 1/2	63	24 1/8	30 3/4	24	30 3/4	11/16
1 1/2	11/16	1 1/2	1	53 3/4	63 1/4	24	31	24	31	3/4

Diameter of bolt circle $D_B = 30\frac{1}{4}$ in. Diameter of cover plate $D_C = 32\frac{3}{4}$ in.

[1]If a thicker shell plate is used than is required for the hydrostatic loading (Sect. 3.3, Shell Design), the excess shell-plate thickness, within a vertical distance, both above and below the centerline of the hole in the tank shell plate, equal to the vertical dimension of the hole in the tank shell plate, may be considered as reinforcement, and the thickness *T* of the manhole attachment flange may be decreased accordingly. In such cases, the reinforcement and the attachment welding shall conform to the design limits specified in Sect. 3.3, for reinforcement of shell openings.

[2]The minimum neck thickness shall be the thickness of the shell plate, or the allowable finished thickness of the bolting flange (see Table 1), whichever is the thinner, but in no case shall the neck in a built-up manhole be thinner than the thicknesses given in Col. 11. If the neck thickness on a built-up manhole is greater than the required minimum, the manhole attachment flange may be decreased accordingly within the limits specified in Sect. 3.3, Shell Design.

TABLE 4
30-IN. SHELL MANHOLE
See Fig. 7. All dimensions in inches.

1	2	3	4	5	6	7	8	9	10	11
Shell Thickness and Manhole Attachment Flange Thickness[1]	Size of Fillet			Attachment Flange		Frame Using Constant-Diameter Ring Die		Built-Up Frame or Frame Using Constant-Diameter Plug Die		
t and T	Weld *A*	Weld *B*	Approx. Radius *R*	Length of Side *L*	Width *W*	Inside Diam. of Manhole Frame ID_R	Max. Diam. of Hole in Shell D_{HR}	Inside Diam. of Manhole Frame ID_P	Max. Diam. of Hole in Shell D_{HP}	Add Reinforcement if Neck Thickness is Less Than[2]
3/16	3/16	3/16	3/16	66	79¼	32⅝	34¼	30	31¾	
¼	3/16	¼	¼	66	79¼	32½	34½	30	32	
5/16	3/16	5/16	5/16	65¾	78¾	32⅜	34½	30	32¼	
⅜	3/16	⅜	⅜	65¾	78¾	32¼	34¾	30	32½	
7/16	3/16	7/16	7/16	65¼	78	32⅛	34¾	30	32¾	
½	3/16	½	½	65¼	78	32	35	30	33	
9/16	3/16	9/16	9/16	65	77½	31⅞	35	30	33¼	
⅝	¼	⅝	⅝	64¾	77	31¾	35¼	30	33½	
11/16	¼	11/16	11/16	64½	76¾	31⅝	35¼	30	33¾	
¾	¼	¾	¾	64½	76¾	31½	35½	30	34	
13/16	5/16	13/16	¾	64¼	76¼	31⅜	35½	30	34¼	
⅞	5/16	⅞	⅞	64¼	76¼	31¼	35¾	30	34½	5/16
15/16	5/16	15/16	⅞	64¼	76¼	31⅛	35¾	30	34¾	7/16
1	⅜	1	1	64¾	76¾	31	36	30	35	7/16
1 1/16	⅜	1 1/16	1	64¾	76¾	30⅞	36	30	35¼	7/16
1⅛	7/16	1⅛	1	65	77	30¾	36¼	30	35½	½
1 3/16	7/16	1 3/16	1	65	77	30⅝	36¼	30	35¾	9/16
1¼	7/16	1¼	1	65¼	77¼	30½	36½	30	36	9/16
1 5/16	½	1 5/16	1	65¼	77¼	30⅜	36½	30	36¼	⅝
1⅜	½	1⅜	1	65½	77½	30¼	36¾	30	36½	⅝
1 7/16	9/16	1 7/16	1	65½	77½	30⅛	36¾	30	36¾	11/16
1½	9/16	1½	1	65¾	77¾	30	37	30	37	¾

Diameter of bolt circle D_B=36¼ in. Diameter of cover plate D_O=38¾ in.

[1]If a thicker shell plate is used than is required for the hydrostatic loading (Sect. 3.3, Shell Design), the excess shell-plate thickness, within a vertical distance, both above and below the centerline of the hole in the tank shell plate. equal to the vertical dimension of the hole in the tank shell plate, may be considered as reinforcement, and the thickness *T* of the manhole attachment flange may be decreased accordingly. In such cases, the reinforcement and the attachment welding shall conform to the design limits specified in Sect. 3.3, for reinforcement of shell openings.

[2]The minimum neck thickness shall be the thickness of the shell plate, or the allowable finished thickness of the bolting flange (see Table 1), whichever is the thinner, but in no case shall the neck in a built-up manhole be thinner than the thicknesses given in Col. 11. If the neck thickness on a built-up manhole is greater than the required minimum, the manhole attachment flange may be decreased accordingly within the limits specified in Sect. 3.3, Shell Design.

TABLE 5
36-IN. SHELL MANHOLE
See Fig. 7. All dimensions in inches.

1	2	3	4	5	6	7	8	9	10	11
Shell Thickness and Manhole Attachment Flange Thickness[1] *t and T*	Size of Fillet			Attachment Flange		Frame Using Constant-Diameter Ring Die		Built-Up Frame or Frame Using Constant-Diameter Plug Die		
	Weld *A*	Weld *B*	Approx. Radius *R*	Length of Side *L*	Width *W*	Inside Diam. of Manhole Frame ID_R	Max. Diam. of Hole in Shell D_{HR}	Inside Diam. of Manhole Frame ID_P	Max. Diam. of Hole in Shell D_{HP}	Add Reinforcement if Neck Thickness is Less Than[2]
3/16	3/16	3/16	3/16	78	93 3/4	38 5/8	40 1/4	36	37 3/4	
1/4	3/16	1/4	1/4	78	93 3/4	38 1/2	40 1/2	36	38	
5/16	3/16	5/16	5/16	77 3/4	93 1/4	38 3/8	40 1/2	36	38 1/4	
3/8	3/16	3/8	3/8	77 3/4	93 1/4	38 1/4	40 3/4	36	38 1/2	
7/16	3/16	7/16	7/16	77 1/4	92 1/2	38 1/8	40 3/4	36	38 3/4	
1/2	3/16	1/2	1/2	77 1/4	92 1/2	38	41	36	39	
9/16	3/16	9/16	9/16	77	92	37 7/8	41	36	39 1/4	
5/8	1/4	5/8	5/8	76 3/4	91 1/2	37 3/4	41 1/4	36	39 1/2	
11/16	1/4	11/16	11/16	76 1/2	91 1/4	37 5/8	41 1/4	36	39 3/4	
3/4	1/4	3/4	3/4	76 1/2	91	37 1/2	41 1/2	36	40	
13/16	5/16	13/16	3/4	76 1/4	90 3/4	37 3/8	41 1/2	36	40 1/4	
7/8	5/16	7/8	7/8	76 1/4	90 3/4	37 1/4	41 3/4	36	40 1/2	
15/16	5/16	15/16	7/8	76 1/4	90 3/4	37 1/8	41 3/4	36	40 3/4	7/16
1	3/8	1	1	76 3/4	91 1/4	37	42	36	41	7/16
1 1/16	3/8	1 1/16	1	76 3/4	91 1/4	36 7/8	42	36	41 1/4	7/16
1 1/8	3/8	1 1/8	1	77	91 1/2	36 3/4	42 1/4	36	41 1/2	1/2
1 3/16	7/16	1 3/16	1	77	91 1/2	36 5/8	42 1/4	36	41 3/4	9/16
1 1/4	7/16	1 1/4	1	77 1/4	91 3/4	36 1/2	42 1/2	36	42	9/16
1 5/16	7/16	1 5/16	1	77 1/4	91 3/4	36 3/8	42 1/2	36	42 1/4	5/8
1 3/8	1/2	1 3/8	1	77 1/2	92	36 1/4	42 3/4	36	42 1/2	5/8
1 7/16	1/2	1 7/16	1	77 1/2	92	36 1/8	42 3/4	36	42 3/4	11/16
1 1/2	9/16	1 1/2	1	77 3/4	92 1/4	36	43	36	43	3/4

Diameter of bolt circle $D_B = 42\frac{1}{4}$ in.   Diameter of cover plate $D_C = 44\frac{3}{4}$ in.

[1] If a thicker shell plate is used than is required for the hydrostatic loading (Sect. 3.3, Shell Design), the excess shell-plate thickness, within a vertical distance, both above and below the centerline of the hole in the tank shell plate, equal to the vertical dimension of the hole in the tank shell plate, may be considered as reinforcement, and the thickness *T* of the manhole attachment flange may be decreased accordingly. In such cases, the reinforcement and the attachment welding shall conform to the design limits specified in Sect. 3.3, for reinforcement of shell openings.

[2] The minimum neck thickness shall be the thickness of the shell plate, or the allowable finished thickness of the bolting flange (see Table 1), whichever is the thinner, but in no case shall the neck in a built-up manhole be thinner than the thicknesses given in Col. 11. If the neck thickness on a built-up manhole is greater than the required minimum, the manhole attachment flange may be decreased accordingly within the limits specified in Sect. 3.3, Shell Design.

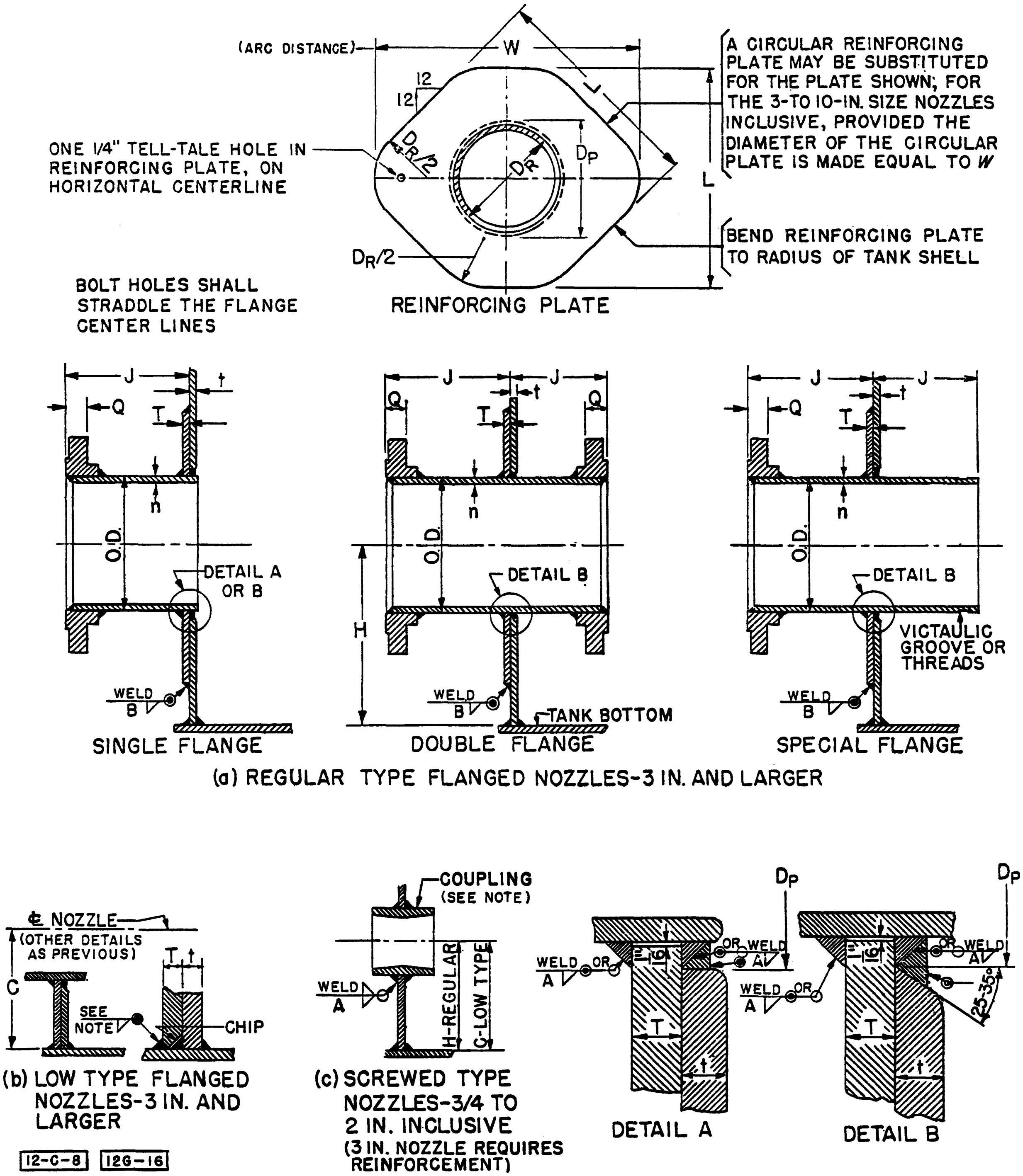


Illustration (b): See Par. 3.3.18 regarding size of welds.

Illustration (c): See Par. 3.6.21: Threaded Connections, regarding couplings used in shell nozzles.

FIG. 8

SHELL NOZZLES

See Tables 6, 7, and 8

TABLE 6
SHELL NOZZLES

See Fig. 8. All dimensions in inches.

	1	2	3	4	5	6	7	8	9
								Distance from Bottom of Tank to Center of Nozzle, min.	
	Size of Nozzle	O.D. of Pipe	Flanged Nozzle Pipe Wall Thickness, min. (1) n	Diameter of Hole in Reinf. Plate D_R	Length of Side of Reinf. Plate L	Width of Reinf. Plate W	Distance Shell to Flange Face, min. J	Regular Type H	Low Type C
Flanged Fittings	36	36	See Table 7, Col. 2	36⅛	72¾	88	14	40	36⅝
	34	34		34⅛	68¾	83¼	13	38	34⅝
	32	32		32⅛	64¾	78½	13	36	32⅝
	30	30		30⅛	60¾	73½	12	34	30⅝
	28	28		28⅛	56¾	68¾	12	32	28⅝
	26	26		26⅛	52¾	64	12	30	26⅝
	24	24	0.50	24⅛	49½	60	12	28	24¾
	22	22	0.50	22⅛	45½	55¼	11	26	22¾
	20	20	0.50	20⅛	41½	50½	11	24	20¾
	18	18	0.50	18⅛	37½	45¾	10	22	18¾
	16	16	0.50	16⅛	33½	40¾	10	20	16¾
	14	14	0.50	14⅛	29½	36	10	18	14¾
	12	12¾	0.50	12⅞	27	33	9	17	13½
	10	10¾	0.50	10⅞	23	28¼	9	15	11½
	8	8⅝	0.50	8¾	19	23¼	8	13	9½
	6	6⅝	0.432	6¾	15¾	19½	8	11	7⅞
	4	4½	0.337	4⅝	12	15¼	7	9	6
	3	3½	0.300	3⅝	10½	13½	7	8	5¼
	*2	2⅜	0.218	2½	--------	--------	6	7	3½
	*1½	1.90	0.200	2	--------	--------	6	6	3
Screwed Fittings	†3	4.00	Coupling	4⅛	11¼	14¼	----	9	5⅝
	*2	2.875	"	3	--------	--------	----	7	3
	*1½	2.200	"	2⅜	--------	--------	----	6	3
	*1	1.576	"	1 11/16	--------	--------	----	5	3
	* ¾	1.313	"	1 7/16	--------	--------	----	4	3

[1]Extra-strong pipe, API Std 5L for sizes up to 12 in. incl.; over 12 in to 24 in. incl. ASTM A 53, A 134, A 135, or A 139, of latest issue. Pipe made from formed plate electrically butt welded, may be substituted for any of the above mentioned pipe sections.

*Flanged and screwed nozzles in 2-in. pipe size and smaller do not require reinforcing plates. D_R will be the diameter of the hole in the shall plate and Weld A will be as given in Col. 6, Table 7. Reinforcing plates may be used if desired.

†Screwed nozzle in the 3-in. pipe size requires reinforcement.

TABLE 7

SHELL NOZZLES: PIPE, PLATE, AND WELDING SCHEDULES

See Fig. 8. All dimensions in inches.

1	2	3	4	5	6
Shell Thickness and Reinf. Plate Thickness [1] *t and T*	36", 34", 32", 30", 28" and 26" Flanged Nozzle Pipe Wall Thickness, min. [2] *n*	Maximum Diameter of Hole in Shell Plate *(D_p)* Equals OD of Pipe Plus the Following Values	Size of Fillet Weld *B*	Size of Fillet Weld *A* for Nozzles Larger than 2"	Size of Fillet Weld *A* for Nozzles 2", 1½", 1" and ¾"
3/16	½	⅝	3/16	¼	¼
¼	½	⅝	¼	¼	¼
5/16	½	⅝	5/16	¼	¼
⅜	½	⅝	⅜	¼	¼
7/16	½	⅝	7/16	¼	¼
½	½	⅝	½	¼	5/16
9/16	½	⅝	9/16	¼	5/16
⅝	½	¾	⅝	5/16	5/16
11/16	½	¾	11/16	5/16	5/16
¾	½	¾	¾	5/16	5/16
13/16	½	15/16	13/16	⅜	5/16
⅞	½	15/16	⅞	⅜	5/16
15/16	½	15/16	15/16	⅜	5/16
1	½	1 1/16	1	7/16	5/16
1 1/16	9/16	1 1/16	1 1/16	7/16	5/16
1⅛	9/16	1 1/16	1⅛	7/16	5/16
1 3/16	⅝	1¼	1 3/16	½	5/16
1¼	⅝	1¼	1¼	½	5/16
1 5/16	11/16	1¼	1 5/16	½	5/16
1⅜	11/16	1⅜	1⅜	9/16	5/16
1 7/16	¾	1⅜	1 7/16	9/16	5/16
1½	¾	1⅜	1½	9/16	5/16

[1]If a thicker shell plate is used than is required for the hydrostatic loading (Sect. 3.3, Shell Design), the excess shell plate thickness, within a vertical distance, both above and below the centerline of the hole in the tank shell plate, equal to the vertical dimension of the hole in the tank shell plate, may be considered as reinforcement, and the thickness *T* of the manhole attachment flange may be decreased accordingly. In such cases, the reinforcement and the attachment welding shall conform to the design limits specified in Sect. 3.3, for reinforcement of shell openings.

[2]API Std 5LX; ASTM A 134, A 135, or A 139 of latest issue. Pipe made from formed plate electrically butt welded, may be substituted for any of the above mentioned pipe sections.

TABLE 8
SHELL NOZZLE FLANGES*
See Fig. 9. All dimensions in inches.

1	2	3	4	5	6	7	8	9	10	11	12
								Diameter of Bore		Diameter of Hub at Point of Welding, min.	
Size of Nozzle	Thickness of Flange, min. Q	Outside Diameter of Flange A	Diameter of Raised Face D	Diameter of Bolt Circle C	Number of Holes	Diameter of Holes	Diameter of Bolts	Slip-On Type Add to OD of Pipe B	Welding-Neck Type B_1	Slip-On Type E	Welding-Neck Type E_1
36	2⅜	46	40¼	42¾	32	1⅝	1½	0.25	Same as Inside Diameter of Pipe	Outside Diameter of Pipe Plus 2n	Outside Diameter of Pipe
34	2 5/16	43¾	37¾	40½	32	1⅝	1½	0.25			
32	2¼	41¾	35¾	38½	28	1⅝	1½	0.25			
30	2⅛	38¾	33¾	36	28	1⅜	1¼	0.25			
28	2 1/16	36½	31¼	34	28	1⅜	1¼	0.25			
26	2	34¼	29¼	31¾	24	1⅜	1¼	0.25			
24	1⅞	32	27¼	29½	20	1⅜	1¼	0.19			
22	1 13/16	29½	25¼	27¼	20	1⅜	1¼	0.19			
20	1 11/16	27½	23	25	20	1¼	1⅛	0.19			
18	1 9/16	25	21	22¾	16	1¼	1⅛	0.19			
16	1 7/16	23½	18½	21¼	16	1⅛	1	0.19			
14	1⅜	21	16¼	18¾	12	1⅛	1	0.19			
12	1¼	19	15	17	12	1	⅞	0.13			
10	1 3/16	16	12¾	14¼	12	1	⅞	0.13			
8	1⅛	13½	10⅝	11¾	8	⅞	¾	0.10			
6	1	11	8½	9½	8	⅞	¾	0.10			
4	15/16	9	6 3/16	7½	8	¾	⅝	0.06			
3	15/16	7½	5	6	4	¾	⅝	0.06			
2	¾	6	3⅝	4¾	4	¾	⅝	0.07			
1½	11/16	5	2⅞	3⅞	4	⅝	½	0.07			

*The facing dimensions for slip-on and welding-neck flanges in sizes 1½ in. through 20 in., and size 24 in. are identical with those specified in ASA B16.5 for 150-lb. steel flanges. The facing dimensions for flanges in sizes 24, 30, and 36 in. are in agreement with ASA B16.1 for 125-lb. cast-iron flanges. The dimensions for flanges in sizes 22, 26, 28, 32, and 34 in. (which are not included in above ASA standards) conform to manufacturer's standards.

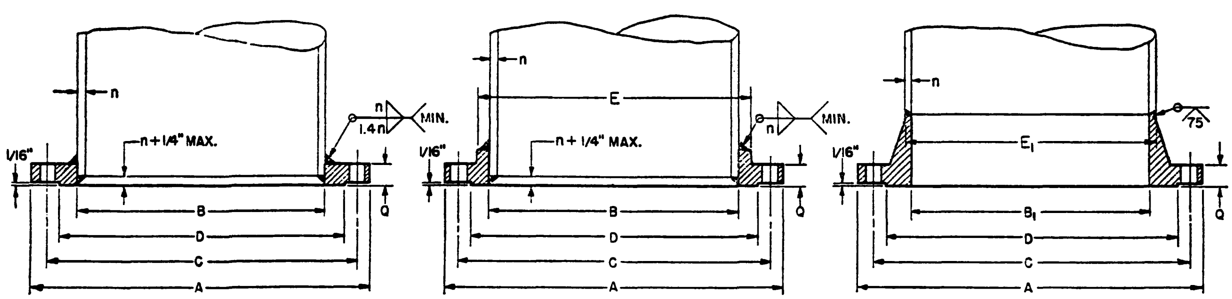


PLATE-RING SLIP-ON WELDING FLANGE

HUB SLIP-ON WELDING FLANGE

WELDING-NECK FLANGE

FIG. 9
SHELL NOZZLE FLANGES
See Table 8

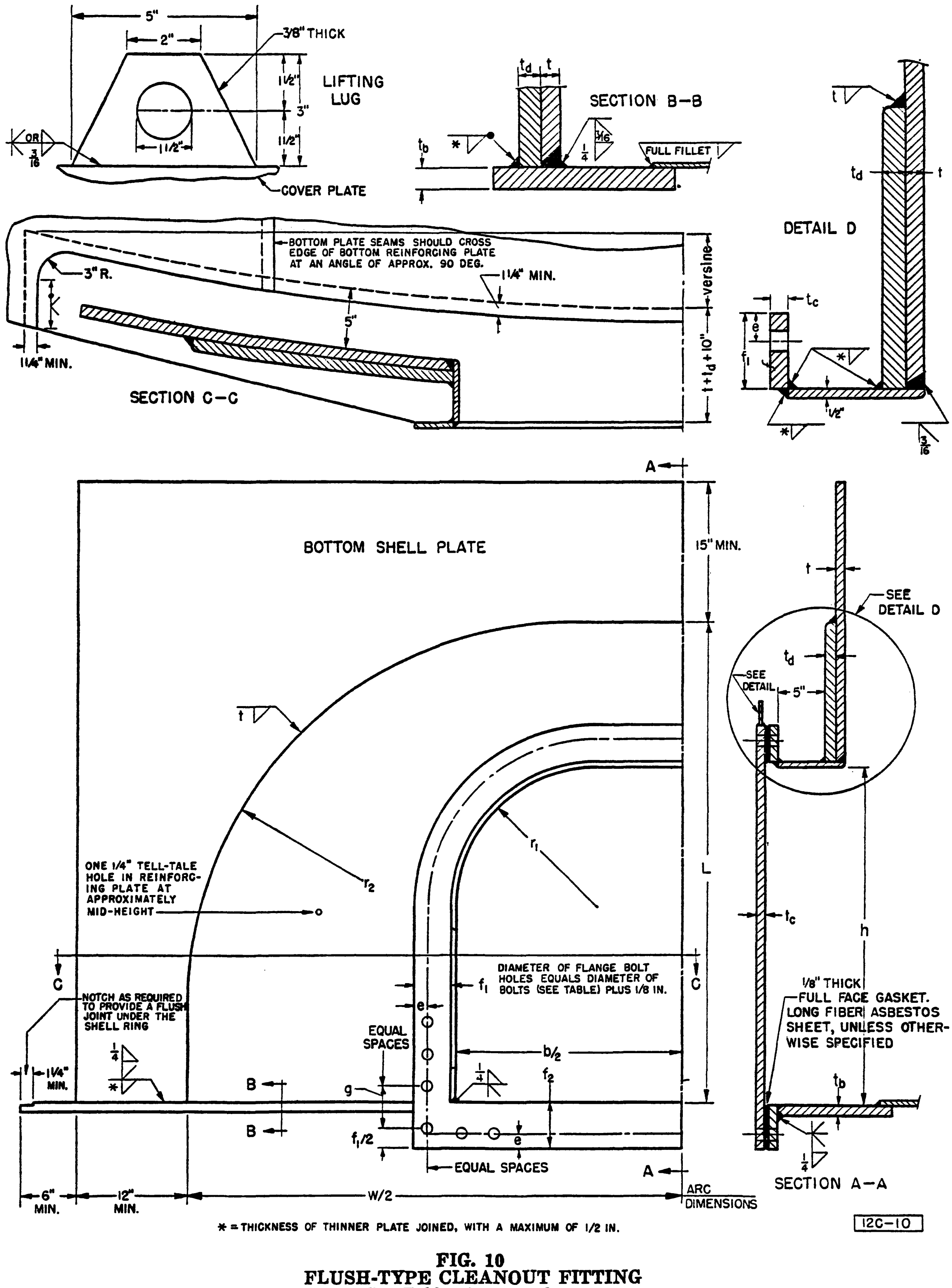


FIG. 10
FLUSH-TYPE CLEANOUT FITTING
See Tables 9, 10, and 11

TABLE 9
FLUSH-TYPE CLEANOUT FITTINGS
See Fig. 10. All dimensions in inches.

1	2	3	4	5	6	7	8	9	10	11
Height of Opening h	Arc Width of Opening b	Arc Width of Shell Reinforcing Plate W	Upper Corner Radius of Opening r_1	Upper Corner Radius of Shell Reinforcing Plate r_2	Edge Distance of Bolts e	Flange Width (Except at Bottom) f_1	Bottom Flange Width f_2	Special Bolt Spacing[1] g	Number of Bolts	Diameter of Bolts
8	16	46	3¼	14	1¼	3½	3½	3¼	22	¾
24	24	72	8	29	1¼	3½	3¾	3½	36	¾
36	48	106	15	41	1½	4	4¾	4¼	46	1
48	48	125	16	51½	1½	4	5	4½	52	1

[1]Spacing at lower corners of cleanout fitting flange. See Fig. 10.

TABLE 10
COVER PLATE, BOLTING FLANGE, AND BOTTOM REINFORCING PLATE THICKNESSES FOR FLUSH-TYPE CLEANOUT FITTINGS
See Fig. 10. All dimensions in inches, except as otherwise stated.

1	2	3	4	5	6	7	8	9	10
		Size of Opening (height h x width b)							
		8 x 16		24 x 24		36 x 48		48 x 48	
Maximum Tank Height, ft. H	Equivalent Pressure*, psi.	Bolting Flange and Cover Plate Thickness, min. t_c	Bottom Reinforcing Plate Thickness t_b	Bolting Flange and Cover Plate Thickness, min. t_c	Bottom Reinforcing Plate Thickness t_b	Bolting Flange and Cover Plate Thickness, min. t_c	Bottom Reinforcing Plate Thickness t_b	Bolting Flange and Cover Plate Thickness, min. t_c	Bottom Reinforcing Plate Thickness t_b
20	8.7	⅜	½	⅜	½	⅝	13/16	⅝	⅞
34	14.7	⅜	½	½	½	¾	1	13/16	1⅛
41	17.8	⅜	½	½	9/16	⅞	1⅛	⅞	1 3/16
53	23	⅜	½	9/16	⅝	15/16	1¼	1	1 5/16
60	26	7/16	½	⅝	11/16	1	1 5/16	1⅛	1⅜

*Equivalent pressure based on water loading.

TABLE 11
THICKNESS AND HEIGHT OF SHELL REINFORCING PLATE FOR CLEANOUT FITTINGS

See Fig. 10. All dimensions in inches, except as otherwise stated.

1	2	3	4	5	6	7	8	9	10
		Size of Opening (height h x width b)							
		8 x 16		24 x 24		36 x 48		48 x 48	
Shell Thickness t	Maximum Tank Height, ft. H	Thickness of Shell Reinforcing Plate t_d	Height of Shell Reinforcing Plate L	Thickness of Shell Reinforcing Plate t_d	Height of Shell Reinforcing Plate L	Thickness of Shell Reinforcing Plate t_d	Height of Shell Reinforcing Plate L	Thickness of Shell Reinforcing Plate t_d	Height of Shell Reinforcing Plate L
3/16	70	1/4	14	5/16	34 1/4	5/16	51 3/4	5/16	68 1/4
1/4	70	5/16	14	3/8	35 1/4	3/8	53	3/8	70 1/2
5/16	70	3/8	14	7/16	35 3/4	7/16	54	7/16	72
3/8	31	7/16	14	1/2	35	9/16	52 1/2	9/16	70 1/2
	70	7/16	14	1/2	36	9/16	53	9/16	70 1/2
7/16	33	9/16	14	5/8	33 3/4	5/8	53	5/8	71 1/2
	70	9/16	14	5/8	35	5/8	53 1/2	5/8	71 1/2
1/2	33	5/8	14	11/16	33 1/2	11/16	53	11/16	72
	70	5/8	14	11/16	35	11/16	54	3/4	70 1/2
9/16	29	11/16	14	3/4	33 1/4	11/16	54	3/4	72
	59	11/16	14	3/4	34 1/2	3/4	54	13/16	71 1/4
5/8	32	3/4	14	7/8	33 1/4	3/4	54	7/8	70 3/4
	58	3/4	14	7/8	33 1/2	13/16	54	7/8	71 3/4
	70	3/4	14	7/8	33 3/4	7/8	53	7/8	72
11/16	36	13/16	14	15/16	33 1/4	13/16	54	15/16	71 1/4
	60	13/16	14	15/16	33 1/4	7/8	54	15/16	72
3/4	41	7/8	14	1	33 1/4	7/8	54	1	71 1/2
	65	7/8	14	1	33 1/4	15/16	54	1 1/16	71
13/16	46	1	14	1 1/8	33 1/4	15/16	54	1 1/8	70 1/2
	70	1	14	1 1/8	33 1/4	1	54	1 1/8	71 1/4
7/8	48	1 1/16	14	1 3/16	33 1/4	1 1/16	52 3/4	1 3/16	70 1/2
	70	1 1/16	14	1 3/16	33 1/4	1 1/16	53 3/4	1 3/16	71 1/4
15/16	48	1 1/8	14	1 1/4	33 1/4	1 1/8	52 1/4	1 1/4	70 1/2
	70	1 1/8	14	1 1/4	33 1/4	1 1/8	53 1/2	1 1/4	71 1/4
1	48	1 3/16	14	1 3/8	33 1/4	1 3/16	51 3/4	1 3/8	69 1/4
	70	1 3/16	14	1 3/8	33 1/4	1 3/16	53	1 3/8	70 1/4
1 1/16	48	1 1/4	14	1 7/16	33 1/4	1 1/4	51 3/4	1 7/16	69
	70	1 1/4	14	1 7/16	33 1/4	1 1/4	52 1/2	1 7/16	70 1/4
1 1/8	48	1 5/16	14	1 1/2	33 1/4	1 5/16	51 3/4	1 1/2	68 3/4
	70	1 5/16	14	1 1/2	33 1/4	1 5/16	52	1 1/2	70
1 3/16	48	1 7/16	14	1 5/8	33 1/4	1 5/8	51 3/4	1 5/8	67 3/4
	70	1 7/16	14	1 5/8	33 1/4	1 5/8	51 3/4	1 5/8	69
1 1/4	70	1 1/2	14	1 11/16	33 1/4	1 7/16	51 3/4	1 11/16	68 3/4
1 5/16	70	1 9/16	14	1 3/4	33 1/4	1 9/16	51 3/4	1 3/4	68 1/2
1 3/8	70	1 5/8	14	1 13/16	33 1/4	1 5/8	51 3/4	1 13/16	68 1/4
1 7/16	70	1 11/16	14	1 15/16	33 1/4	1 11/16	51 3/4	1 15/16	67 1/4
1 1/2	70	1 3/4	14	2	33 1/4	1 3/4	51 3/4	2	67

NOTE: Dimensions t_d and L may be varied within the limits defined in Par. 3.3.20 through 3.3.23.

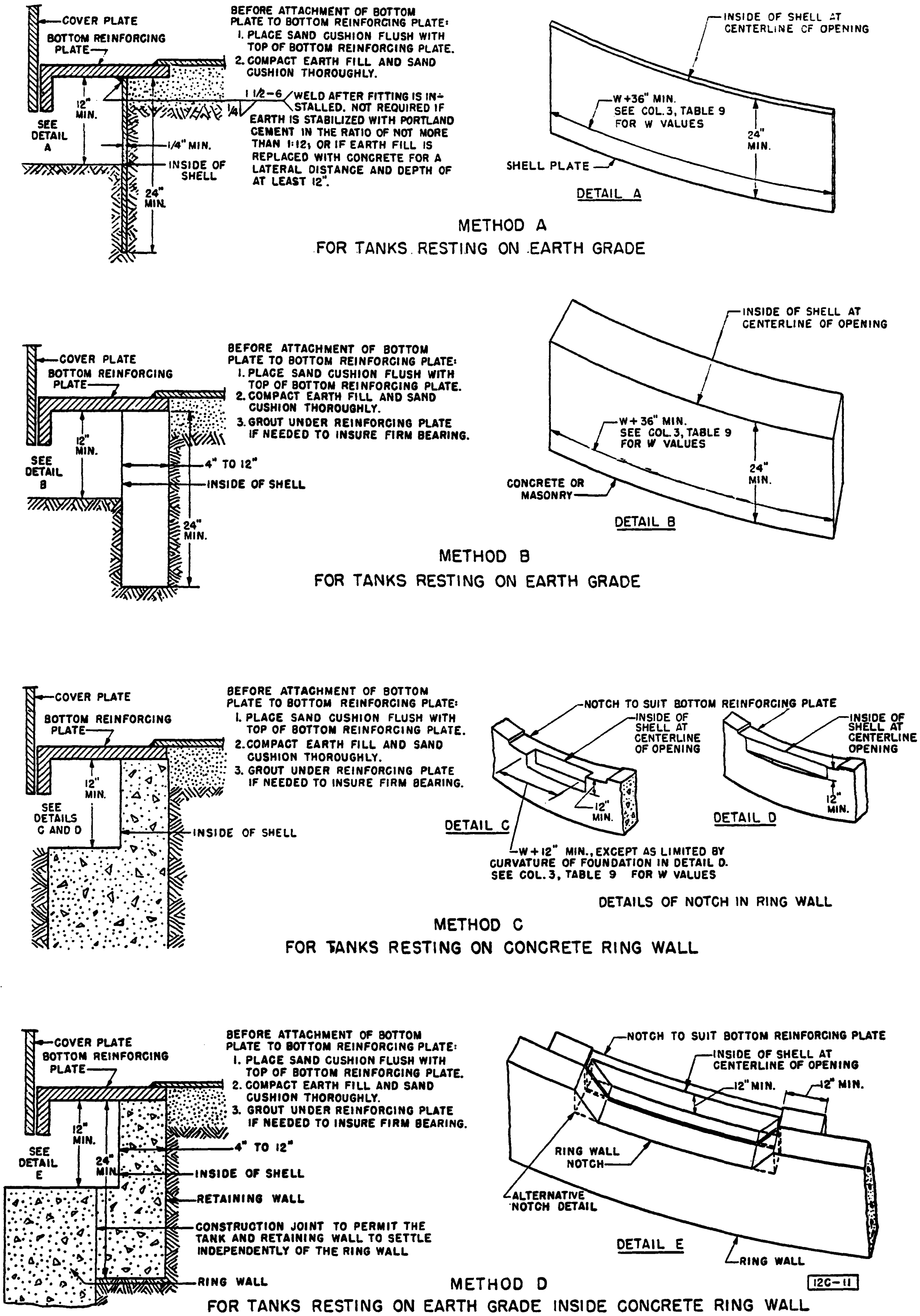


FIG. 11
FLUSH-TYPE CLEANOUT-FITTING SUPPORTS
See Par. 3.6.9, 3.6.10, and 3.6.11

TABLE 12
ROOF MANHOLES

See Fig. 12. All dimensions in inches.

1	2	3	4	5	6	7	8	9
Size of Manhole	Inside Diameter of Neck *ID*	Cover Plate Diameter D_C	Bolt Circle Diameter D_B	Number of Bolts	Gasket Diameter *ID*	*OD*	Hole Diameter in Roof or Reinforcing Plate D_P	Outside Diameter of Reinforcing Plate D_R
20	20	26	23½	16	20	26	20⅝	42
24	24	30	27½	20	24	30	24⅝	46

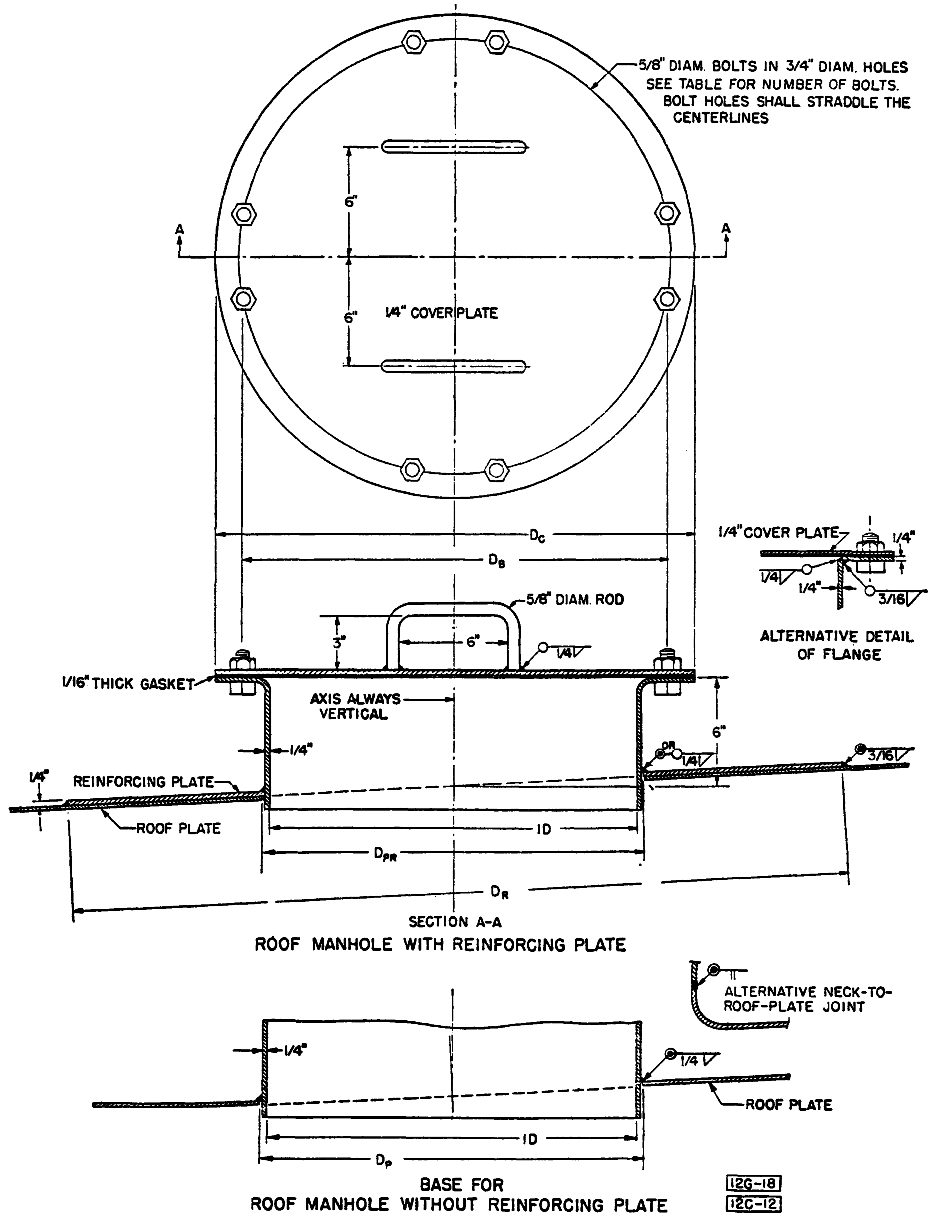


FIG. 12
ROOF MANHOLES
See Table 12

TABLE 13
FLANGED ROOF NOZZLES

See Fig. 13. All dimensions in inches.

1	2	3	4	5
Nominal Size of Nozzle	Outside Diameter of Pipe Neck	Diameter of Hole in Roof Plate or Reinforcing Plate D_P	Height of Nozzle H	Outside Diameter of Reinforcing Plate D_R
1½	1.900	2	6	5*
2	2⅜	2½	6	7*
3	3½	3⅝	6	9*
4	4½	4⅝	6	11*
6	6⅝	6¾	6	15*
8	8⅝	8⅞	6	18
10	10¾	11	8	22
12	12¾	13	8	24

*Reinforcing plates are not required on 6-in. and smaller nozzles, but may be used if desired.

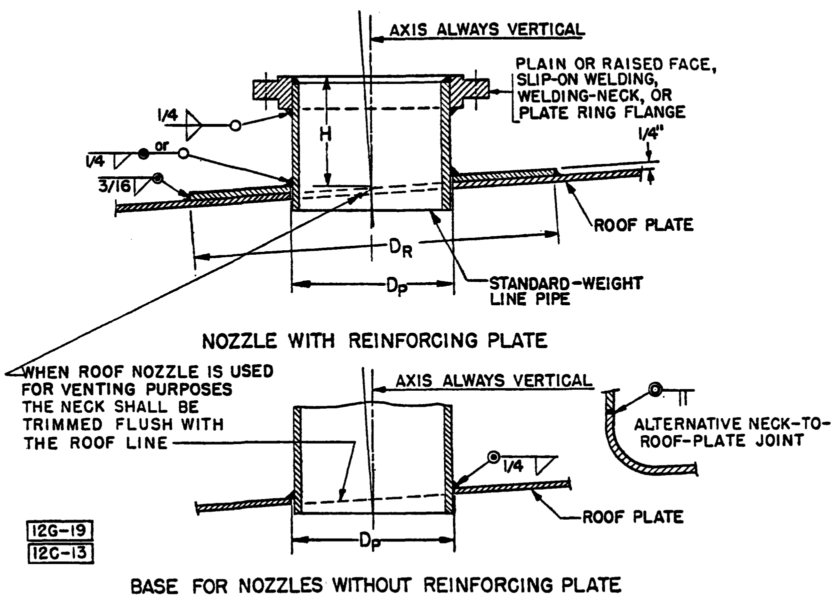


FIG. 13
FLANGED ROOF NOZZLES
See Table 13

Requirements:

1. Slip-on welding and welding-neck flanges shall conform to the requirements for 150-lb. forged carbon-steel raised-face flanges as given in ASA B16.5.
2. Plate ring flanges shall conform to all dimensional requirements for slip-on welding flanges except that the extended hub on the back of the flange may be omitted.

TABLE 14
SCREWED ROOF NOZZLES

See Fig. 14. All dimensions in inches.

1	2	3	4
Nominal Size of Nozzle	Nominal Size of Coupling	Diameter of Hole in Roof Plate or Reinforcing Plate D_P	Diameter of Reinforcing Plate D_R
¾	¾	$1\frac{7}{16}$	4*
1½	1½	$2\frac{11}{32}$	5*
1½	1½	$2\frac{11}{32}$	5*
2	2	3	7*
3	3	4⅛	9*
4	4	$5\frac{11}{32}$	11*
6	6	$7\frac{17}{32}$	15*
8	8	9⅞	18
10	10	12	22
12	12	14¼	24

*Reinforcing plates are not required on 6-in. and smaller nozzles, but may be used if desired.

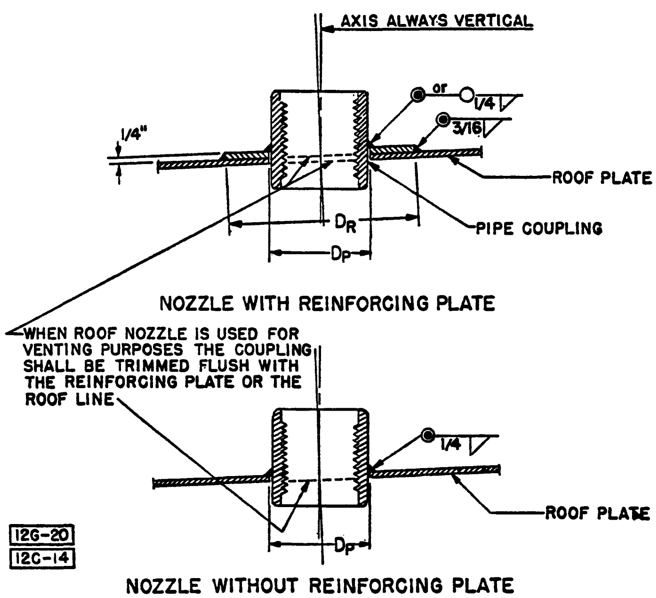


FIG. 14
SCREWED ROOF NOZZLES
See Table 14

See Par. 3.6.21 for thread requirements.

TABLE 15
WELDED WATER DRAW-OFF ELBOW

See Fig. 15. All dimensions in inches.

1	2	3	4	5	6
Nominal Pipe Size ([1])	Distance Center of Elbow to Shell *B*	Distance Center of Outlet to Bottom *C*	Diameter of Hole in Tank Bottom D_P	Diameter of Reinforcing Plate D_R	Distance Center of Elbow to Face of Outlet Flange *E*
2	7½	6	3⅛	6¼	12
3	8½	7	4¼	7¾	13
4	9½	7$\frac{13}{16}$	5¼	9¾	14
6	11	9⅝	7⅜	12¾	16
8	13	12⅜	9⅜	16½	18

[1]Extra-strong pipe, API Std 5L.

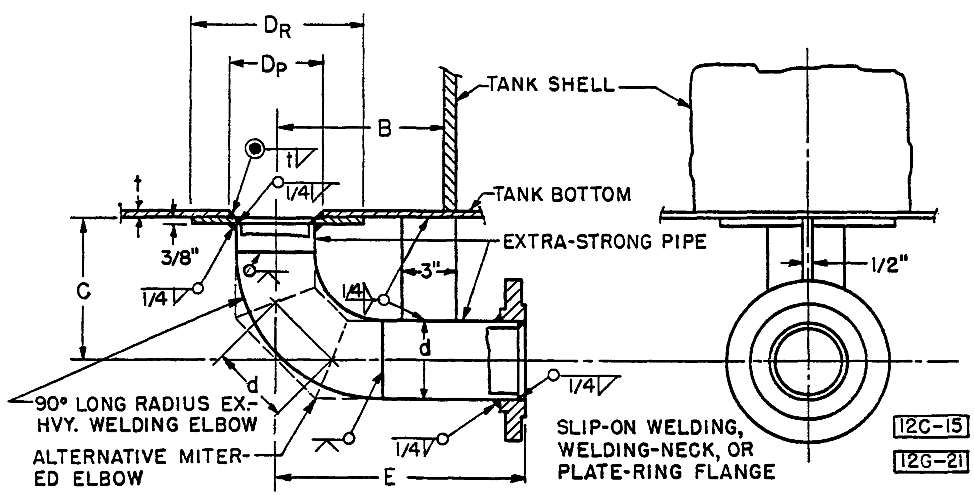


FIG. 15
WELDED WATER DRAW-OFF ELBOW
See Table 15

Requirements:

1. Slip-on welding and welding-neck flanges shall conform to the requirements for 150-lb. forged carbon-steel raised-face flanges as given in ASA B16.5.
2. Plate ring flanges shall conform to all dimensional requirements for slip-on welding flanges except that the extended hub on the back of the flange may be omitted. Plate material for ring flanges shall conform to the requirements of Par. 2.1 or to ASTM A 201, grade A.

TABLE 16
CAST STEEL WATER DRAW-OFF ELBOW

See Fig. 16. All dimensions in inches.

1	2	3	4	5
	SIZE A			
	2	4	6	8
B=Thickness of Walls	1/2	9/16	11/16	3/4
Tank Flange				
C=Diameter of Flange	7	10	13	15
D=Thickness of Flange	5/8	15/16	1	1 1/8
Pipe Flange				
J=Diameter of Flange	6	9	11	13 1/2
K=Thickness of Flange	5/8	15/16	1	1 1/8
L=Diameter of Bolt Circle	4 3/4	7 1/2	9 1/2	11 3/4
M=Number of Bolts	4	8	8	8
N=Size of Bolts	5/8	5/8	3/4	3/4
P=Size of Holes	3/4	3/4	7/8	7/8
Q=Diameter of Raised Face	3 5/8	6 3/16	8 1/2	10 5/8
R=Centerline of Ell to Face of Tank Flange	5 1/2	7 1/2	9	10 1/4
S=Centerline of Tank Flange to Centerline of Pad	7 1/2	9	10 1/2	11 1/2
T=Centerline of Tank Flange to Face of Pipe Flange	16	18	20	22
U=Width of Pad	2 1/4	2 5/8	3	3 3/8
V=Thickness of Pad	1 5/16	1 9/16	1 13/16	2 1/16
For Through Bolting				
W	2 7/8	3 3/4	5 1/16	6 1/4
X	7 3/4	9 3/4	12 5/8	15 1/4
Y	3/4	7/8	1	1 1/8

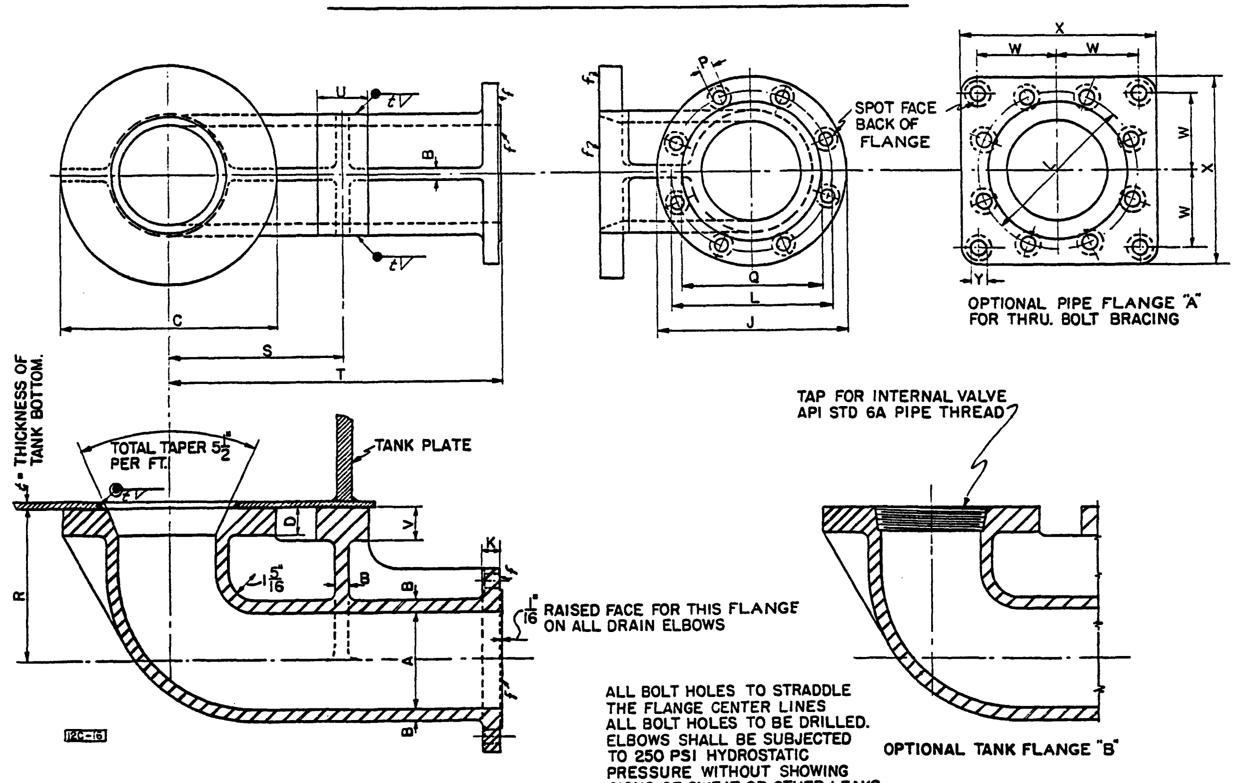
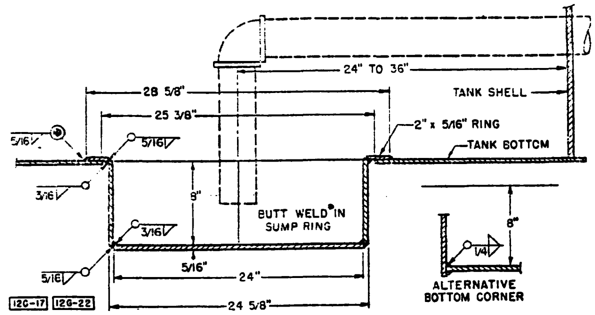


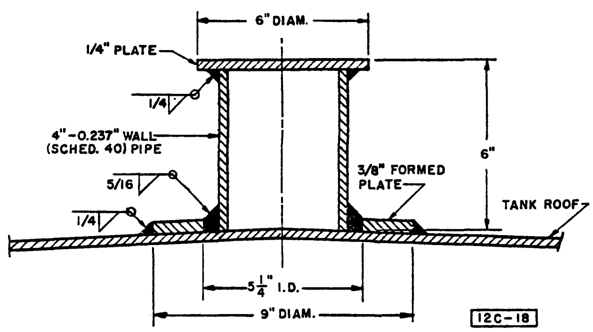
FIG. 16
CAST-STEEL WATER DRAW-OFF ELBOW
See Table 16



Erection Procedure:

1. Cut hole in bottom plate.
2. Make neat excavation to conform to shape of draw-off sump.
3. Place and weld sump.

FIG. 17
DRAW-OFF SUMP



NOTE: Where seams or other attachments are located at the center of the tank roof, the scafford support shall be located as near to the center as possible.

FIG. 18
SCAFFOLD CABLE SUPPORT

TABLE 17

PLATFORMS AND WALKWAYS

1. All parts to be made of metal.
2. Width of floor level (minimum)........................24"
3. Flooring of grating or non-slip material.
4. Height of top railing above floor([1])...................42"
5. Height of toe board (minimum)........................ 3"
6. Space between top of floor and bottom of toe board (maximum) ....¼"
7. Height of mid-rail—approximately ½ the distance top of walkway to top of railing.
8. Distance between railing posts (maximum)....96"
9. The completed structure shall be capable of supporting a moving concentrated load of 1000 lb. and the hand railing structure shall be capable of withstanding a load of 200 lb. applied in any direction at any point on the top rail.
10. Railings to be on both sides of platform, discontinuing where necessary for access.
11. At handrail openings any space between the tank and the platform wider than 6 in. should be floored.
12. 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 jointly 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.*

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[1]Handrail height as required by ASA specifications: mandatory in some states.

TABLE 18

STAIRWAYS

1. All parts to be made of metal.
2. Width of stairs (minimum)..................................24"
3. Angle* of stairway with a horizontal line (maximum) ....50°
4. Width of stair treads (minimum)...................... 8"
   The run (defined as the horizontal distance between the noses of successive tread-pieces) and the rise shall be such that the sum of twice the rise, plus the run, shall be not less than 24 in. nor more than 26 in. Rises shall be uniform throughout the height of the stairway.
5. Treads of grating or non-slip material.
6. Top railing shall join the platform hand rail without offset, and the height measured vertically from tread level at nose of tread shall be ....30-34"
7. Distance between railing posts (maximum) measured along the slope of railing..................96"
8. The completed structure shall be capable of supporting a moving concentrated load of 1000 lb. and the hand railing structure shall be capable of withstanding a load of 200 lb. applied in any direction at any point on the top rail.
9. Hand rails shall be on both sides of straight stairs, also on circular stairs when the clearance between tank shell and stair stringer exceeds 8 in.
10. Circumferential stairways should be completely supported on the shell of the tank and ends of the stringers should be clear of the ground.

---

*For tank stairways the preferred angle appears to be approximately 45 deg. It is recommended that the same angle be employed for all stairways in a tank group or plant area.

TABLE 19

STAIRWAY RISE, RUN, AND ANGLE RELATIONSHIPS

Height of Rise, in. *R*	$2R + r = 24$ in. Width of Run, in. *r*	Angle, deg.	Angle, min.	$2R + r = 26$ in. Width of Run, in. *r*	Angle, deg.	Angle, min.
5¼	13½	21	15	....	....	....
5½	13	22	56	15	20	09
5¾	12½	24	43	14½	21	38
6	12	26	34	14	23	12
6¼	11½	28	30	13½	24	53
6½	11	30	35	13	26	34
6¾	10½	32	45	12½	28	23
7	10	35	00	12	30	15
7¼	9½	38	20	11½	32	13
7½	9	39	50	11	34	18
7¾	8½	42	22	10½	36	26
8	8	45	00	10	38	40
8¼	7½	47	43	9½	41	00
8½	....	....	....	9	43	23
8¾	....	....	....	8½	45	49
9	....	....	....	8	48	22

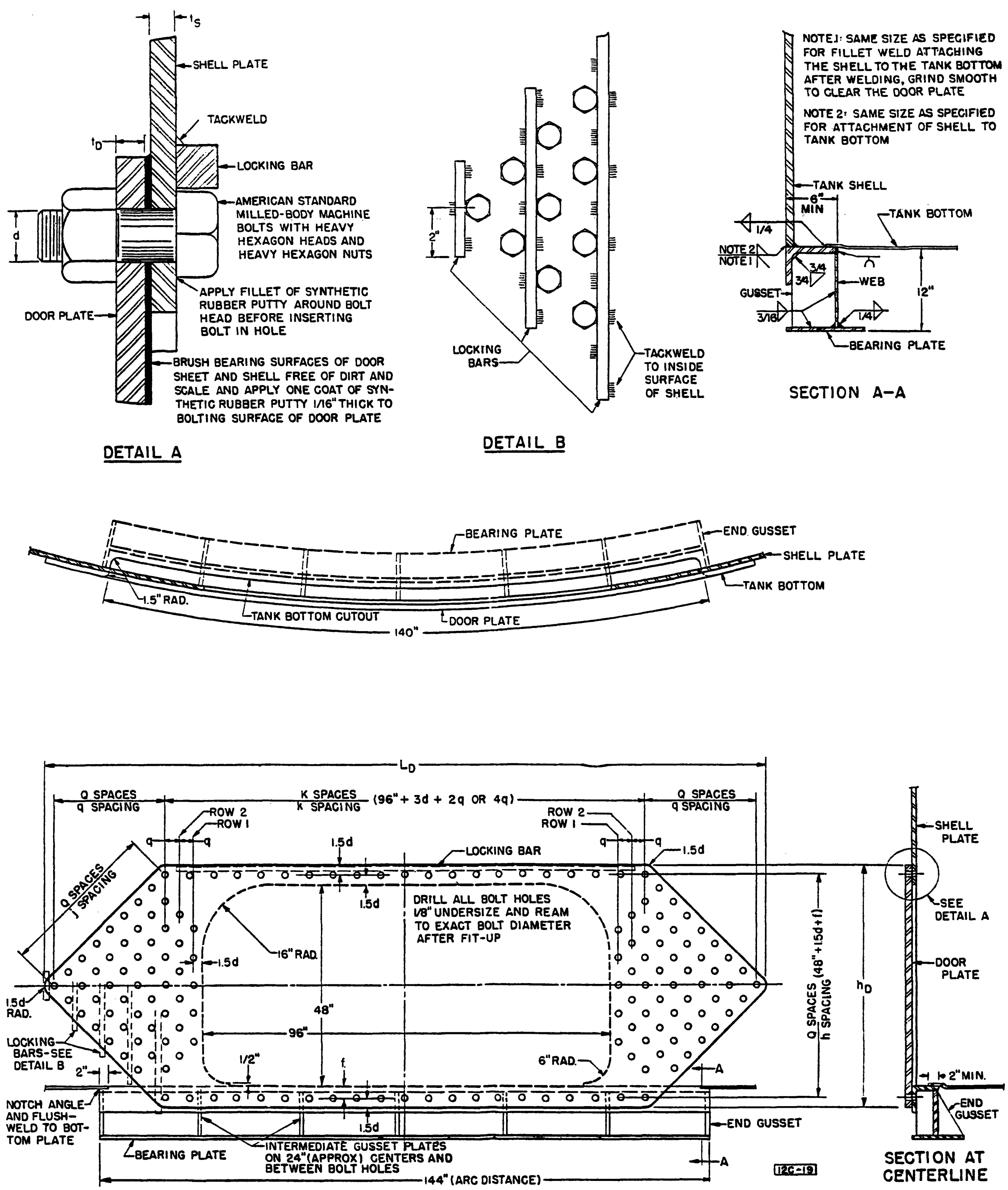


FIG. 19

FLUSH-TYPE BOLTED DOOR SHEET

See Table 20

TABLE 20

FUSH-TYPE BOLTED DOOR SHEETS

See Fig. 19. All dimensions in inches.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Shell Thickness t_s	Q	q	h	j	K	k	t_D	h_D	f	L_D	No. of Bolts Row 1	No. of Bolts Row 2	No. of Bolts Total	Diam. of Bolt d	Lgth. of Bolt	Lgth. Bolt Thd.	Sq. Lock Bar	Angle	Web	Intermediate Gusset	End Gusset	Bearing Plate
¼	7	1 15/16	7.375	4.165	36	2.837	7/16	53⅞	2½	132	....	7	156	¾	2	1⅛	⅝	6x4x⅜	¼x11⅝	¼x5 x11⅝	¼x8x11⅝	¼x9
5/16	8	1 15/16	6.453	3.766	30	3.275	7/16	53⅞	2½	132	....	....	146	¾	2	1 1/16	⅝	6x4x⅜	¼x11⅝	¼x5 x11⅝	¼x8x11⅝	¼x9
⅜	8	1 15/16	6.453	3.766	30	3.404	7/16	53⅞	2½	136	3	6	164	¾	2	1	⅝	6x4x⅜	¼x11⅝	¼x5 x11⅝	¼x8x11⅝	¼x9
7/16	8	2¼	6.477	3.945	24	4.297	½	54 7/16	2½	142⅜	....	2	138	⅞	2¼	1⅛	¾	6x4x½	⅜x11⅜	⅜x5 x11⅜	⅜x8x11⅜	⅜x9
½	8	2¼	6.477	3.945	22	4.892	9/16	54 7/16	2½	146⅞	3	6	148	⅞	2½	1¼	¾	6x4x½	⅜x11⅜	⅜x5 x11⅜	⅜x8x11⅜	⅜x9
9/16	8	2 7/16	6.500	4.063	20	5.194	⅝	55	2½	146⅝	....	2	130	1	2¾	1⅜	¾	6x4x⅝	⅜x11¼	⅜x5 x11¼	⅜x8x11¼	⅜x9
⅝	8	2 7/16	6.500	4.063	20	5.194	11/16	55	2½	146⅝	....	6	138	1	2½	1¼	¾	6x4x⅝	⅜x11¼	⅜x5 x11¼	⅜x8x11¼	⅜x9
11/16	8	2⅞	6.586	4.371	20	4.969	¾	56 1/16	3	149⅞	....	....	126	1⅛	2¾	1⅜	1	6x4x¾	⅜x11⅛	⅜x5 x11⅛	⅜x8x11⅛	⅜x9
¾	8	2⅞	6.586	4.371	20	5.256	⅞	56 1/16	3	155⅝	....	4	134	1⅛	3	1½	1	6x4x¾	⅜x11⅛	⅜x5 x11⅛	⅜x8x11⅛	⅜x9
13/16	8	3 1/16	6.609	4.504	20	4.988	15/16	56⅝	3	154	....	....	126	1¼	3¼	1⅝	1	6x6x⅞	½x10⅞	½x4½x10⅞	½x8x10⅞	½x9
⅞	8	3 1/16	6.609	4.504	20	5.294	1	56⅝	3	160	....	2	130	1¼	3¼	1½	1	8x6x⅞	½x10⅞	½x4½x10⅞	½x8x10⅞	½x12
1	8	3 1/16	6.609	4.504	20	5.600	1⅛	56⅝	3	166¼	3	6	144	1¼	3½	1⅜	1	8x6x1	½x10¾	½x4½x10¾	½x8x10¾	½x12
1⅛	8	3¼	6.633	4.645	20	5.383	1 5/16	57 3/16	3	164½	....	6	138	1⅜	3¾	1½	1	8x6x1	½x10¾	½x4½x10¾	½x8x10¾	½x12
1¼	8	3¼	6.633	4.645	20	5.656	1 7/16	57 3/16	3	171	5	6	148	1⅜	4¼*	1 11/16	1	8x6x1	½x10¾	½x4½x10¾	½x8x10¾	½x12
1⅜	8	3 7/16	6.656	4.785	20	5.713	1⅝	57¾	3	175¾	3	6	144	1½	4½*	1 11/16	1	8x6x1	½x10¾	½x4½x10¾	½x8x10¾	½x12
1½	8	3 7/16	6.656	4.785	20	5.713	1¾	57¾	3	175¾	5	6	148	1½	5*	1⅞	1	8x6x1	½x10¾	½x4½x10¾	½x8x10¾	½x12

NOTE: Use American Standard washers on both sides of plate to ⅝ in. shell thickness.

*Special length bolts shall be furnished for bolting the bottom of the door sheet to the supporting truss.

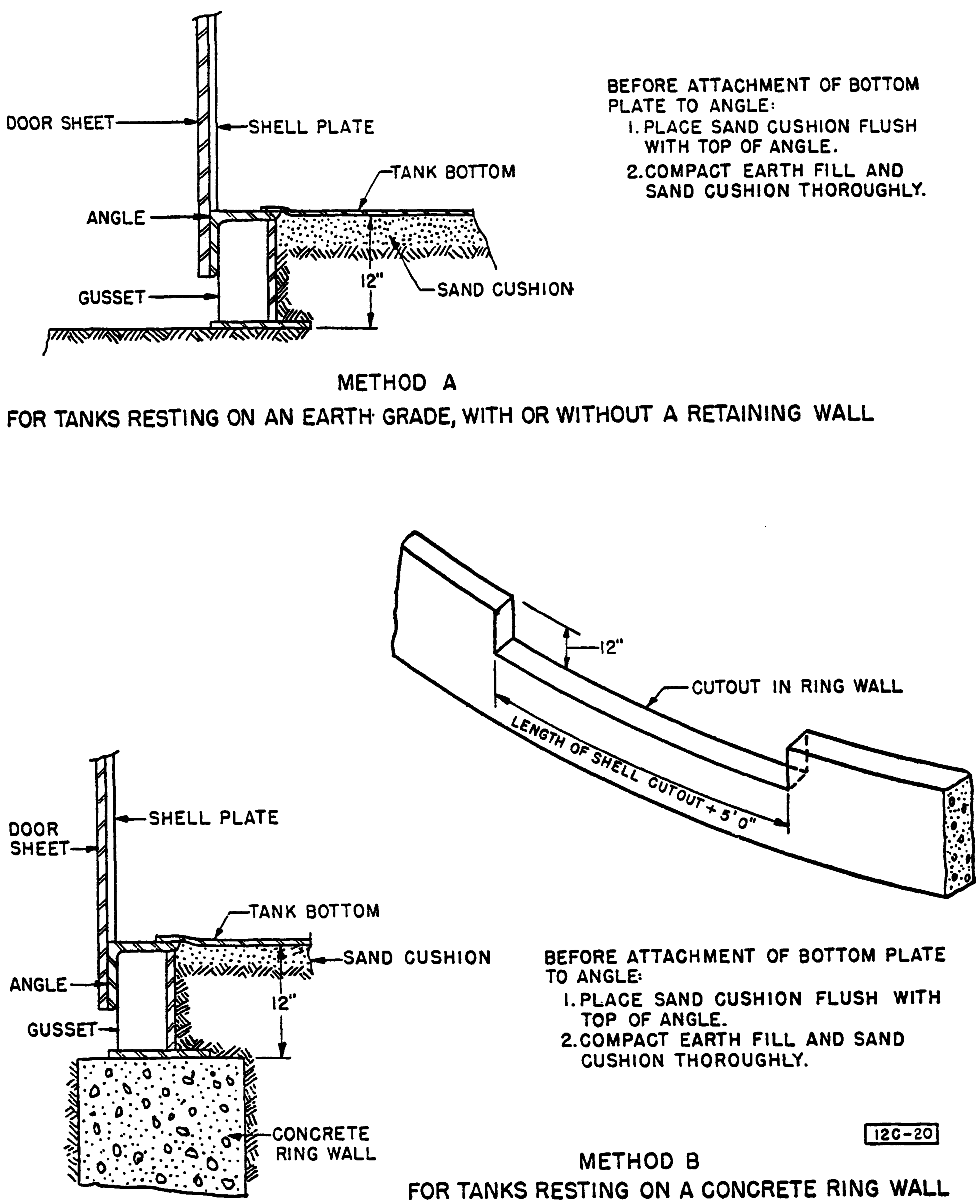
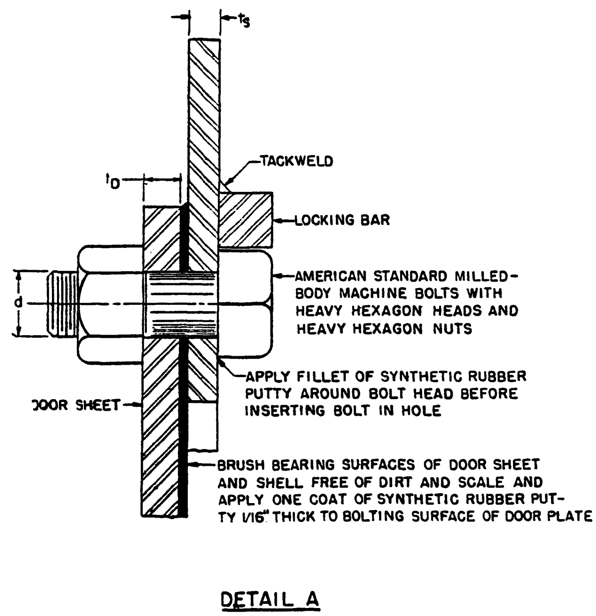
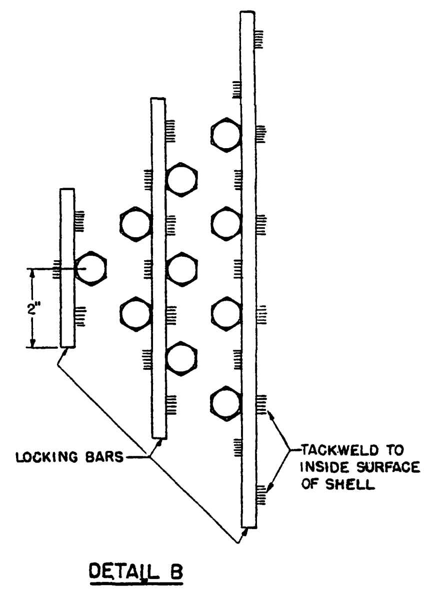


FIG. 20
FLUSH-TYPE BOLTED DOOR SHEET SUPPORTS





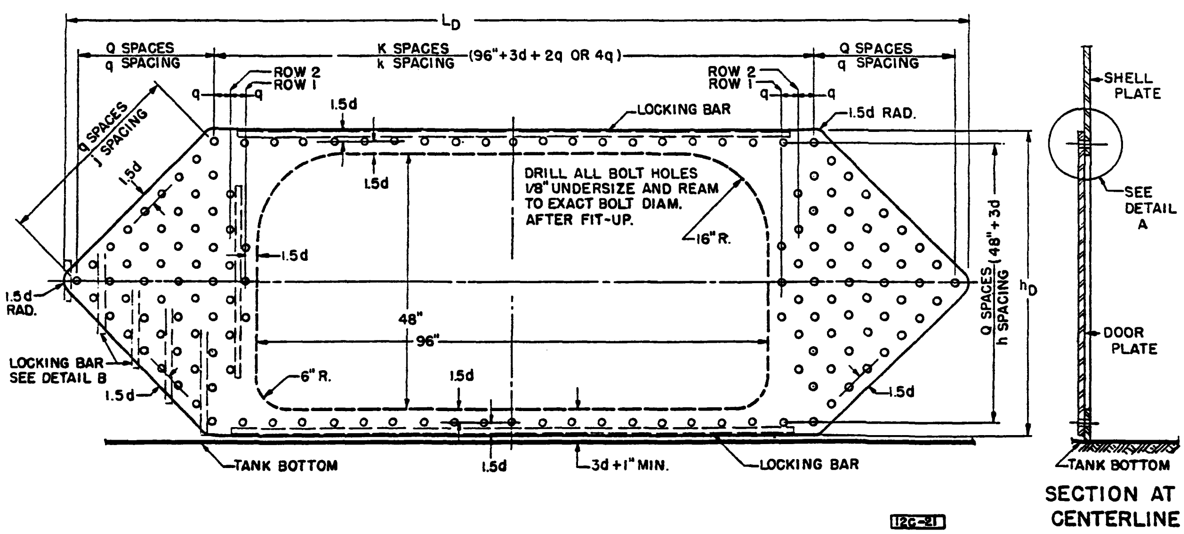


FIG. 21
RAISED-TYPE BOLTED DOOR SHEET
See Table 21

TABLE 21
RAISED-TYPE BOLTED DOOR SHEETS

See Fig. 21. All dimensions in inches.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Shell Thickness t_s	Q	q	h	j	K	k	t_D	h_D	L_D	No. of Bolts Row 1	Row 2	Total	Diam. of Bolt d	Lgth. of Bolt	Bolt Thd. Lgth.	Square Locking Bar
1/4	7	1 15/16	7.179	4.080	36	2.837	7/16	52 1/2	131 7/8	....	5	152	3/4	2	1 1/8	5/8
5/16	7	1 15/16	7.179	4.080	30	3.404	7/16	52 1/2	131 7/8	....	7	144	3/4	2	1 1/16	5/8
3/8	8	1 15/16	6.281	3.691	30	3.404	7/16	52 1/2	135 7/8	....	8	164	3/4	2	1	5/8
7/16	8	2 1/4	6.328	3.883	24	4.109	1/2	53 1/4	137 3/4	....	....	136	7/8	2 1/4	1 1/8	3/4
1/2	8	2 1/4	6.328	3.883	22	4.688	9/16	53 1/4	142 3/8	....	6	144	7/8	2 1/2	1 1/4	3/4
9/16	8	2 7/16	6.375	4.012	20	4.950	5/8	54	141 5/8	....	....	128	1	2 3/4	1 3/8	3/4
5/8	8	2 7/16	6.375	4.012	20	5.194	3/4	54	146 5/8	....	4	136	1	2 1/2	1 1/4	3/4
11/16	8	2 7/8	6.422	4.309	20	4.969	13/16	54 3/4	149 3/4	....	....	128	1 1/8	2 3/4	1 3/8	1
3/4	8	2 7/8	6.422	4.309	20	5.256	7/8	54 3/4	155 5/8	....	2	132	1 1/8	3	1 1/2	1
13/16	8	3 1/16	6.469	4.453	20	4.988	15/16	55 1/2	153 5/8	....	....	128	1 1/4	3 1/4	1 5/8	1
7/8	8	3 1/16	6.469	4.453	20	4.988	1	55 1/2	153 5/8	....	....	128	1 1/4	3 1/4	1 1/2	1
1	8	3 1/16	6.469	4.453	20	5.294	1 3/16	55 1/2	160 1/8	....	6	140	1 1/4	3 1/2	1 7/16	1
1 1/8	8	3 1/16	6.469	4.453	20	5.600	1 3/8	55 1/2	166 1/4	5	8	154	1 1/4	3 3/4	1 3/8	1
1 1/4	8	3 1/4	6.516	4.602	20	5.656	1 1/2	56 1/4	171	3	6	146	1 3/8	4 1/4	1 5/8	1
1 3/8	8	3 1/4	6.516	4.602	20	5.656	1 11/16	56 1/4	171	7	8	158	1 3/8	4 1/2	1 9/16	1
1 1/2	8	3 7/16	6.563	4.754	20	5.712	1 13/16	57	175 3/4	5	6	150	1 1/2	5	1 13/16	1

NOTE: Use American Standard washers on both sides of plate up to 5/8 in. shell thickness.

4. FABRICATION

4.1 GENERAL

Workmanship

4.1.1 All work of fabricating API standard tanks shall be done in accordance with this specification, with the permissible alternatives specified in the inquiry or order form. The workmanship and finish shall be first class in every respect, subject to the closest inspection by the manufacturer inspector, whether or not the purchaser waives any part of the inspection.

4.1.2 When material requires straightening, the work shall be done by pressing or other non-injurious method, prior to any layout or shaping. Heating or hammering is not permissible unless the material is heated to a forging temperature.

4.1.3 Finish of Plate Edges. The edges of plates may be sheared, machined, chipped, or machine oxygen cut. Shearing shall be limited to 3/8-in. thickness of plates for butt-welded joints and to 5/8-in. thickness for lap-welded joints. When edges of plates are oxygen cut, the resulting surface shall be uniform and smooth, and freed of scale and slag accumulations before welding. A fine film of rust adhering after wire brushing on cut or sheared edges that are to be welded, need not be removed. Circumferential edges of roof and bottom plates may be manually oxygen cut.

4.1.4 Shaping of Shell Plates. Shell plates shall be shaped to suit the curvature of the tank and the erection procedure according to the following schedule:

Nominal Plate Thickness, in.	Nominal Tank Diameter, ft.
3/16 to 3/8, excl.	40 and less
3/8 to 1/2, excl.	60 and less
1/2 to 5/8, excl.	120 and less
5/8 and over	all

4.1.5 Marking. All special plates, when cut to shape before shipment, and roof-supporting structural members shall be marked as shown on the manufacturer's drawings.

4.1.6. Shipping. Plates and tank material shall be loaded on cars in such manner as to insure delivery without damage. Bolts, nuts, railing connections, nipples, and other small parts shall be boxed, or put in kegs or bags for shipment.

4.2 SHOP INSPECTION

4.2.1 The purchaser inspector shall be permitted free entry to all parts of the manufacturer's works concerned with the contract, whenever any work under the contract is being performed. The manufacturer shall afford the purchaser inspector, free of cost to purchaser, all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification, and shall furnish free of cost to purchaser any samples or specimens of materials for the purpose of qualifying welders in accordance with Sect. 7.3. 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 the mill will roll the plates and when fabrication will be started, so that the purchaser inspector may be on hand when required. The usual mill test of plates shall be deemed sufficient to prove the quality of the steel furnished (except as noted in Par. 4.2.2). Mill test reports shall be furnished to the purchaser when requested.

4.2.2 Mill and shop inspection shall not release the manufacturer from responsibility for replacing any defective material and repairing any defective workmanship that may be discovered in the field.

4.2.3 Any material or workmanship which in any way fails to meet the requirements of this specification will be rejected by the purchaser inspector, and the material involved shall not be used under the contract. Material which shows injurious defects subsequent to its acceptance at the mill, at the manufacturer's works, or during erection and test of the tank, will be rejected and the manufacturer will be notified to this effect in writing and required promptly to furnish new materials and make the necessary replacements or make suitable repairs.

5. ERECTION

5.1 GENERAL

5.1.1 The subgrade for receiving the tank bottom shall be provided by the purchaser, unless otherwise specified on the purchase order, and shall be uniform and level.

5.1.2 The manufacturer shall furnish all labor, tools, welding equipment and cables, false work, scaffolding, and other equipment necessary for the erection of tanks complete and ready for use. Power for welding shall be supplied by the manufacturer, unless other arrangements are made in the purchase order.

5.1.3 No paint or foreign material shall be used between surfaces in contact in the construction of the tank proper.

5.1.4 Paint or other protection for structural work inside and outside of the tank shall be as specified on the order and shall be applied by competent workmen.

5.1.5 For any riveted work on attachments to tank, or in structural work, the requirements of API Std 12A shall be followed.

5.1.6 Holes made for erection purposes shall be closed by any of the methods specified in Part 6: Testing Shell Joints, as applicable to holes through butt welds in plates of similar thickness.

5.1.7 Lugs attached by welding to the exterior of the tank, and needed only for purposes of erection, shall be removed and any noticeable projections of weld metal chipped from the plate. The plate must not be gouged or torn in the process of removing lugs.

5.2 DETAILS OF WELDING

General

5.2.1 Tanks and their structural attachments shall be welded by the shielded metal-arc or the submerged-arc process, using suitable equipment. The welding may be performed manually, automatically, or semi-automatically according to procedures and by welders and welding operators qualified under Part 7: Welding Procedure and Welder Qualifications, and in a manner to insure complete fusion with the base metal within the limits required by the applicable paragraphs and illustrations.

5.2.2 Welding shall not be done when the surfaces of the parts to be welded are wet from rain, snow, or ice, when rain or snow is falling on such surfaces, nor during periods of high winds unless the welder and work are properly shielded. Welding shall not be done when the base metal temperature is less than 0 deg. F. When the base metal temperature is within the range 0 to 32 deg. F., inclusive, or the thickness is in excess of 1¼ in., the base metal within 3 in. of the place where welding is to be started shall be heated to a temperature warm to the hand.

5.2.3 Each layer of weld metal or multi-layer welding shall be cleaned of slag and other deposits before applying the next layer.

5.2.4 The edges of all welds shall merge with the surface of the plate without a sharp angle. There shall be no undercutting of the base metal, except that on horizontal butt joints permitting partial penetration, undercutting not to exceed $\frac{1}{32}$ in. in depth is permissible, subject to the restrictions of Par. 3.3.12.

5.2.5 The weld metal on both sides of all butt joints except the off-set faces of horizontal joints, shall be built up in the form of a reinforcement so that all of the finished face in the area of fusion shall extend above the surface of the adjoining plates, preferably not more than $\frac{1}{16}$ in.

5.2.6 At all lap joints, the plates shall be held in close contact during the welding operation.

5.2.7 The method proposed by the manufacturer to hold the plates in position for welding shall be submitted for approval to the purchaser inspector, if such approval has not already been given in writing by the purchaser.

5.2.8 Tack welds used in the assembly of the vertical joints of tank shells and those used for assembling the tank shell to the bottom, shall be removed and shall not remain in the finished joint when the joints are welded manually. When such joints are welded by the submerged-arc process, the tack welds shall be thoroughly cleaned of all welding slag but need not be removed provided they are sound and are thoroughly fused into the subsequently deposited weld metal. Tack welds in the bottom, roof, and circumferential joints of the tank shell need not be removed provided they are sound and the subsequently applied weld beads are thoroughly fused into the tack welds.

Bottoms

5.2.9 The bottom plates, after being laid out and tacked, and if not otherwise specified, shall be joined by welding the joints in a sequence that the manufacturer has found to result in the least distortion due to shrinkage, and to thus provide, as nearly as possible, a plane surface.

5.2.10 It is recommended that the sequence or order of welding the seams joining the bottom plates be specified by the manufacturer on approval plans, so that the purchaser may object if he so desires; but the manufacturer should follow a practice that will produce the minimum inequalities in the bottom-plate surface when the tank is completed.

5.2.11 The welding of shell to bottom shall be practically completed before starting the completion of welding of bottom joints that may have been left open to compensate for shrinkage of any welds previously made.

5.2.12 Shell plates may be aligned by metal clips attached to the bottom plates, and the shell tack welded to the bottom, before continuous welding is started between the bottom edge of the shell plate and the bottom plates.

Tank Shells

5.2.13 Plates to be joined by butt welding shall be matched accurately and retained in position during the welding operation. Misalignment in completed vertical joints shall not exceed 10 per cent of the plate thickness or 1/16 in., whichever is the larger.

5.2.14 In completed horizontal butt joints, the upper plate shall not project beyond the face of the lower plate at any point by more than 20 per cent of the thickness of the upper plate, with a maximum of 1/8 in., except that a projection of 1/16 in. is permissible for upper plates less than 5/16 in. thick.

5.2.15 The reverse side of double-welded vertical butt joints, and portions of horizontal joints specified to have complete penetration and fusion, shall be cleaned thoroughly prior to the application of the first bead to this side, in a manner that will leave the exposed surface satisfactory for fusion of the weld metal to be added. This may be done by chipping, grinding, or melting out, or where the back of the initial bead is smooth and free from crevices which might entrap slag, by other methods which may, upon field inspection, be acceptable to the purchaser. In the case of submerged-arc welds, the cleaning shall conform to the requirements established in the Welding Procedure Qualification, Sect. 7.2.

5.2.16 Roofs: Special Note. This specification does not include special stipulations on erection of the roof. Structural rafters, etc., must be reasonably true to line and surface.

5.3 TESTING, INSPECTION, AND REPAIRS

Weld Inspection

5.3.1 **Butt Welds.** Inspections for quality of welds joining shell plates to shell plates shall be made by the sectioning methods specified in Sect. 6.1, except that, by agreement between the purchaser and the manufacturer, inspections of butt-welded shell joints for which complete penetration and fusion are specified, shall be made by the radiographic methods described in Sect. 6.2. Where visual inspection by purchaser inspector indicates unsatisfactory welds between shell plates, acceptance or rejection shall be based on inspection of segments or radiographs representing the areas in question.

5.3.2 Fillet Welds. Inspections of fillet welds shall be made by visual examination. Where visual inspection by purchaser inspector indicates unsatisfactory welds, acceptance or rejection shall be based on sectioning such areas by chipping with a mechanical round-nosed chipping tool.

5.3.3. All costs of cutting segments, of making radiographs, and of making any necessary repairs shall be borne by the manufacturer, except that if the purchaser inspector requires segments or radiographs in excess of the number specified in Part 6, or chipouts of fillet welds in excess of one per 100 ft. of weld and no defect is disclosed the cost of the additional tests shall be borne by the purchaser.

5.3.4 **Testing the Bottom.** Upon completion of the welding of the tank bottom it shall be tested by one of the following methods.

a. Air pressure or vacuum shall be applied to the joints, using soap suds, linseed oil, or other suitable material for the detection of leaks.

b. After attachment of at least the lowest shell course, oil or water, to be supplied by the purchaser, shall be pumped underneath the bottom maintaining a head of 6 in. of liquid by holding that depth around the edge of the bottom inside of a temporary dam. The oil or water line for testing may be installed temporarily by running through a manhole to a temporary flange connection at one or more points in the bottom of the tank, or may be installed permanently in the sub-grade beneath the tank. The method of installation should be governed by the nature of the sub-grade.

5.3.5 All reasonable care shall be taken to preserve the prepared subgrade under the tank.

5.3.6 **Testing the Shell.** Upon completion of the entire tank, and before any external oil piping has been connected to the tank, the shell shall be tested by one of the following methods.

a. If water is available for testing, the tank shall be filled with water, and inspected frequently during the filling operation. For tanks with tight roofs, the filling height shall be two inches above the top leg of the top angle. For open-top tanks, the filling height shall be the top of the top angle or the bottom of any overflow which limits the filling height.

b. If sufficient water to fill the tank is not available, the test may be made by: 1, painting all joints on the inside with a highly penetrating oil, such as automobile-spring oil, carefully examining the outside of the joints for leakage; 2, applying an internal air pressure or external vacuum as specified for roof test in Par. 5.3.7, carefully examining the outside of the joints for leakage; or 3, any combination of the methods stipulated in 1 and 2.

5.3.7 **Testing the Roof.** Upon completion, the tank roof shall be tested by applying an internal air pressure or external vacuum to the seams, using soap suds, linseed oil, or other suitable material for the detection of leaks. The internal pressure shall not exceed the weight of the roof plates.

Repairs

5.3.8 All defects found in welds shall be called to the attention of the purchaser inspector and his approval shall be obtained before they are repaired. All completed repairs shall be subject to the approval of the purchaser inspector.

5.3.9 Pinhole leaks or porosity in tank bottom joints may be repaired by applying an additional weld bead over the defective area. Other defects or cracks in tank bottom joints shall be repaired as required in Par. 6.1.17.

5.3.10 All defects, cracks, or leaks in shell joints or in the shell to bottom joint, shall be repaired in accordance with Par. 6.1.17.

5.3.11 Isolated pinhole leaks in roof joints may be caulked mechanically; but for any indication of considerable porosity in the joints, or of cracking, an additional bead of weld metal shall be laid over the affected sections. Mechanical caulking is not permitted for any other repairs.

5.3.12 Repairs of defects discovered after the tank is filled with water for test shall be made with the water level at least one foot below the point being repaired, or with the tank empty if repairs are on or near the tank bottom. No welding shall be done on any tank unless all lines connecting thereto have been completely blanked off. No repairs shall be attempted on tanks while filled with oil, nor on tanks which have contained oil until the tank has been emptied, cleaned, and gas-freed in a safe manner. No repairs shall be attempted by the manufacturer on a tank which has contained oil except in a manner approved in writing by the purchaser, and in the presence of the purchaser inspector.

5.3.13 Cleaning Up. Upon completion of erection, the manufacturer shall remove or dispose of all rubbish and other unsightly material caused by his operations, and shall leave the premises in as good condition as he found them.

Inspection

5.3.14 The inspector representing the purchaser shall have at all times 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.

5.3.15 Any material or workmanship shall be subject to the requirements as to replacements, as in Par. 4.2.3. Material damaged by defective workmanship or otherwise showing defects, will be rejected and the manufacturer will be notified to this effect in writing; and will be required to furnish new material promptly or correct defective workmanship.

5.3.16 Acceptance. Before acceptance, all work shall be completed to the satisfaction of the purchaser inspector and the entire tank, when filled with oil, must be tight and free from leaks.

NOTE: Vacuum Testing. *Vacuum testing is conveniently performed by means of a metal testing box 6 in. wide by 30 in. long, with a glass window in the top. The open bottom is sealed against the tank surface by a sponge-rubber gasket. Suitable connections, valves, and gages should be provided.*

About 30 in. of the seam under test is brushed with a soap-suds solution or linseed oil. In freezing weather, a non-freezing solution may be necessary. The vacuum box is placed over the coated section of seam, and a vacuum applied to the box. The presence of porosity in the seam is indicated by bubbles or foam produced by air sucked through the welded seam.

A vacuum can be drawn on the box by any convenient method, such as connection to a gasoline or diesel motor intake manifold, or to an air ejector or special vacuum pump.

The gage should register a partial vacuum of at least 2 lb. per sq. in.

6. TESTING SHELL JOINTS

6.1 SECTIONING METHOD

6.1.1 Application. Sectional testing shall be confined to tank shell joints, particularly the vertical joints subject to primary stress from weight or pressure of tank contents. It need not be applied to roofs, flat tank bottoms resting directly on a grade or foundation, nor to the welds between flat tank bottoms and the first ring of the tank shell, nor to the welds connecting the top curb angle to the shell or to the roof, nor to welds connecting manholes or other appurtenances to the tank.

6.1.2 Sectional Specimens. Sectional specimens are segments cut from the welded joints in such manner as to remove a portion of the plates bounding the welded joint and thereby obtain two cross sections of the weld. The segments must expose the full cross sections of the welded joint. Segments shall be cut with a cylindrical cutting tool.

Number and Location of Specimens

6.1.3 Segments shall be cut as specified below.

a. **Vertical Joints.** One segment shall be cut from the first 10 ft. of completed vertical joint of each type and thickness welded by each welder or welding operator. Thereafter, without regard to the number of welders or welding operators working thereon, one additional segment shall be cut from each additional 100 ft. (approximately) and any remaining major fraction thereof, of vertical joint of the same type and thickness.

b. **Horizontal Joints.** One segment shall be cut from the first 10 ft. of completed horizontal joint of each type and thickness (based on the thickness of the thicker plate at the joint), without regard to the number of welders or welding operators working thereon. Thereafter, one additional segment shall be cut from each additional 200 ft. (approximately) and any remaining major fraction thereof, of horizontal joint of the same type and thickness.

c. For the purposes of this section, plates shall be considered of the same thickness when the difference in the specified or design thickness does not exceed 0.03 in.

d. When two or more tanks are erected in the same location for the same purchaser, either concurrently or continuously, the number of segments to be taken may be based on the aggregate footage of welds of the same type and thickness in such group of tanks rather than on the footage in each individual tank.

6.1.4 It is to be recognized that the same welder or welding operator may, or may not weld both sides of the same butt joint. It is therefore permissible to test the work of two welders or welding operators with one segment if they weld opposite sides of the same butt joint. When a segment of this type is rejected, it shall be determined by further tests whether one or both welders or welding operators were at fault.

6.1.5 Insofar as possible, an equal number of segments shall be cut from the work of each welder and welding operator, except that this requirement shall not apply where the length of joint welded by a welder or welding operator is very much less than average.

6.1.6 The locations for cutting the test segments may be determined by the purchaser inspector.

6.1.7 Test segments shall be taken as the work progresses, as soon as practicable after all the joints accessible from one scaffold position have been welded.

Size of Sectional Segments

6.1.8 The diameter of the segment shall be not less than the width of the finished weld plus $\frac{1}{8}$ in., with a minimum of $\frac{1}{2}$ in.

6.1.9 The segment shall be removed on the center of the weld in such a manner that at least $\frac{1}{16}$ in. of parent metal will be removed with the segment on each of the two sides.

Preparation of Sectional Segments

6.1.10 Without further finishing or preparation, the segments shall be etched for inspection by placing in boiling 50 percent muriatic (hydrochloric) acid until there is a clear definition of the structure of the weld. (This will require approximately one-half hour.)

6.1.11 To preserve the appearance of the etched segments they should, after etching, be washed in clear water, the excess water removed, then immersed in alcohol, and dried. The etched surfaces may then be preserved by coating with a thin, clear lacquer.

Inspection of Sectional Segments

6.1.12 The etched segments shall be examined to ascertain the extent of weld defects, such as gas pockets, slag inclusions, incomplete fusion, undercutting, and cracks.

6.1.13 The etched surfaces of the segments shall show no cracks; and shall show complete penetration and complete fusion between the weld metal and the base metal within the depth of penetration required for the applicable joint.

6.1.14 Slag inclusion shall be permissible where it occurs between layers of the weld, is substantially parallel to the plate surface, and its width is not more than one half the width of the weld metal; and when it occurs across the thickness of the plate and is equal to not more than 10 percent of the thickness of the thinner plate.

6.1.15 Gas pockets are permissible provided the combined area of all gas pockets does not exceed 0.02 sq. in. per sq. in. (2 per cent) of weld metal, no pocket exceeds $\frac{1}{16}$ in. in greatest dimension, and there are not more than six gas pockets approaching this maximum dimension, per square inch of weld metal.

6.1.16 If any segment is defective, additional segments shall be cut from the work of the same welder or welding operator, approximately two feet on each side of the defective segment. If either of these additional segments is defective, more segments shall be cut at intervals of approximately two feet, until the limits of the defective welding have been definitely established; or the contractor may replace all the welding done by that welder or welding operator without cutting additional segments.

6.1.17 Defects in welds should be removed by chipping or melting out from one or both sides of the joint, as required, and rewelding. Only sufficient cutting out of the joints is required as is necessary to correct the defects.

6.1.18 All replaced welds in joints shall be checked by repeating the original test procedure.

Closure of Openings

6.1.19 All openings cut in shell joints for examination by the sectioning method shall be closed by the manufacturer. Closure of plug openings shall be in accordance with any of the methods described in Par. 6.1.20 to 6.1.24, inclusive, where such are applicable to the particular joint and thickness of material.

6.1.20 Plug openings in horizontal joints may be filled by inserting a disc in the hole in a mid-position between the surfaces of the thinner plate. The disc shall be at least ⅛ in. thinner than the thickness of the thinner plate and shall have a fairly close fit in the hole. The upper side of the hole on each side of the disc shall be tapered sufficiently to permit depositing a sound weld in the opening. Both sides of the disc shall be welded over completely, fusing the circular edges of the disc with the plate and making the surfaces of the weld substantially flush with the plate surfaces.

6.1.21 Plug openings in vertical or horizontal joints, where the thickness of the plates or of the thinner plate at the joint is not greater than one third the diameter of the hole, shall be filled completely with weld metal applied from the outside of the tank shell. Before welding, place a backing plate on the inside of the tank shell over the opening, taper the upper side of the hole from the backing plate outward, sufficiently to permit depositing a sound weld in the opening.

6.1.22 Plug openings in vertical or horizontal joints, where the thickness of the plates or of the thinner plate at the joint is not less than one third, nor greater than two thirds the diameter of the hole shall be filled completely with weld metal applied from both sides of the tank shell. Before welding, taper the upper side of the hole from the center outward on both sides of the plate, sufficiently to permit depositing a sound weld in the opening.

6.1.23 Plug openings in vertical or horizontal butt joints, where the thickness of the plates or of the thinner plate at the joint does not exceed ⅞ in., shall be filled completely with weld metal applied from the outside of the tank shell. Before welding, place a backing plate on the inside of the tank shell or a thin disc (not over ⅛ in. thick) at the bottom of the hole; chip a vertical or horizontal groove on the outside of the plate, extending from the hole in opposite directions. The length of the groove on each side of the opening shall have a slope of about 1 in 1½ extending from the bottom of the hole to the surface. The groove at the opening shall have sufficient width to provide a taper to the bottom of the hole to permit depositing a sound weld in the opening.

6.1.24 Plug openings in vertical or horizontal butt joints, in plates of any thickness, shall be filled completely with weld metal applied from both sides of the plate. Before welding, place a thin disc (not over ⅛ in. thick) in the hole at the middle of the plate and chip vertical or horizontal grooves on both sides of the plate extending from the hole in opposite directions. The groove on each side of the opening shall have a slope along its length of about 1 in 1½ extending from the middle of the plate to the surface. The groove at the opening shall have sufficient width to provide a taper to the middle of the plate to permit depositing a sound weld in the opening.

Record of Segments

6.1.25 The segments, after removal, shall be properly stamped or tagged for identification; and, after etching, kept in proper containers, with a record of their place of removal as well as of the welder or welding operator who performed the welding.

6.1.26 A record shall be made by the erector of all segments and their identification marks, on a developed shell-plate diagram.

6.1.27 The segments shall be the property of the purchaser, unless otherwise agreed upon between the purchaser and the erector.

6.2 RADIOGRAPHIC METHOD

6.2.1 Application. As an alternative for the sectioning method stipulated in Sect. 6.1, and if so agreed upon between the purchaser and the manufacturer, shell joints for which complete penetration and complete fusion are specified shall be examined by X-ray or Gamma ray methods, in accordance with the following procedures.

> NOTE: *Examination by radiographic methods shall not be required for roof-plate or bottom-plate welds nor for welds joining roof plates to top angle, top angle to shell plate, shell plates to bottom plates, or appurtenances to tanks. Such methods are not recommended for horizontal shell joints for which partial penetration is specified, nor for horizontal welds which are not required to have complete penetration and complete fusion (see Par. 3.3.12).*

6.2.2 Preparation for Examination. In the preparation of butt-welded joints for radiographic examination, the weld ripples or weld surface irregularities on both the inside and the outside, shall be removed by any suitable mechanical process to a degree such that the resulting radiographic contrast, due to any remaining irregularities, cannot mask or be confused with that of any objectionable defect. Also the weld surface shall merge smoothly into the plate surface. The finished surface of the reinforcement shall have a reasonably uniform crown, preferably not more than $\frac{1}{16}$ in., but not to exceed the following values:

Plate Thickness, in.	Maximum Thickness of Reinforcement, in.
Up to ½, incl.	$\frac{1}{16}$
Over ½ to 1, incl.	$\frac{3}{32}$
Over 1	⅛

6.2.3. Number and Location of Radiographs. Where radiography is applicable as an alternate to sectioning, the number and location of spot radiographs shall comply with the requirements for number and location of sections as given for testing shell joints by sectioning methods (Par. 6.1.3 to 6.1.9, incl.) except that at least 25 per cent of the selected spots for the vertical seams shall be at junctions of the vertical and circumferential joints, with a minimum of two such intersections per tank.

6.2.4 Film. Each radiograph shall clearly show a minimum of 3 in. of weld length. The film shall be centered on the weld and shall be of sufficient width to permit adequate space for the location of identification marks and thickness gage or penetrameter.

6.2.5 Procedure. The weld shall be radiographed with a technique which will determine quantitatively the size of defects with thicknesses equal to or greater than 2 per cent of the thickness of the thinner of the two plates joined.

6.2.6 Penetrameters. As a check on the radiographic technique employed, a thickness gage or penetrameter as herein described shall be used to determine whether the requirements of Par. 6.2.5 are being met and shall be used in the following manner.

a. The penetrameter shall be placed on the side of the plate nearest the source of radiation.

b. One penetrameter shall be used for each film, to be placed parallel to and adjacent to the weld seam at the approximate center of the spot to be examined, with the small hole at the top for vertical welds and to the right for horizontals welds.

c. The density of the material of the penetrameter shall be substantially the same as that of the plate under examination.

d. The thickness of the penetrameter shall be not more than 2 per cent of the thickness of the thinner of the two plates joined, except that in no case shall the thickness be less than 0.005 in. When the weld reinforcement is not removed, a shim shall be placed under the penetrameter such that the total thickness being radiographed under the penetrameter is the same as the total thickness through the weld.

e. In each penetrameter there shall be three holes of diameters equal respectively to two, three, and four times the penetrameter thickness, but in no case less than $\frac{1}{16}$ in. except, when gamma rays are used as a source of radiation, the minimum hole diameter need not be less than $\frac{3}{32}$ in. The smallest hole must be distinguishable on the radiograph.

f. The penetrameter shall conform to Fig. 22.

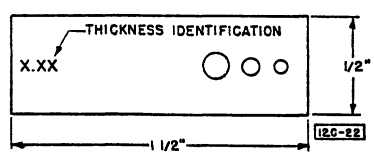


FIG. 22
RADIOGRAPHIC PENETRAMETER
See Par. 6.2.6

g. Each penetrameter shall carry an identifying number representing to two significant figures the minimum thickness of plate for which it may be used.

h. The images of these identifying numbers shall appear clearly on the radiograph.

6.2.7 Film Location. The film, during exposure, shall be as close to the surface of the weld as practical.

6.2.8 Film Defects. All radiographs shall be free from excessive mechanical processing defects which would interfere with proper interpretation of the radiographs.

6.2.9 Identification Markers. Identification markers, the images of which will appear on the film, shall be placed adjacent to the weld opposite the penetrameter, and their locations accurately and permanently marked near the weld on the outside surface of the structure, so that a defect appearing on the radiograph may be accurately located.

6.2.10 Reference Marker. There shall also be a suitable reference marker on each film.

6.2.11 Submission of Radiographs. Prior to any repairs of welds, the radiographs shall be submitted to the inspector with such information regarding the radiographic technique used as he may request.

Radiographic Standards

6.2.12 Sections of welds that are shown by radiography to have any of the following imperfections shall be judged unacceptable.

a. Any crack, incomplete fusion, or incomplete penetration.

b. Any individual elongated inclusion having a length greater than two thirds the thickness of the thinner plate of the joint, except that, regardless of the plate thickness, no such inclusion shall be longer than ¾ in. and no such inclusion shorter than ¼ in. shall be cause for rejection.

c. Any group of inclusions in line, where the sum of the longest dimensions of all such imperfections is greater than T (where T is the thickness of the thinner plate joined) in a length of $6T$, except when each of the individual spaces between imperfections is greater than three times the length of the longer of the adjacent imperfections. When the length of the radiograph is less than $6T$, the permissible sum of the lengths of all inclusions shall be proportionately less than T, provided the limits of the deficient welding are clearly defined.

d. Porosity in excess of that shown as acceptable in the standards shown in Fig. 23 through 26.

6.2.13 When a section of weld is shown by a radiograph to be unacceptable under the provisions of Par. 6.2.12, or the limits of the deficient welding are not defined by such radiograph, two adjacent spots shall be examined by radiography. If the weld at either of these sections fails to comply with the requirements of Par. 6.2.12, additional nearby spots shall be examined until the limits of unacceptable welding are determined or, at the option of the erector, all the welding performed by the welder or welding operator on that joint shall be replaced, in which case the inspector shall have the option of requiring that one radiograph be taken at any selected location on any other joint on which the same welder (or operator) has welded. If any of such additional spots fails to comply with the requirements of Par. 6.2.12, the limits of unacceptable welding shall be determined as specified for the initial section.

Repair of Defective Welds

6.2.14 Defects in welds shall be repaired by chipping or melting out such defects from one or both sides of the joint, as required, and rewelding. Only sufficient cutting out of defective joints is required as is necessary to correct the defects.

6.2.15 All repair welds in joints shall be checked by repeating the original test procedure.

Record of Radiographic Examination

6.2.16 A record shall be made by the erector of all films, with their identification marks, on a developed shell-plate diagram.

6.2.17 After the completion of the structure, the films shall be the property of the purchaser, unless otherwise agreed upon between the purchaser and the erector.

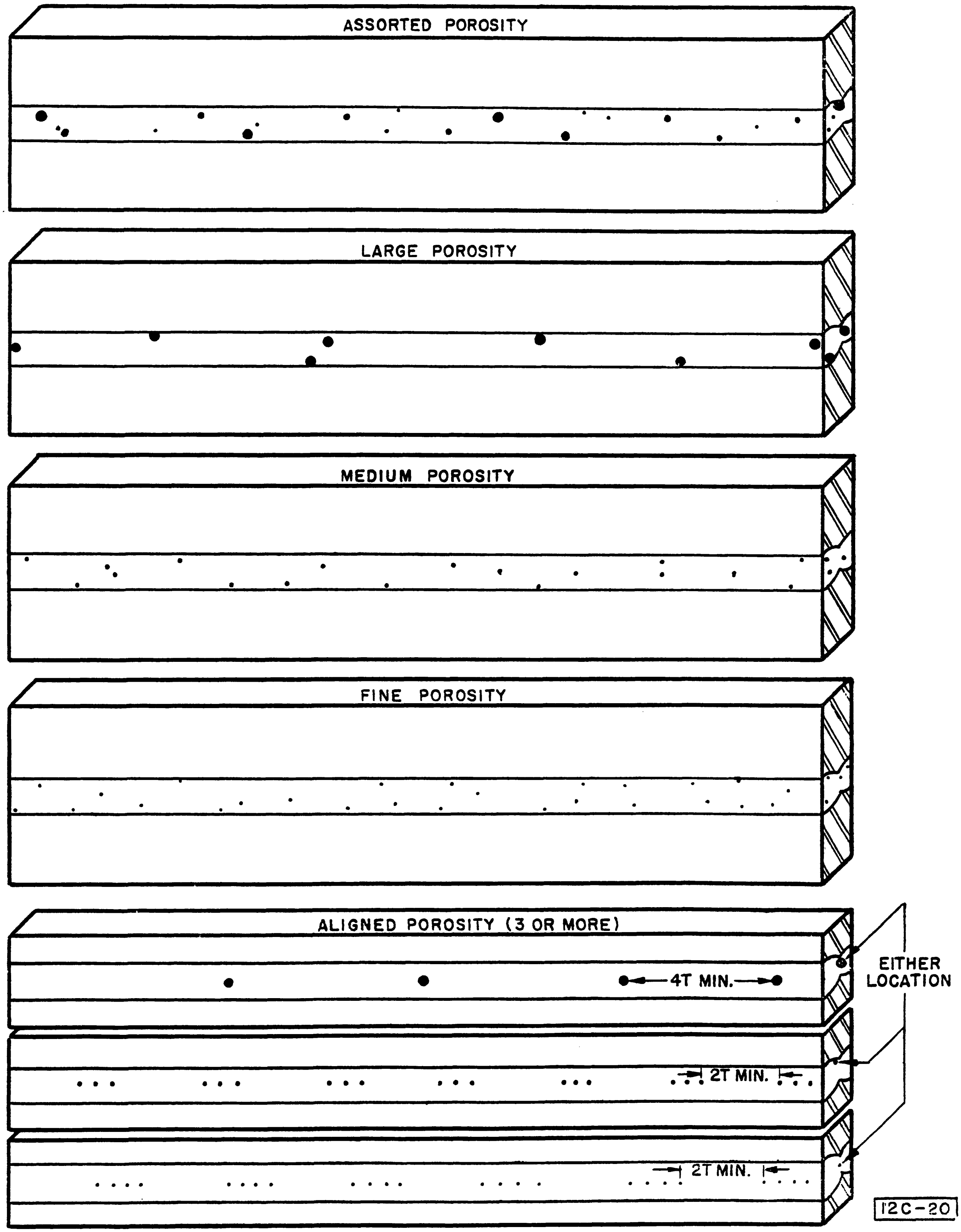


FIG. 23
RADIOGRAPHIC POROSITY STANDARDS, PLATE THICKNESSES ¼ IN. AND LESS
Specimens shown are ¼ in. thick

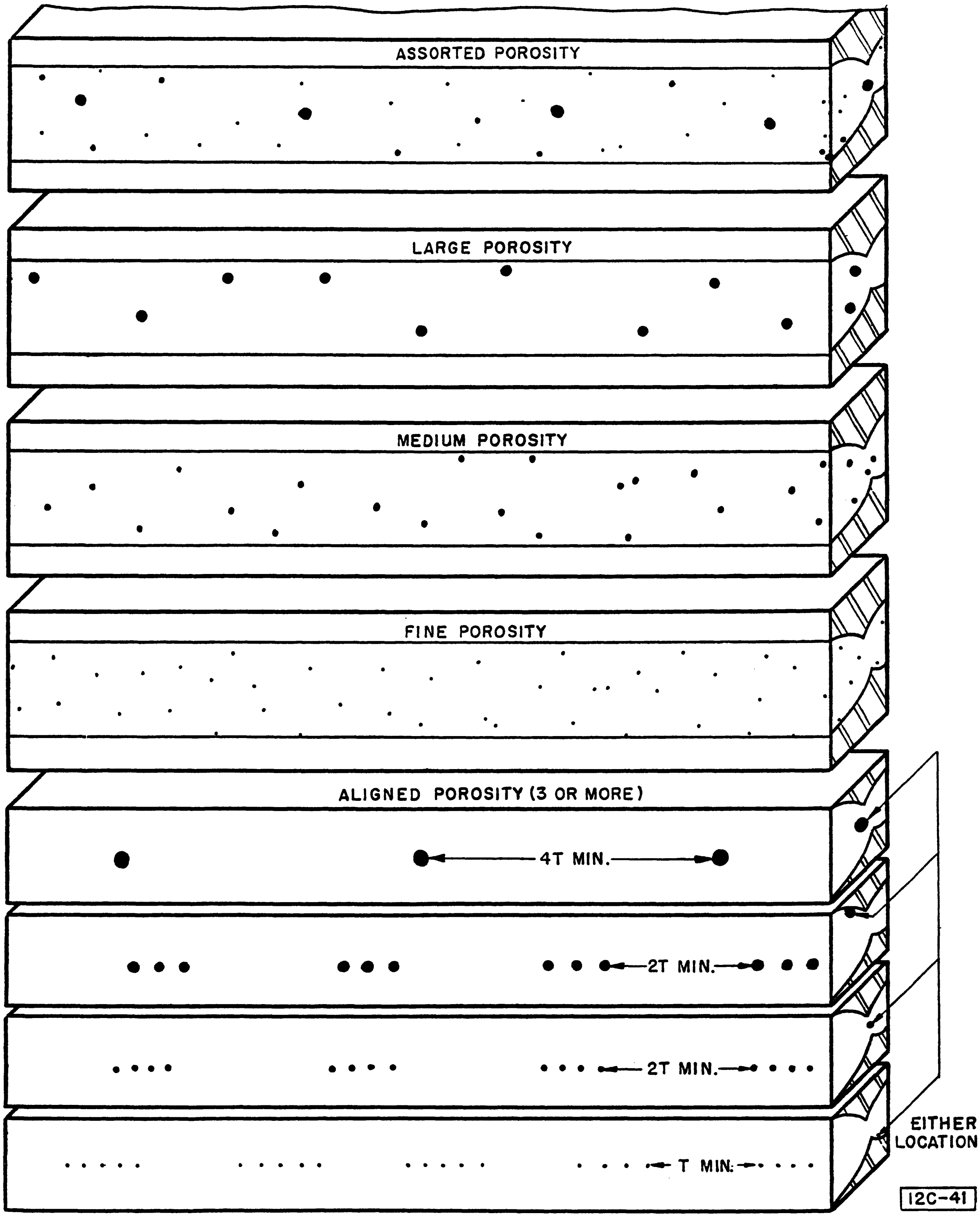


FIG. 24

RADIOGRAPHIC POROSITY STANDARDS, PLATE THICKNESSES OVER ¼ TO ½ IN. INCL.

Specimens shown are ½ in. thick

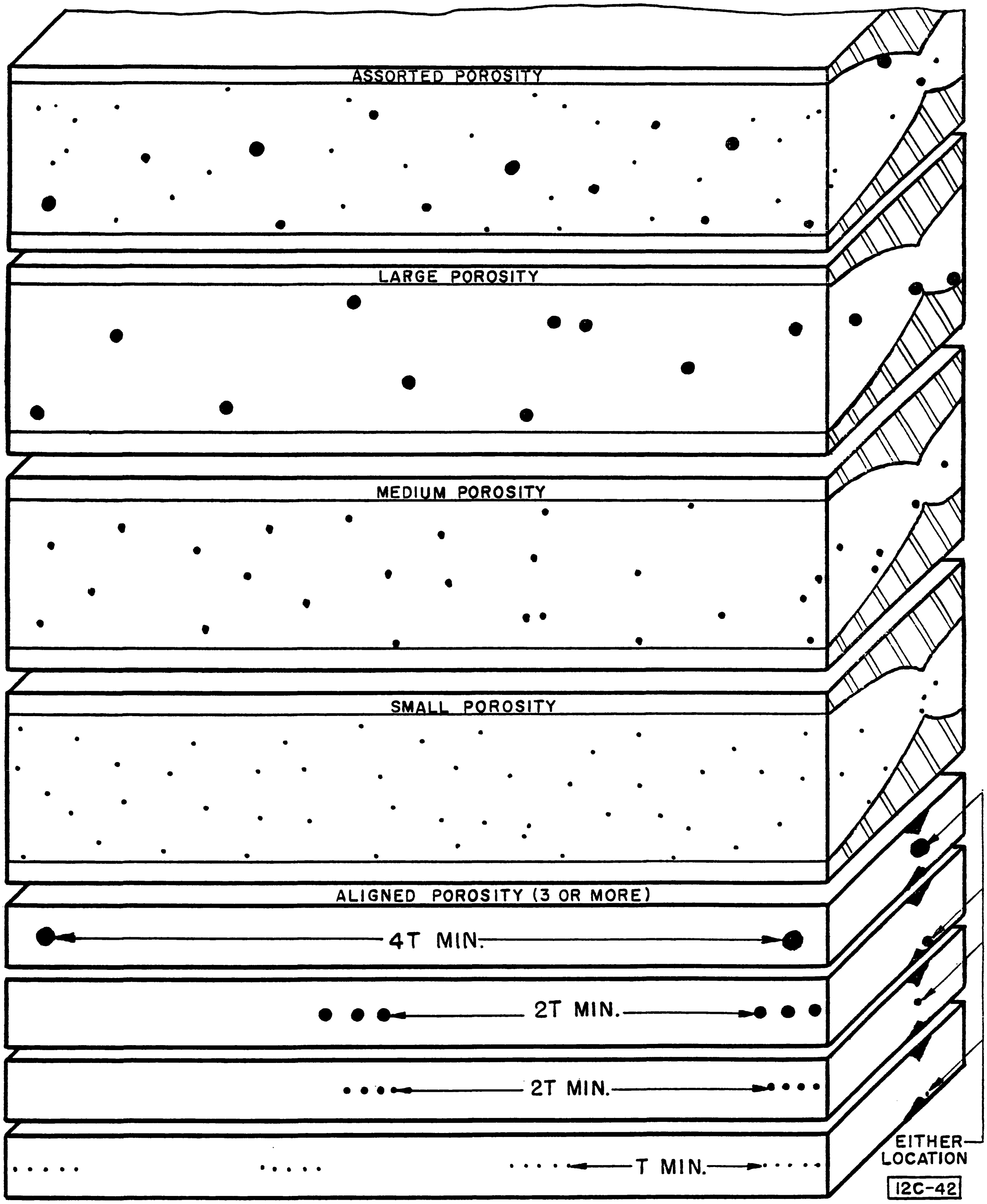


FIG. 25
RADIOGRAPHIC POROSITY STANDARDS, PLATE THICKNESS OVER ½ TO 1¼ IN., INCL.
Specimens shown are 1¼ in. thick

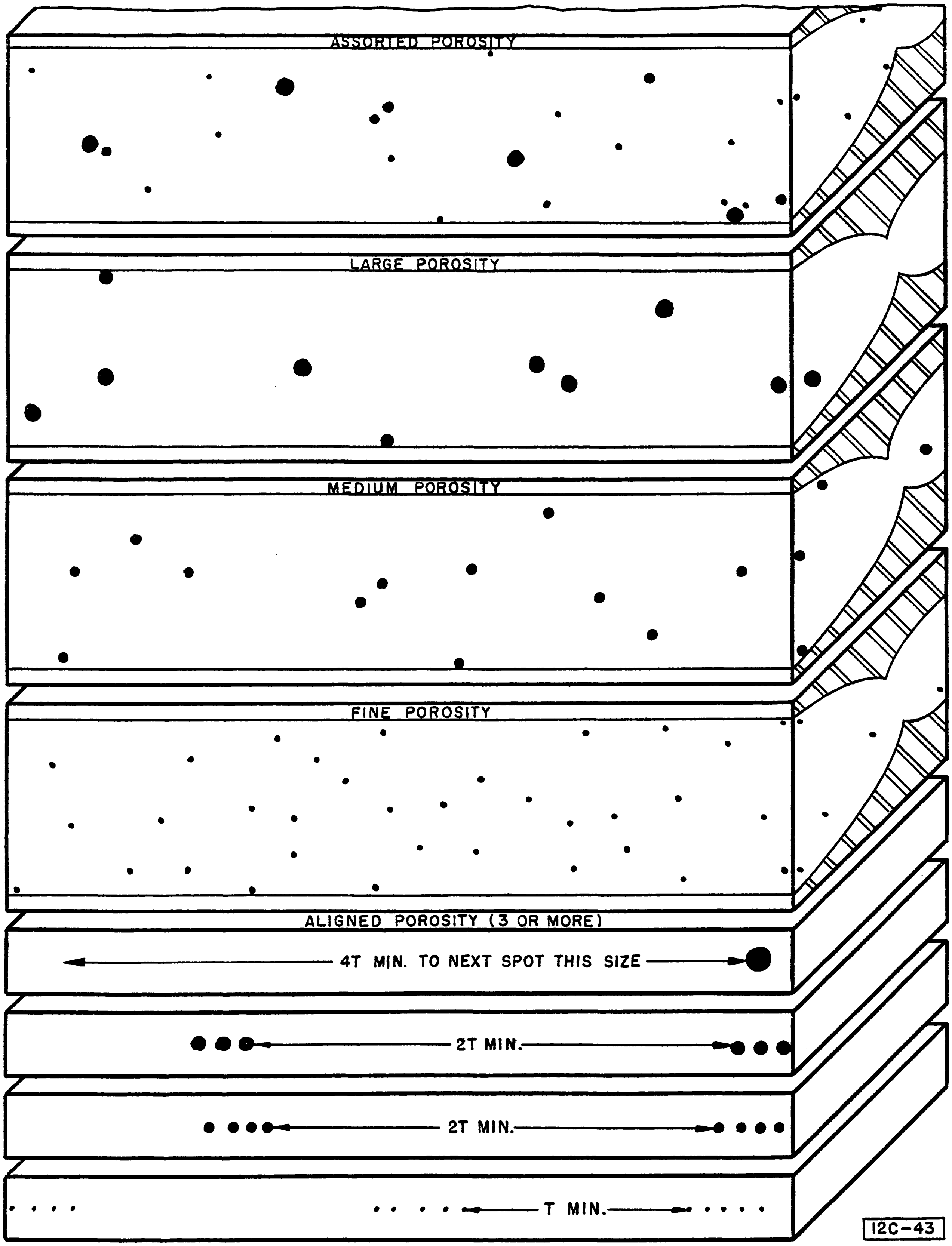


FIG. 26
RADIOGRAPHIC POROSITY STANDARDS, PLATE THICKNESSES OVER 1¼ TO 1½ IN., INCL.
Specimens shown are 1⅜ in. thick

7. WELDING PROCEDURE AND WELDER QUALIFICATIONS

7.1 GENERAL

7.1.1 Definitions. The following requirements on welding procedure and welder qualifications pertain to the welding processes permitted under Par. 5.2.1. The following definitions shall apply:

a. Welder: One who is capable of performing a manual or semi-automatic welding operation.

b. Welding Operator: One who operates machine or automatic welding equipment.

c. Manual Welding: Welding wherein the entire welding operation is performed and controlled by hand.

d. Automatic Welding (Machine Welding): Welding with equipment which performs the welding operation under the observation and control of an operator.

e. Semi-Automatic Arc Welding: Arc welding with equipment which controls only the filler-metal feed. **The advance of the welding is manually controlled.**

7.1.2 Procedure Qualification. The manufacturer shall conduct tests of his procedures to demonstrate their suitability in making welds which conform to the specified requirements. Procedure qualification tests shall be made in accordance with Sect. 7.2.

Welder Qualification

7.1.3 The manufacturer shall conduct tests of all welders and welding operators to demonstrate their ability to make acceptable welds.

7.1.4 Welders who perform manual welding (except tack welding) shall be qualified in accordance with Sect. 7.3. Welders who operate semi-automatic welding equipment and welding operators who operate automatic welding equipment need not be qualified in accordance with Sect. 7.3, but shall be qualified by performing the procedure qualification tests as given in Sect. 7.2 or in lieu thereof, for automatic welding on horizontal joints only, qualification of each operator may be achieved on actual construction welding in accordance with the testing procedure given in Par. 6.1.3b.

7.1.5 Reports. The manufacturer shall submit certified qualification test reports as evidence that the procedure qualification tests required in Par. 7.1.2 were conducted. The manufacturer shall certify that the welder and welding operator qualification tests required by Par. 7.1.3 and 7.1.4 were made.

7.2 WELDING PROCEDURE QUALIFICATION

Limitation of Variables

7.2.1 The procedure of welding shall be established and recorded by the manufacturer as a welding procedure specification, and shall be followed. A form for the procedure specification is given in Par. 7.4.1 herein. It is not necessary that this exact form be used, but the information contained therein should be set forth in any alternative form which is adopted.

7.2.2 If any changes are made in a procedure, the procedure specification shall be revised or amended to show these changes. The following schedule shows changes requiring requalification. Any change marked P or PO shall require requalification of the procedure. Any change marked PO or O shall require requalification of the welder.

P **a. A change in welding electrode from one ASTM A 233 classification number[1] to another.**

P **b. An increase in the diameter of the electrode over that called for in the welding procedure specification.**

P **c. A change of more than 15 per cent above or below the specified mean arc voltage and amperage for each size electrode used.**

P **d. For a specified welding groove, a change of more than plus or minus 25 per cent in the specified number of passes. If the area of the groove is increased, it is also permissible to increase the number of passes in proportion to the increased area.**

PO **e. A change in the position in which welding** is done as indicated by Par. 7.2.5 to 7.2.7, inclusive, and Par. 7.3.9 to 7.3.21, inclusive.

O **f. In the case of vertical welds, a change from the progression specified for any pass from upward to downward or vice versa.**

P **g. A decrease in the preheating temperature.**

P **h. A change in the type of welding groove. (Example, change from a V to a U groove.)**

P **i. A change in the shape of any one type of welding groove involving: 1, a decrease in the included angle of the welding groove, or a decrease in the width of the groove; 2, a decrease in the root opening of a welding groove; or 3, an increase in the root face of a welding groove.**

PO **j. For submerged-arc welding, a change in compostion of the electrode.**

PO **k. For submerged-arc welding, a change in the brand or make of the flux. (Requalification is not required for a change in flux particle size.)**

PO **l. For submerged-arc welding, a change from multiple pass per side to single pass per side.**

PO **m. For submerged-arc welding, a change from single arc to multiple arc, or vice versa.**

7.2.3 Types of Tests and Purposes. The types of tests outlined below are to determine the tensile strength, ductility, and degree of soundness of welded joints made under a given procedure specification. The tests used are as follows:

A. For groove welds:

1. Reduced-section tension test (for tensile strength).

[1]See Par. 2.4 for requirements on welding electrodes.

2. Free-bend test (for ductility).
3. Root-bend test (for soundness).
4. Face-bend test (for soundness).
5. Side-bend test (for soundness).

B. For fillet welds:
1. Transverse shear test (for shear strength).
2. Free-bend test (for ductility).
3. Fillet-weld-soundness test (for soundness).

7.2.4 Base Material and Its Preparation. The base material shall comply with the requirements for any grade of plate stipulated in Part 2. Qualification with such material shall qualify the procedure for any other grade of plate permitted under Part 2. The preparation for welding shall comply with the requirements specified in the procedure specification (Sect. 7.4). For all types of welded joints the length of the weld and the dimensions of the base material shall be such as to provide sufficient material for the test specimens called for hereinafter.

7.2.5 Position of Test Welds. All welds that will be encountered in actual construction shall be classified as being 1, flat; 2, horizontal; 3, vertical; or 4, overhead, in accordance with the definitions of welding positions given in Fig. 27 for groove welds and in Fig. 28 for fillet welds. Each procedure shall be tested in the manner stated below for each position for which it is to be qualified.

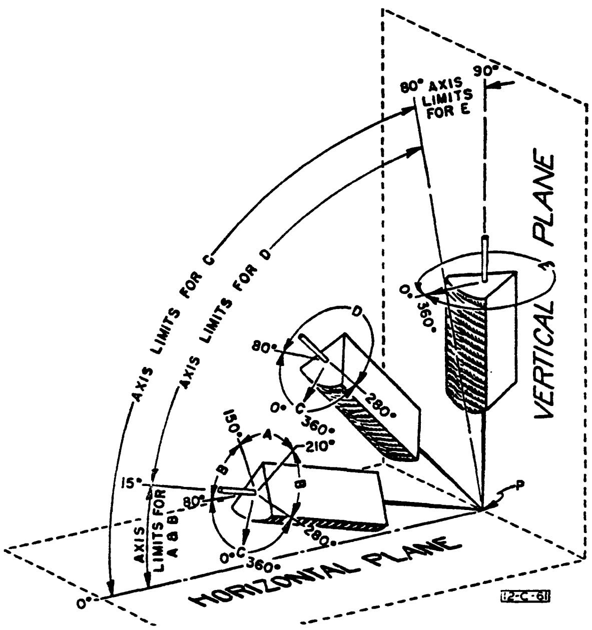


FIG. 27
POSITIONS OF GROOVE WELDS

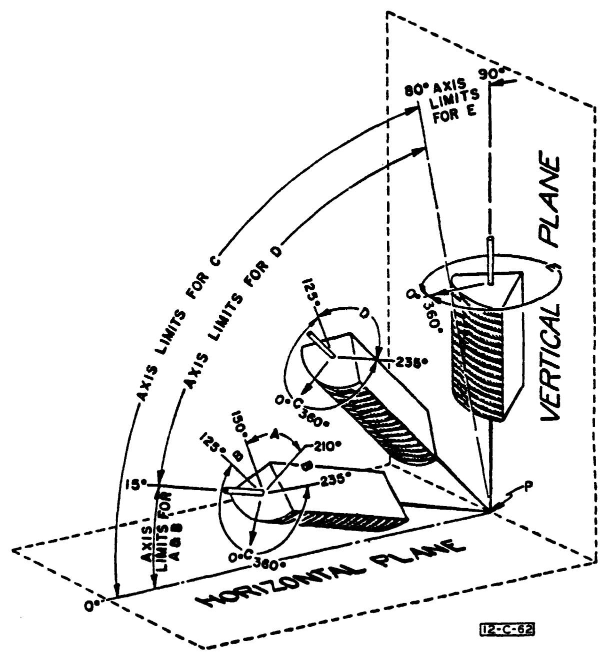


FIG. 28
POSITIONS OF FILLET WELDS

The horizontal reference plane is taken to lie always below the weld under consideration.

Inclination of axis is measured from the horizontal reference plane toward the vertical.

Angle of rotation of face is measured from a line perpendicular to the axis of the weld and lying in a vertical plane containing this axis. The reference position (0°) of rotation of the face invariably points in the direction opposite to that in which the axis angle increases. The angle of rotation of the face of weld is measured in a clockwise direction from this reference position (0°) when looking at point *P*.

TABULATION OF POSITIONS OF GROOVE WELDS

Position	Diagram Reference	Inclination of Axis	Rotation of Face
Flat	A	0° to 15°	150° to 210°
Horizontal	B	0° to 15°	80° to 150°
			210° to 280°
Overhead	C	0° to 80°	0° to 80°
			280° to 360°
Vertical	D	15° to 80°	80° to 280°
	E	80° to 90°	0° to 360°

TABULATION OF POSITIONS OF FILLET WELDS

Position	Diagram Reference	Inclination of Axis	Rotation of Face
Flat	A	0° to 15°	150° to 210°
Horizontal	B	0° to 15°	125° to 150°
			210° to 235°
Overhead	C	0° to 80°	0° to 125°
			235° to 360°
Vertical	D	15° to 80°	125° to 235°
	E	80° to 90°	0° to 360°

7.2.6 Groove Welds. In making the tests to qualify groove welds in plate, the test plates shall be welded in the following positions:

a. Flat position: The test plates shall be placed in an approximately horizontal plane and the weld metal deposited from the upper side. See Fig. 29 (a).

b. Horizontal position: The test plates shall be placed in an approximately vertical plane with the welding groove approximately horizontal. See Fig. 29 (b).

c. Vertical position: The test plates shall be placed in an approximately vertical plane with the welding groove approximately vertical. See Fig. 29 (c).

d. Overhead position: The test plates shall be placed in an approximately horizontal plane and the weld metal deposited from the under side. See Fig. 29 (d).

NOTE: ***The type of groove shall comply with the procedure specification.***

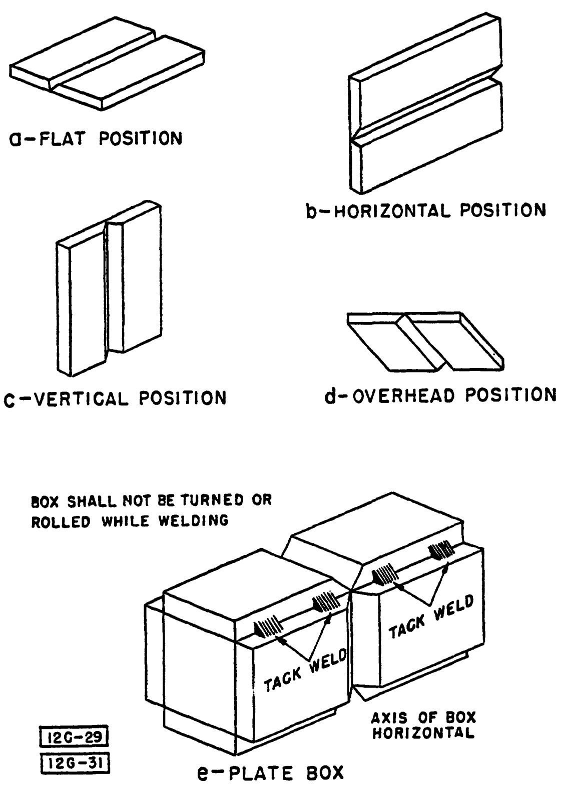


FIG. 29
POSITIONS OF TEST PLATES FOR GROOVE WELDS

NOTE: For procedure qualification the type of groove shall comply with welding procedure specification (Sect. 7.4); for welder qualification the shape of the groove and backing strip shall be as shown in Fig. 42 and 43.

7.2.7 Fillet Welds. In making the tests to qualify in the following positions:
fillet welds in plate, the test plates shall be welded

a. Flat position: The test plates shall be so placed that each fillet weld is deposited with its axis approximately horizontal and its throat approximately vertical. See Fig. 30 (a).

b. Horizontal position: The test plates shall be so placed that each fillet weld is deposited on the upper side of the horizontal surface and against the vertical surface. See Fig. 30 (b).

c. Vertical position: The test plates shall be so placed that each fillet weld is deposited with its axis approximately vertical. See Fig. 30(c).

d. Overhead position: The test plates shall be so placed that each fillet weld is deposited on the under side of the horizontal surface and against the vertical surface. See Fig. 30 (d).

NOTE: ***The above arrangement of test plates refers only to the making of the fillet welds. The closing weld between fillet welds in the fillet-weld-soundness test may be made in any position. See Fig. 30***

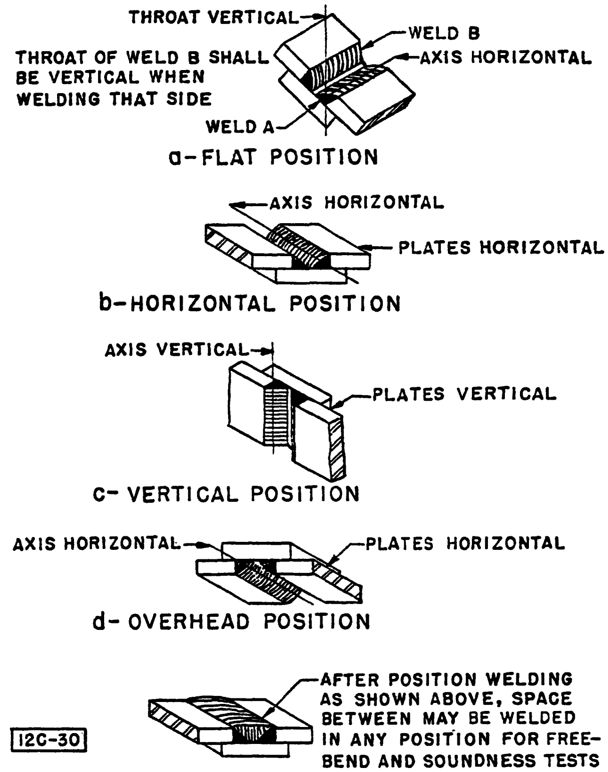


FIG. 30
POSITIONS OF TEST PLATES FOR FILLET WELDS

Number of Test Welds Required

7.2.8 Groove Welds. For groove welds, one test weld shall be made for each procedure and position to be used in construction. If the construction involves welding of material ¾ in. thick or less, the test weld shall be made on material ⅜ in. thick. If the construction involves welding of material over ¾ in. thick, but not greater than 1¼ in. thick, the test weld shall be made on material of either the maximum thickness to be welded or on material 1 in. thick. If the construction involves welding of material over 1¼ in. thick, the test weld shall be made on material of the maximum thickness. If a test is made on either the maximum or 1-in. thickness, no test need be made on the ⅜-in. thickness.

TABLE 22

PROCEDURE QUALIFICATION TESTS FOR GROOVE WELDS IN PLATE

1	2	3	4	5	6	7
Maximum Thickness to be Welded in Construction, in.	Test Plate Thickness, in.	Number and Type of Tests Required				
		Reduced-Section Tension See Fig. 33	Free-Bend See Fig. 34	Root-Bend See Fig. 35	Face-Bend See Fig. 35	Side-Bend See Fig. 36
Up to and including ¾	⅜	2	2	2	2	–
Over ¾ to and including 1¼	Maximum to be welded or 1	2	2			4
Over 1¼	Maximum to be welded	2	2			4

7.2.9 Fillet Welds. For fillet welds two transverse shear test welds shall be made for each procedure and position to be used in construction. For each type of test weld, one shall be made with the maximum size single-pass fillet weld and one with the minimum size multiple-pass fillet weld that will be used in construction. In addition, one test weld for the free-bend and fillet-weld-soundness tests shall be made with the maximum size single-pass fillet weld (not over ⅜ in.) that will be used in construction, for each procedure and position to be used in construction.

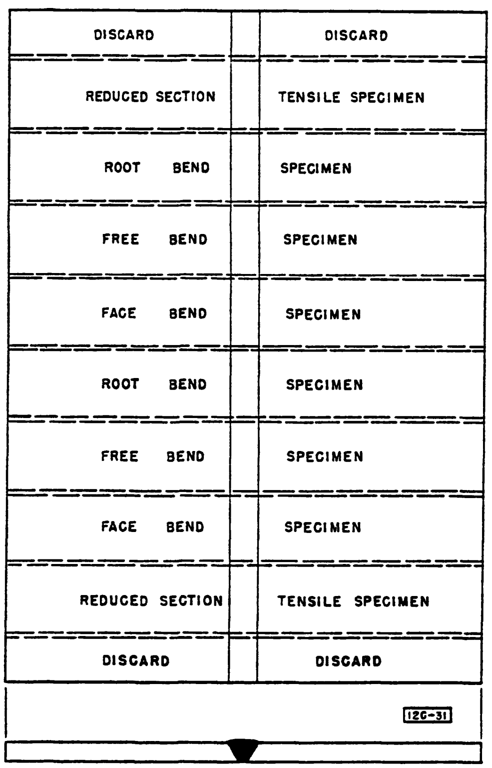


FIG. 31
ORDER OF REMOVAL OF TEST SPECIMENS FROM WELDED TEST PLATE FOR PLATE ⅜ IN. THICK

7.2.10 Welding Procedure. The welding procedure shall comply in all respects with the welding procedure specification (Sect. 7.4).

Test Specimens—Number, Type, and Preparation

7.2.11 Groove Welds. For groove welds in plate, the method of preparing the specimens shall be in accordance with the figures referred to in Table 22, and the number of tests required shall be as given in the table. The test specimens shall be removed in the order given in Fig. 31 and 32.

7.2.12 Fillet Welds. The transverse shear test specimen shall be prepared for testing as shown in Fig. 37. The test weld for the free-bend and soundness test shall be made as shown in Fig. 38. From the test weld there shall be taken two free-bend test specimens, which shall be prepared for testing as shown in Fig. 34, and two fillet-weld-soundness test specimens, which shall be prepared for testing as shown in Fig. 39.

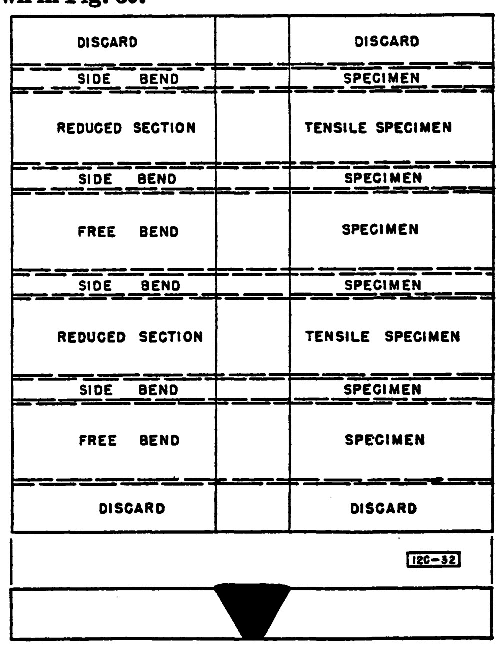


FIG. 32
ORDER OF REMOVAL OF TEST SPECIMENS FROM WELDED TEST PLATE FOR PLATE OVER ¾ IN. THICK

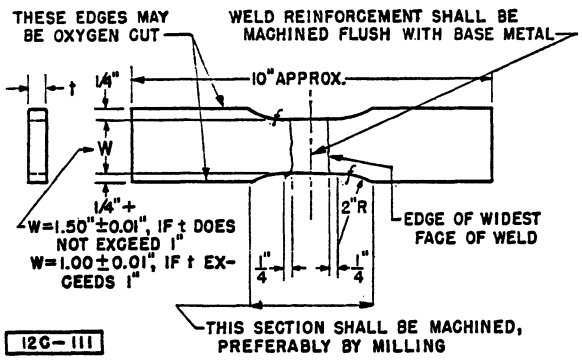
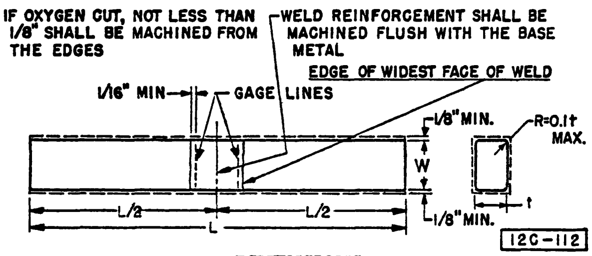


FIG. 33
REDUCED-SECTION TENSION SPECIMEN



DIMENSIONS

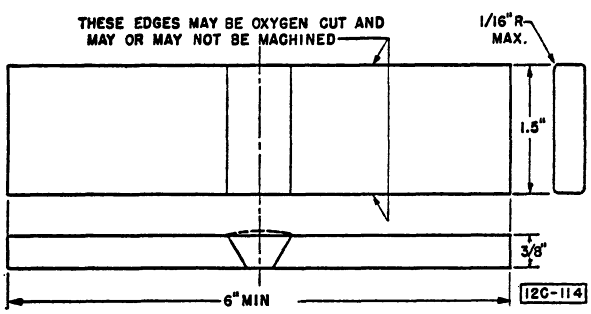
t, in.	3/8	3/4	1	1 1/4	1 1/2
W, in.	9/16	1 1/8	1 1/2	1 7/8	2 1/4
L min., in.	8	11	12	13 1/2	15
*B min., in.	1 1/4	2	2	2	2

*See Fig. 40.

NOTE: The length L is not mandatory.

NOTE: If desired, the edges of the specimen may be prepared by machine oxygen cutting, followed by rounding of the corners with a file, although this may be a more severe test.

FIG. 34
FREE-BEND SPECIMEN



NOTE: Weld reinforcement and backing strip, if any, shall be removed flush with the surface of the specimen. If a recessed strip is used this surface of the specimen may be machined to a depth not exceeding the depth of the recess to remove the strip, except that in such cases the thickness of the finished specimen shall be that specified above.

FIG. 35
FACE- AND ROOT-BEND SPECIMEN

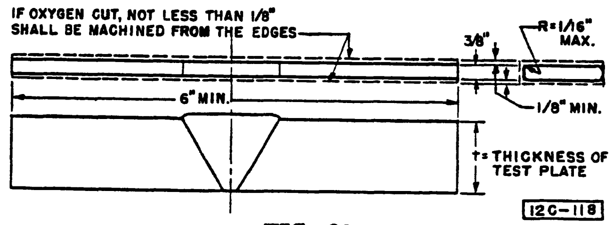


FIG. 36
SIDE-BEND SPECIMEN

Method of Testing Specimens

7.2.13 Reduced-Section Tension Specimen. Before testing, the least width and corresponding thickness of the reduced section shall be measured in inches. The specimen shall be ruptured under tensile load and the maximum load in pounds shall be determined. The cross-sectional area shall be obtained as follows: cross-sectional area=width × thickness. The tensile strength, in pounds per square inch, shall be obtained by dividing the maximum load by the cross-sectional area.

7.2.14 Free-Bend Test Specimens

a. The gage lines indicated in Fig. 34 shall be lightly scribed on the face of the weld. The gage length (distance between gage lines) shall be approximately 1/8 in. less than the width of the face of the weld, and shall be measured in inches to the nearest 0.01 in.

b. Each specimen may be bent initially by the use of a fixture complying with the requirements of Fig. 40. The surface of the specimen containing the gage lines shall be directed toward the supports. The weld shall be at midspan of both the supports and the loading block. Alternatively, the initial bend may be made by holding each specimen in the jaws of a vise with one third the length of the specimen projecting from the jaws, then bending the specimen away from the gage lines through an angle of 30 to 45 deg. by blows of a hammer. The other end of the specimen shall be bent in the same way. In order that the final bend shall be centered on the weld the initial bends shall be symmetrical with respect to the weld, and both ends shall be bent thru the same angle. The initial bend may also be started at the weld by placing the specimen in the guided-bend test jig shown in Fig. 41.

c. Compressive forces shall be applied to the ends of the specimen, continuously decreasing the distance between the ends. (Any convenient means such as a vise or a testing machine may be used for the final bend.) When a crack or other open defect exceeding 1/16 in. in any direction appears on the convex face of the specimen, the load shall be removed immediately. If no crack appears, the specimen shall be bent double. Cracks occurring on the corners of the specimen during testing shall not be considered.

d. The elongation shall be determined by measuring the minimum distance between the gage lines, along the convex surface of the weld, to the nearest 0.01 in. and subtracting the initial gage length. The per cent elongation shall be obtained by dividing the elongation by the initial gage length and multiplying by 100.

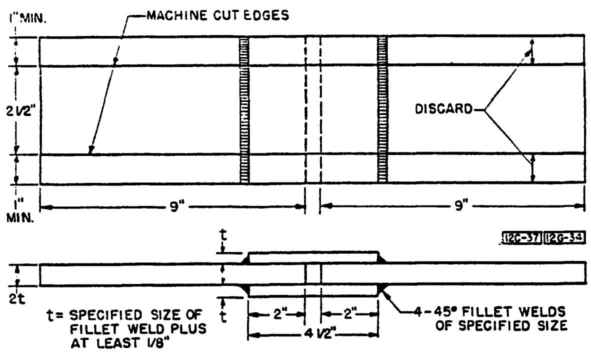


FIG. 37

TRANSVERSE FILLET-WELD SHEARING SPECIMEN

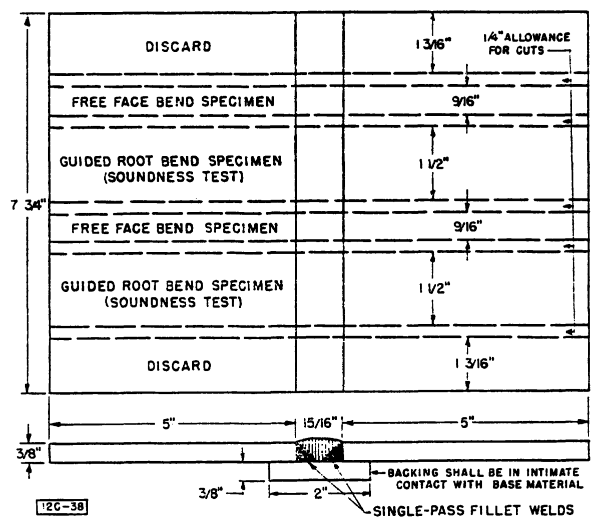


FIG. 38

TEST WELD FOR FREE-BEND AND SOUNDNESS TESTS

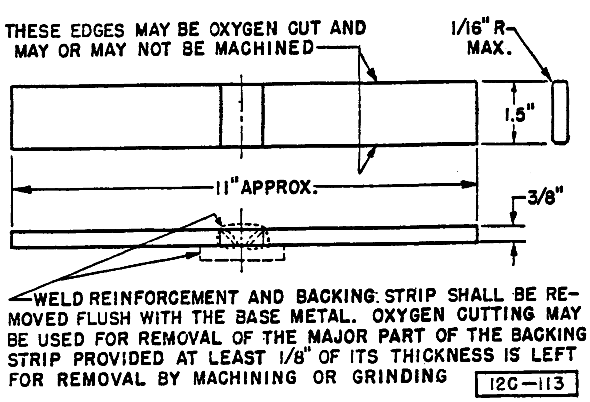


FIG. 39

FILLET-WELD-SOUNDNESS TEST SPECIMEN

7.2.15 Root-, Face-, Side-Bend, and Fillet-Weld-Soundness Specimens

a. Each specimen shall be bent in a jig having the contour shown in Fig. 41 and otherwise substantially in accordance with that figure. Any convenient means may be used for moving the male member with relation to the female member. The specimen shall be placed on the female member of the jig with the weld at midspan. The two members of the jig shall be forced together until the curvature of the specimen is such that a 1/32-in. diameter wire cannot be passed between the curved portion of the male member and the specimen. The specimen shall then be removed from the jig.

b. Face-bend specimens shall be placed on the female member of the jig with the face of the weld directed toward the gap.

c. Root-bend and fillet-weld-soundness specimens shall be placed on the female member of the jig with the root of the weld directed toward the gap.

d. The side-bend specimens shall be placed on the female member of the jig with that side showing the greater defects, if any, directed toward the gap.

7.2.16 Transverse Shear Test Specimens. Before testing, the length of the individual welds shall be measured in inches and if any weld varies by more than 1/16 in. from the length specified in Fig. 37, then the length of each weld and its location shall be recorded. The average size of the fillet welds shall also be recorded. The specimen shall be ruptured under tensile load and the maximum load in pounds shall be determined. The shearing strength of the welds in pounds per linear inch shall be obtained by dividing the maximum force by the sum of the lengths of the welds which ruptured. The shearing strength of the welds in pounds per square inch shall be obtained by dividing the shearing strength in pounds per linear inch by the average theoretical throat dimension of the welds in inches.

Minimum Test Results Required

7.2.17 Reduced-Section Tension Test. The tensile strength shall be not less than 95 per cent of the minimum of the specified tensile range of the base material used.

7.2.18 Free-Bend Test. The elongation shall be not less than 20 per cent.

7.2.19 Root-, Face-, Side-Bend, and Fillet-Weld Soundness Tests. The convex surface of the specimen shall be examined for the appearance of cracks or other open defects. Any specimen in which a crack or other open defect is present after the bending, exceeding 1/8 in. measured in any direction, shall be considered as having failed. Cracks occurring on the corners of the specimen during testing shall not be considered.

7.2.20 Transverse Shear Test. The shearing strength of the welds in pounds per square inch shall be not less than 87½ per cent of the minimum of the specified tensile range of the base material.

7.2.21 Qualification of Horizontal Shell Joints. The welding for horizontal butt joints of the tank shell, which do not require complete penetration, shall have the procedure qualified by the reduced-section tension test only. The reduced-section tension test shall give values not less than 63 per cent of the minimum tensile strength requirement of the parent material.

7.2.22 Records. Records of the test results shall be kept by the manufacturer and shall be available to those authorized to examine them.

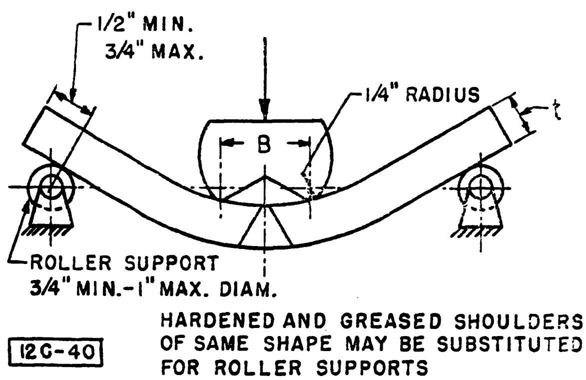


FIG. 40
INITIAL BEND FOR FREE-BEND SPECIMENS
See Fig. 34 for Dimension B

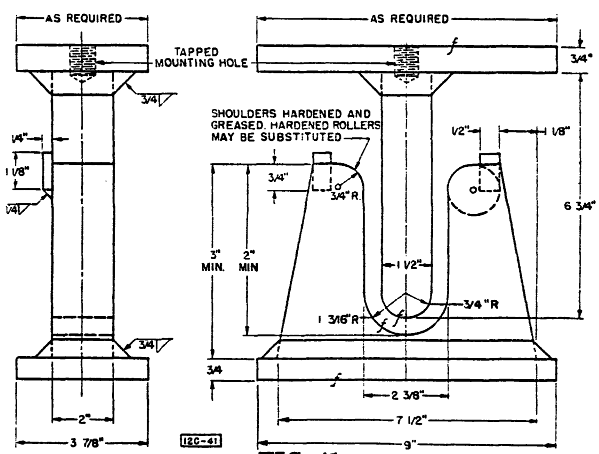


FIG. 41
GUIDED-BEND TEST JIG

7.3 WELDER QUALIFICATION

7.3.1 The following requirements are intended to apply only to the manual application of the arc-welding process. See Par. 7.1.4 for qualification of welders who operate semi-automatic welding equipment and welding operators who operate automatic welding equipment.

7.3.2 For the qualification of a welder the following rules shall apply. If certain changes are made in a procedure specification, welder requalification may be required in accordance with Par. 7.2.2.

Types of Tests Required

7.3.3 The qualification tests described herein are specially devised tests to determine the welder's ability to produce sound welds, and may or may not conform in every detail to the requirements of the welding procedure specification (Sect. 7.4). It is not intended that the practices required in the qualification tests shall be used as a guide for welding during actual construction. The latter shall be done in accordance with the requirements of the welding procedure specification.

7.3.4 The tests used for welder qualification are as follows, except that, if a welder is qualified to make groove welds, he shall be considered as qualified to make fillet welds.

A. For groove weld:
   1. Root-bend test.
   2. Face-bend test.
   3. Side-bend test.

B. For fillet welds:
   Fillet-weld-soundness test.

Base Material and Its Preparation

7.3.5 The base material shall comply with requirements of any grade of plate stipulated in Part 2. For all types of welded joints the length of the weld and the dimensions of the base material shall be such as to provide sufficient material for the test specimens called for hereinafter.

7.3.6 For groove welds, where the thickness of the material is 3/8 in. for the tests as specified in Par. 7.3.13 the preparation of the base material for welding shall be for a single V-groove butt joint meeting the requirements of Fig. 42.

7.3.7 For groove welds, where the thickness of the material exceeds 3/8 in. for the tests as specified in Par. 7.3.13, the preparation of the base material for welding shall be for a single V-groove butt joint meeting the requirements of Fig. 43.

7.3.8 For fillet welds, the preparation of the base material for welding shall be as shown in Fig. 44.

Position of Test Welds (Groove Welds)

7.3.9 For the purpose of determining the ability of a welder to make groove welds in various positions the following positions for test are required.

a. **Flat Position:** Plates placed in an approximately horizontal plane and the weld metal deposited from the upper side. (See Fig. 29 (a).) This test will qualify the welder for flat position welds.

b. **Horizontal Position:** Plates placed in an approximately vertical plane with the welding groove approximately horizontal. (See Fig. 29(b).) This test will qualify the welder for flat and horizontal positions.

c. **Vertical Position:** Plates placed in an approximately vertical plane with the welding groove approximately vertical. (See Fig. 29(c).) This test will qualify the welder for flat and vertical positions.

d. **Overhead Position:** Plates placed in an approximately horizontal plane and the weld metal deposited from the under side. (See Fig. 29(d).) This test will qualify the welder for flat and overhead positions.

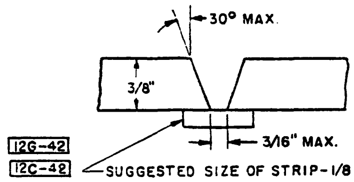
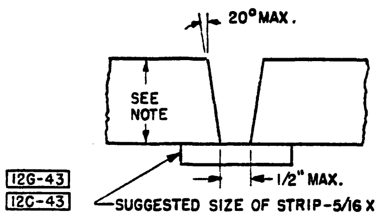


FIG. 42
BUTT-JOINT FOR WELDER QUALIFICATION FOR PLATE ¾ IN. THICK AND UNDER



Note: See Par. 7.3.13

FIG. 43
BUTT-JOINT FOR WELDER QUALIFICATION FOR PLATE OVER ¾ IN. THICK

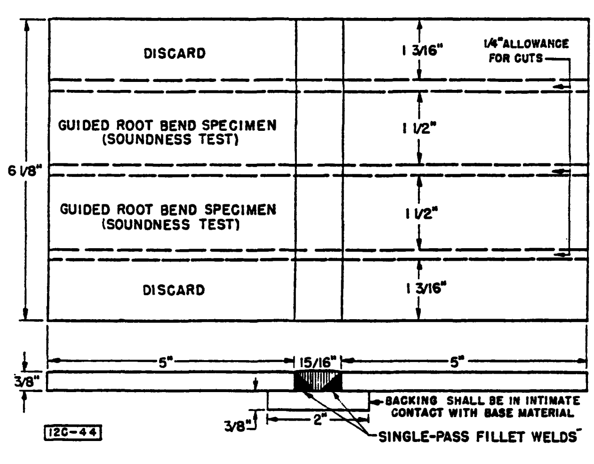


FIG. 44
TEST WELD FOR SOUNDNESS TESTS (WELDER QUALIFICATION ONLY)

e. Plate Box: A plate box placed with its axis in an approximately horizontal plane with the welding groove in an approximately vertical plane. The box shall not be rolled or turned during welding, thus requiring the welder to deposit weld metal from the flat, vertical and overhead positions. (See Fig. 29(e).) This test will qualify the welder for welds made in the flat, vertical, and overhead positions, and for the incidental pipe welding required in the fabrication and attachment of appurtenances.

7.3.10 If a welder is tested in either position, Fig. 29(b), (c), (d), or (e), he need not be tested in position (a); and if tested in position (e), he need not be tested in positions (c) or (d).

Position of Test Welds (Fillet Welds)

7.3.11 For the purpose of determining the ability of a welder to make fillet welds in various positions in plate, the following positions for test are required.

a. Flat Position: Plates placed in such position that each weld is deposited with its axis approximately horizontal and with its throat approximately vertical. (See Fig. 30(a).) This test will qualify the welder for flat welds.

b. Horizontal Position: Plates placed in such position that each weld is deposited on the upper side of the horizontal surface and against the vertical surface. (See Fig. 30(b).) This test will qualify the welder for flat and horizontal fillet welds.

c. Vertical Position: Plates placed in such position that each weld is made vertically. (See Fig. 30(e).) This test will qualify the welder for flat, horizontal, and vertical fillet welds.

d. Overhead Position: Plates placed in such position that each weld is deposited on the under side of the horizontal surface and against the vertical surface. (See Fig. 30(d).) This test will qualify the welder for flat, horizontal, and overhead fillet welds.

> NOTE: *The above arrangement of test plates refers only to the making of the fillet weld. The closing weld between fillet welds in the fillet-weld-soundness test may be made in any position. (See Fig. 30)*

7.3.12 If a welder is tested in either positions 30(b), (c), or (d), he need not be tested in position (a); and if tested in positions (c) or (d), he need not be tested in position (b).

Number of Test Welds Required

7.3.13 Groove Welds. For groove welds (either single or double beveled) one test weld shall be made in each position for which the welder is to be qualified, as defined in Par. 7.3.9. If the construction involves welding of material ¾ in. thick or less, the test weld shall be made on material ⅜ in. thick, as shown in Fig. 42. If the construction involves welding of material over ¾ in. thick, the test weld shall be made on material of either the maximum thickness to be welded on or material 1 in. thick, as shown in Fig. 43. If a test weld is made in either the maximum or 1-in. thickness, no test weld need be made in the ⅜-in. thickness.

7.3.14 Fillet Welds. For fillet welds, one test weld as shown in Fig. 38 shall be made for each position for which the welder is to be qualified, as defined by Par. 7.3.11.

7.3.15 **Welding Procedure.** The welder shall follow the welding procedure specified by the welding procedure specification (Sect. 7.4), except that if the form of the test joint differs from the forms of joint as shown in the welding procedure specification to such a degree that it is necessary, in welding the test joint, to change the electrode diameter or the number and arrangement of passes from that called for in the welding procedure specification, such changes shall be permissible.

Test Specimens—Number, Type, and Preparation

7.3.16 **Groove Welds.** For groove welds in plate, the method of preparing the specimens shall be in accordance with the figures referred to in Table 21 herein and the number of tests required shall be as given in the table.

TABLE 23

WELDER QUALIFICATION TESTS FOR GROOVE WELDS

1	2	3	4	5
		Number and Type of Tests Required		
Maximum Thickness for which Welder is to be Qualified, in.	Thickness of Material for Test Weld, in.	Root Bend See Fig. 35	Face Bend See Fig. 35	Side Bend See Fig. 36
Up to and including ¾	⅜	1	1	--
Over ¾	Maximum but need not exceed 1	--	--	2

7.3.17 **Fillet Welds.** Two test specimens shall be removed from each test weld and prepared for testing as shown in Fig. 39.

Method of Testing Specimens

7.3.18 **Root-, Face-, Side-Bend-, and Fillet-Weld Soundness Specimens**

a. Each specimen shall be bent in a jig substantially in accordance with Fig. 41. Any convenient means may be used for moving the male member with relation to the female member. The specimen shall be placed on the female member of the jig with the weld at midspan. The two members of the jig shall be forced together until the curvature of the specimen is such that a $\frac{1}{32}$-in. diameter wire cannot be passed between the curved portion of the male member and the specimen. The specimen shall then be removed from the jig.

b. Face-bend specimens shall be placed on the female member of the jig with the face of the weld directed toward the gap.

c. Root-bend and fillet-weld-soundness specimens shall be placed on the female member of the jig with the root of the weld directed toward the gap.

d. The side-bend specimen shall be placed on the female member of the jig with that side showing the greater defects, if any, directed toward the gap.

Test Results Required

7.3.19 **Root-, Face-, Side-Bend, and Fillet-Weld-Soundness Test.** The convex surface of the specimen shall be examined for the appearance of cracks or other open defects. Any specimen in which a crack or other open defect is present after the bending, exceeding ⅛ in. measured in any direction, shall be considered as having failed. Cracks occurring on the corners of the specimen during testing shall not be considered.

Retests

7.3.20 In case a welder fails to meet the requirements of one or more test welds, a retest may be allowed under the following conditions.

a. An immediate retest may be made which shall consist of two test welds of each type on which the welder failed, all of which shall meet all the requirements specified for such welds.

b. A retest may be made provided there is evidence that the welder has had further training or practice. In this case, a complete retest shall be made.

7.3.21 **Radiographic Examination of Test Plates.** Unless otherwise specified on the purchase order, in lieu of the testing procedure for groove welds as specified in Par. 7.3.18, the manufacturer may elect to test such test plates by the radiographic method, in which case the following provisions shall apply.

a. Test plates shall be prepared and welded as provided for groove welds in Par. 7.3.13. The test weld shall be 6 to 8 in. long.

b. The preparation of the test plates for radiographic examination and radiographic procedure shall conform to the applicable requirements of Sect. 6.2. The radiograph shall clearly show the test plate weld for its full length, less 1½ in. at each end.

c. The welder shall be considered as qualified if the radiograph conforms to the requirements of Par. 6.2.12.

7.3.22 **Period of Effectiveness.** A qualified welder may be deemed qualified indefinitely provided:

a. He has not changed his employer.

b. His employment as an API tank welder, or as a welder on work requiring welding procedures similar to those specified herein has been continuous except for periods not in excess of three months at any one time, and not in excess of three months cumulative time in each six-month period.

c. There is no specific reason to question his ability.

For a welder who is disqualified under case b. above, the requalification test need be made in the ⅜-in. thickness only.

7.3.23 Records. The manufacturer shall maintain a record of each welder employed by him showing the dates and results of qualification tests and the work-identification mark assigned to him, and such records shall be available to those authorized to examine them.

7.3.24 Delayed Test Reports. A welder will be permitted to make fillet welds in the horizontal position, such as intermediate joints on bottom and roof plates, provided he has made the required test specimens which for a good reason have not been tested nor reported on, and provided the manufacturer foreman and the purchaser inspector are satisfied with the appearance of the welding.

7.4 WELDING PROCEDURE SPECIFICATION

7.4.1 The following form is provided as a guide for the establishment of the required welding procedure specification. See Par. 7.2.1. It is not necessary that this exact form be used but the information shown should be set forth on any alternative form. Also, if desired, the form may be augmented to show the results of the required procedure qualification tests.

Date____________________

Welding process____

If machine: Single or multiple pass____

Single or multiple arc____

Base material or materials:

Specification____________________Grade____________________Thickness____________________

Specification____________________Grade____________________Thickness____________________

Filler material:

Specification____Grade______________________________

Preheat temperature range____

Position____

(Flat, horizontal, vertical, or overhead. If vertical state whether upward or downward. See Par. 7.2.5 and 7.2.6.)

Other essential variables____

____

Manufacturer______________________________

By____________________________________

8. MARKING

8.1 Tanks made in accordance with this specification by manufacturers authorized to use the API monogram shall be identified by a name plate bearing the API monogram, the manufacturer's name, the number of his certificate of authority to use the API monogram, and other information as shown in Fig. 45 herein.

8.2 The name plate shall be attached to the tank shell adjacent to a manhole, or to a manhole reinforcing plate immediately above the manhole. A name plate attached directly to the shell plate or reinforcing plate shall be fastened by continuous welding or brazing all around the plate, or the name plate may be riveted or otherwise permanently attached to an auxiliary plate of ferrous material which shall be attached to the tank shell plate or reinforcing plate by continuous welding. The name plate shall be rolled or cast corrosion-resistant metal.

8.3 When a tank is fabricated and erected by a single organization, the name and certificate number shall appear on the name plate both as fabricator and erector.

8.4 When a tank is fabricated by one organization and erected by another, both must have applied for and received a Certificate of Authority to Use the API Monogram, and the names and certificate numbers of both shall appear on the name plate, or separate name plates shall be applied by each.

8.5 Unless otherwise agreed upon, when a tank is fabricated by one organization and erected by another, the erecting manufacturer shall be considered as having the primary responsibility, and shall take such precautions as are necessary to assure himself and the purchaser that the materials from which the tank is made and the fabrication of such materials are in accord with all applicable requirements.

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

8.7 Authority to use the API monogram will be granted to any manufacturer under the rules and regulations given in Appendix E. The API monogram shall not be used by manufacturers who have not applied for and received the certificate of authority.

8.8 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. If an authorized licensee does not use the monogram in any two consecutive years his certificate shall be cancelled. 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.

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

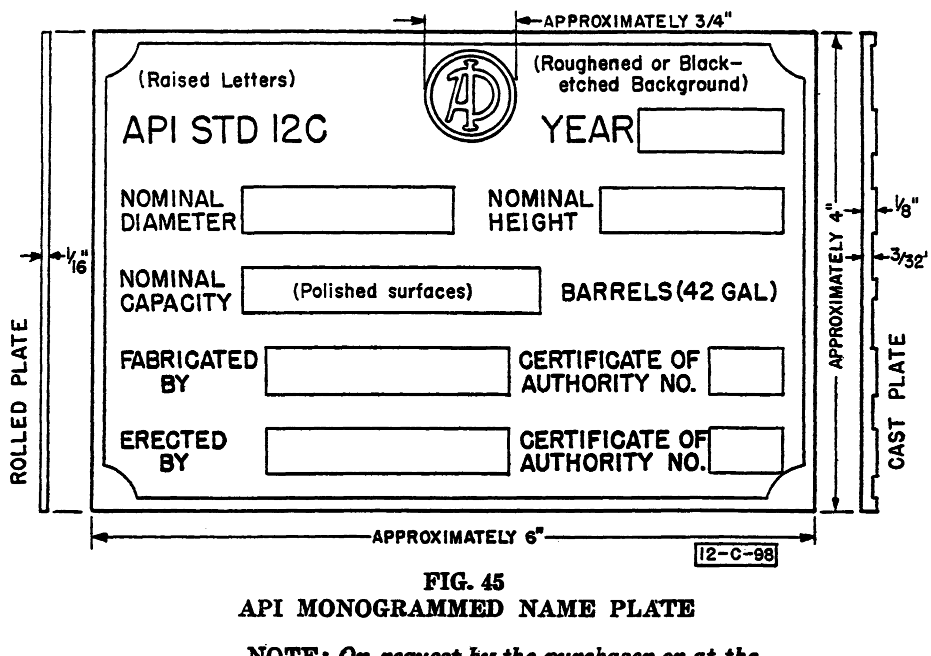


FIG. 45
API MONOGRAMMED NAME PLATE

NOTE: ***On request by the purchaser or at the discretion of the manufacturer, additional pertinent information may be shown on the name plate, and the size of the name plate shall be increased proportionately.***

APPENDIX A
REFERENCE AND TYPICAL DESIGN DATA

The data in this appendix are not mandatory, and are presented for the convenience of tank users and manufacturers.

Typical Sizes, Capacities, and Shell-Plate Thicknesses. The following tables show typical sizes, capacities, and shell-plate thicknesses for tanks which may be built under this specification. In these tables no standardized relationship between tank sizes and course widths is implied.

Table 24—Sizes and Capacities for Tanks with 72-in. Courses.

Table 25—Shell-Plate Thicknesses for Tanks with 72-in. Courses.

Table 26—Sizes and Capacities for Tanks with 96-in. Courses.

Table 27—Shell-Plate Thicknesses for Tanks with 96-in. Courses.

Fig. 46 shows typical designs of stiffening-ring sections for open-top tank shells and Table 28 gives the corresponding section moduli.

TABLE 24

TYPICAL SIZES AND CORRESPONDING NOMINAL CAPACITIES FOR TANKS WITH 72-IN. BUTT-WELDED COURSES

1	2	3	4	5	6	7	8	9	10	11
		Tank Height (Feet)								
	Approx. Capacity per Foot of Height (Bbl.)	12	18	24	30	36	42	48	54	60
		Number of Courses in Completed Tank								
Tank Diameter (Ft.)		2	3	4	5	6	7	8	9	10
10	14.0	170	250	335	420	505	....	....	....	....
15	31.5	380	565	755	945	1 130	....	....	....	....
20	56.0	670	1 010	1 340	1 680	2 010	2 350	2 690	....	....
25	87.4	1 050	1 570	2 100	2 620	3 150	3 670	4 200	4 720	5 250
30	126	1 510	2 270	3 020	3 780	4 530	5 290	6 040	6 800	7 550
35	171	2 060	3 080	4 110	5 140	6 170	7 200	8 230	9 250	10 280
40	224	2 690	4 030	5 370	6 710	8 060	9 400	10 740	12 090	13 430
45	283	3 400	5 100	6 800	8 500	10 200	11 900	13 600	15 300	17 000
50	350	4 200	6 290	8 390	10 490	12 590	14 690	16 790	18 880	20 980
60	504	6 040	9 060	12 090	15 110	18 130	21 150	24 170	27 190	30 220
70	685	8 230	12 340	16 450	20 560	24 680	28 790	32 900	37 010	41 130
80	895	10 740	16 120	21 490	26 860	32 230	37 600	42 970	48 350	53 720
90	1133	13 600	20 390	27 190	33 990	40 790	47 590	54 390	61 180	67 980
100	1399	16 790	25 180	33 570	41 970	50 360	58 750	67 140	75 540	83 930
120	2014	....	36 260	48 340	60 430	72 510	84 600	96 690	108 800	12 900
140	2742	....	49 350	65 800	82 250	98 700	115 100	131 600	148 000	164 500
160	3581	....	....	....	107 400	128 900	150 400	171 900	193 400	214 900
180	4532	....	....	....	136 000	163 200	190 400	217 500	244 800	254 300
200	5595	....	....	....	167 900	201 400	235 000	268 600	284 500	D=174
220	6770	....	....	....	203 100	243 700	284 400	322 300 D=219	D=194	

The above nominal capacities are based on the formula: Capacity (42-gal. bbl.) $=0.14\ D^2H$; Where D=center-line shell diameter, and H=listed tank height.

Capacities and diameters below the heavy lines (Col. 9-11) are maximum for the tank heights shown, based on the 1½-in. maximum permissible thickness of shell plates and maximum allowable design stresses.

TABLE 25

SHELL-PLATE THICKNESSES FOR TYPICAL SIZES OF TANKS WIH 72-IN. BUTT-WELDED COURSES

1	2	3	4	5	6	7	8	9	10	11	12
	Tank Height (Feet)										Maximum Allowable Height[1] for Diameters Listed (Ft.)
	6	12	18	24	30	36	42	48	54	60	
	Number of Courses in Completed Tank										
	1	2	3	4	5	6	7	8	9	10	
Tank Diam. (Ft.)	Shell Plate Thickness (Inches)										
10	3/16	3/16	3/16	3/16	3/16	3/16	......	......	......	......	......
15	3/16	3/16	3/16	3/16	3/16	3/16	......	......	......	......	......
20	3/16	3/16	3/16	3/16	3/16	3/16	3/16	3/16	......	......	......
25	3/16	3/16	3/16	3/16	3/16	3/16	3/16	0.19	0.20	0.22	......
30	3/16	3/16	3/16	3/16	3/16	3/16	0.19	0.21	0.24	0.26	......
35	3/16	3/16	3/16	3/16	3/16	0.19	0.21	0.24	0.27	0.30	......
40	3/16	3/16	3/16	3/16	0.19	0.21	0.24	0.28	0.31	0.35	......
45	3/16	3/16	3/16	3/16	0.19	0.23	0.27	0.31	0.35	0.39	......
50	¼	¼	¼	¼	¼	0.26	0.30	0.35	0.39	0.43	......
60	¼	¼	¼	¼	0.26	0.31	0.36	0.41	0.47	0.52	......
70	¼	¼	¼	0.25	0.30	0.36	0.42	0.48	0.54	0.61	......
80	¼	¼	¼	0.27	0.34	0.41	0.48	0.55	0.62	0.69	......
90	¼	¼	¼	0.31	0.38	0.46	0.54	0.62	0.70	0.78	......
100	¼	¼	0.25	0.34	0.43	0.51	0.60	0.69	0.78	0.86	......
120	5/16	5/16	0.31	0.41	0.51	0.62	0.72	0.83	0.93	1.03	......
140	5/16	5/16	0.35	0.47	0.60	0.72	0.84	0.96	1.08	1.21	......
160	5/16	5/16	0.40	0.54	0.68	0.82	0.96	1.10	1.24	1.38	65.3
180	5/16	5/16	0.45	0.61	0.76	0.92	1.08	1.24	1.39	......	58.2
200	5/16	0.32	0.50	0.67	0.85	1.02	1.20	1.37	......	......	52.5
220	⅜	⅜	0.55	0.74	0.94	1.13	1.32	......	......	......	47.8

Plate thicknesses shown above in fractions are thicker than required for hydrostatic loading but for practical reasons have been fixed at the values given; therefore, plates for these courses may be ordered on a weight basis. Plate thicknesses shown above in decimals are based on maximum allowable stresses and therefore plates for these courses must be ordered on a thickness basis (see Par. 2.2 and 3.3.4 for thickness requirements and methods of ordering).

In deriving the plate thickness values shown, it was assumed, on the basis of average mill practice, that the edge thickness of plates 72 in. wide and ordered on the weight basis, would underrun the nominal thickness by 0.03 in. Par. 2.2 permits an actual thickness to underrun a calculated or specified thickness by 0.01 in.; consequently fractional thickness values are shown only when the fractional value exceeds the calculated thickness of the course in question by more than 0.02 in.

[1]Based on the 1½-in. maximum permissible thickness of shell plates and the maximum allowable design stresses.

TABLE 26

TYPICAL TANK SIZES AND CORRESPONDING NOMINAL CAPACITIES FOR TANKS WITH 96-IN. BUTT-WELDED COURSES

1	2	3	4	5	6	7	8	9
		Tank Height (Feet)						
	Approx. Capacity per Foot of Height (Bbl.)	16	24	32	40	48	56	64
Tank Diameter (Ft.)		Number of Courses in Completed Tank						
		2	3	4	5	6	7	8
10	14.0	225	335	450	....	....	....	....
15	31.5	505	755	1 010	1 260	....	....	....
20	56.0	900	1 340	1 790	2 240	2 690	....	....
25	87.4	1 400	2 100	2 800	3 500	4 200	4 900	5 600
30	126	2 020	3 020	4 030	5 040	6 040	7 050	8 060
35	171	2 740	4 110	5 480	6 850	8 230	9 600	10 960
40	224	3 580	5 370	7 160	8 950	10 740	12 530	14 320
45	283	4 530	6 800	9 060	11 330	13 600	15 860	18 130
50	350	5 600	8 390	11 190	13 990	16 790	19 580	22 380
60	504	8 060	12 090	16 120	20 140	24 170	28 200	32 230
70	685	10 960	16 450	21 930	27 420	32 900	38 380	43 870
80	895	14 320	21 490	28 650	35 810	42 970	50 130	57 300
90	1133	18 130	27 190	36 260	45 320	54 390	63 450	72 520
100	1399	22 380	33 570	44 760	55 950	67 140	78 340	89 530
120	2014	....	48 340	64 460	80 580	96 690	112 800	128 900
140	2742	....	65 800	87 740	109 700	131 600	153 500	175 500
160	3581	....	....	114 600	143 200	171 900	200 500	229 200
180	4532	....	....	145 000	181 300	217 500	253 800	238 100
200	5595	....	....	179 100	223 800	268 600	274 200	D=163
220	6770	....	....	216 700	270 800	322 300 D=219	D=187	

The above nominal capacities are based on the formula: Capacity (42-gal. bbl.)=0.14 D^2H; Where D=center-line shell diameter, and H=listed tank height.

Capacities and diameters below the heavy lines (Col. 9-11) are maximum for the tank heights shown, based on the 1½-in. maximum permissible thickness of shell plates and maximum allowable design stresses.

TABLE 27

SHELL-PLATE THICKNESSES FOR TYPICAL SIZES OF TANKS WITH 96-IN. BUTT-WELDED COURSES

1	2	3	4	5	6	7	8	9	10
	Tank Height (Feet)								Maximum Allowable Height[1] for Diameters Listed (Ft.)
	8	16	24	32	40	48	56	64	
	Number of Courses in Completed Tank								
Tank Diameter (Ft.)	1	2	3	4	5	6	7	8	
	Shell Plate Thickness (Inches)								
10	3/16	3/16	3/16	3/16	......	......	......	......	......
15	3/16	3/16	3/16	3/16	3/16	......	......	......	......
20	3/16	3/16	3/16	3/16	3/16	3/16	......	......	......
25	3/16	3/16	3/16	3/16	3/16	0.19	0.20	0.23	......
30	3/16	3/16	3/16	3/16	0.19	0.21	0.24	0.28	......
35	3/16	3/16	3/16	0.19	0.20	0.24	0.28	0.33	......
40	3/16	3/16	3/16	0.19	0.23	0.28	0.32	0.37	......
45	3/16	3/16	0.19	0.21	0.26	0.31	0.36	0.42	......
50	1/4	1/4	1/4	0.25	0.29	0.35	0.40	0.46	......
60	1/4	1/4	1/4	0.27	0.34	0.41	0.48	0.55	......
70	1/4	1/4	0.25	0.32	0.40	0.48	0.56	0.65	......
80	1/4	1/4	0.27	0.37	0.46	0.55	0.64	0.74	......
90	1/4	1/4	0.31	0.41	0.52	0.62	0.72	0.83	......
100	1/4	0.25	0.34	0.46	0.57	0.69	0.80	0.92	......
120	5/16	5/16	0.41	0.55	0.69	0.83	0.97	1.10	......
140	5/16	0.31	0.47	0.64	0.80	0.96	1.13	1.29	......
160	5/16	0.35	0.54	0.73	0.91	1.10	1.29	1.47	65.3
180	5/16	0.40	0.61	0.82	1.03	1.24	1.45	......	58.2
200	5/16	0.44	0.67	0.91	1.14	1.37	......	......	52.5
220	3/8	0.48	0.74	1.00	1.25	......	......	......	47.8

Plate thicknesses shown above in fractions are thicker than required for hydrostatic loading, but for practical reasons have been fixed at the values given; therefore, plates for these courses may be ordered on a weight basis. Plate thicknesses shown above in decimals are based on maximum allowable stresses and therefore plates for these courses must be ordered on a thickness basis (see Par. 2.2 and 3.3.4 for thickness requirements and methods of ordering.)

In deriving the plate thickness values shown, it was assumed, on the basis of average mill practice, that the edge thickness of plates 96 in. wide and ordered on the weight basis, would underrun the nominal thickness by 0.05 in. Par. 2.2 permits an actual thickness to underrun a calculated or specified thickness by 0.01 in.; consequently fractional thickness values are shown only when the fractional value exceeds the calculated thickness of the course in question by more than 0.04 in.

[1]Based on the 1½-in. maximum permissible thickness of shell plates and the maximum allowable design stresses.

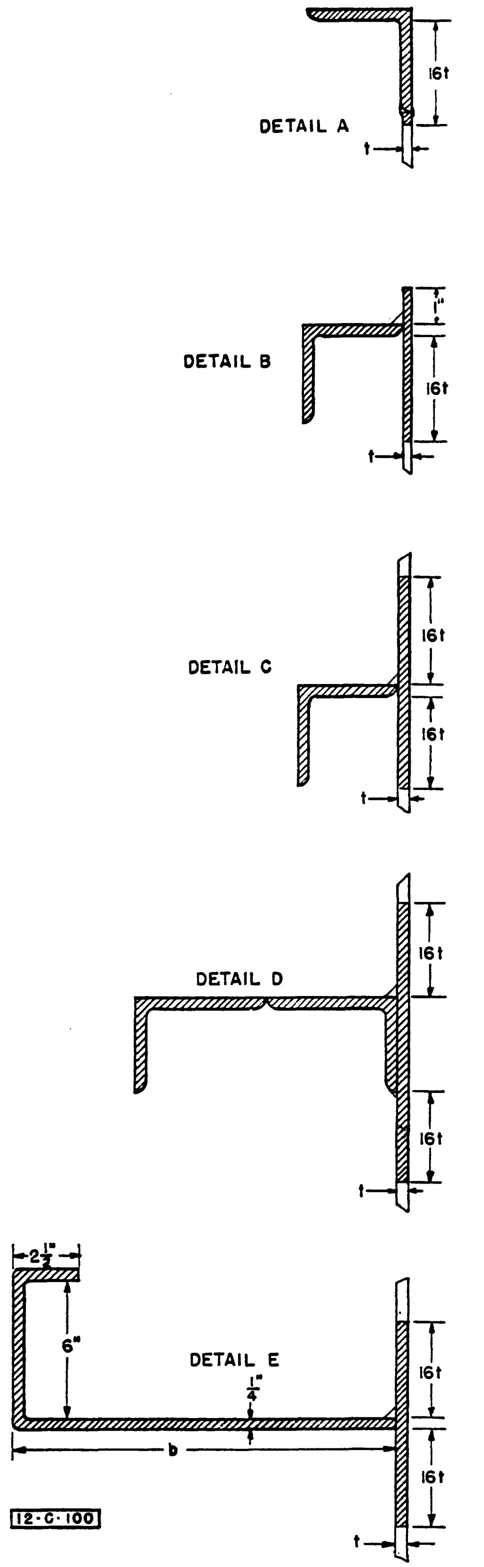


FIG. 46
TYPICAL STIFFENING-RING SECTIONS ON TANK SHELLS
See Table 28

TABLE 28
SECTION MODULI OF VARIOUS STIFFENING-RING SECTIONS ON TANK SHELLS

1	2	3
Member Size, in.	Shell Thickness, in. 3/16	1/4
	Section Moduli, in. Cubed	
Top Angle: Detail A, Fig. 46		
2½ x 2½ x ¼	0.41	0.42
2½ x 2½ x 5/16	0.51	0.52
3 x 3 x ⅜	0.89	0.91
Curb Angle: Detail B, Fig. 46		
2½ x 2½ x ¼	1.61	1.72
2½ x 2½ x 5/16	1.89	2.04
3 x 3 x ¼	2.32	2.48
3 x 3 x ⅜	2.78	3.35
4 x 4 x ¼	3.64	4.41
4 x 4 x ⅜	4.17	5.82
One Angle: Detail C, Fig. 46		
2½ x 2½ x ¼	1.68	1.78
2½ x 2½ x 5/16	1.98	2.12
4 x 3 x ¼	3.50	3.73
4 x 3 x 5/16	4.14	4.45
5 x 3 x 5/16	5.53	5.95
5 x 3½ x 5/16	6.13	6.60
5 x 3½ x ⅜	7.02	7.61
6 x 4 x ⅜	9.02	10.56
Two Angles: Detail D, Fig. 46		
4 x 3 x 5/16	11.27	11.78
4 x 3 x ⅜	13.06	13.67
5 x 3 x 5/16	15.48	16.24
5 x 3 x ⅜	18.17	18.89
5 x 3½ x 5/16	16.95	17.70
5 x 3½ x ⅜	19.99	20.63
6 x 4 x ⅜	27.74	28.92
Formed Plate: Detail E, Fig. 46		
b = 10	......	22.3
12	......	28.1
14	......	34.3
16	......	40.8
18	......	47.7
20	......	54.9
22	......	62.4
24	......	70.3
26	......	78.5
28	......	87.0
30	......	95.9
32	......	105.1
34	......	114.7
36	......	124.5
38	......	134.7
40	......	145.3

APPENDIX B

RECOMMENDED PRACTICE FOR CONSTRUCTION OF FOUNDATIONS FOR API VERTICAL CYLINDRICAL OIL-STORAGE TANKS

Scope

B.1 The following recommendations are intended to establish certain minimum basic requirements for the design and construction of foundations under vertical, steel oil-storage tanks with flat bottoms. They are suggestive rather than mandatory and are offered as an outline of good practice and to point out some precautions that should be observed in constructing such foundations.

B.2 Due to the wide variety of surface, subsurface, and climatic conditions which may be met, it obviously is not practicable to establish design data to cover all such situations. The matter of allowable soil loading and the exact type of subsurface construction to use, necessarily must be decided for each individual case after careful consideration. The same rules and precautions should be used in their selection as would be applicable in designing or building foundations for any other structure of comparable magnitude.

Subsurface Construction

B.3 At any tank site the nature of the subsurface conditions must be known in order to estimate the amount of settlement that will be experienced and its probable result. This information may be obtained by exploratory work, consisting of making deep borings, making load and soil tests, and by review of experience and history of similar structures in the vicinity. The subgrade must be capable of sustaining the load of the tank and its contents without unequal or non-uniform settlement which would distort the tank and introduce stresses from external causes. The total of final uniform settlement must not be sufficient to strain connecting piping or produce inaccuracies of gaging, nor should it continue to a point where the tank bottom is below the surrounding ground surface.

B.4 Some of the many variations in conditions requiring special engineering consideration are:

a. Hillside sites where part of a tank may be on undisturbed ground or rock, and part on fill or other construction or where the depth of required fill is variable.

b. Sites on swampy or filled ground where there are layers of muck or compressible vegetation at or below the surface or where unstable or corrosive materials may have been deposited as fill.

c. Sites underlain by layers of plastic clay which may temporarily support heavy loads but which will settle excessively over long periods of time.

d. Sites adjacent to water courses or deep excavations, where lateral stability of the ground is questionable.

e. The presence of immediately adjacent heavy structures which distribute some of their load to the subsoil under the tank site and thereby reduce its capacity to carry additional load without excessive settlement.

f. Sites where tanks may be exposed to flood waters resulting in possible uplift, displacement, or scour.

B.5 It should be recognized that, if the subgrade is weak and inadequate to carry the load of the filled tank without excessive settlement, no shallow or superficial construction under the tank bottom will much improve it. One or more of the following general methods will probably have to be used.

a. Remove the objectionable material and replace it with other suitable and compact material.

b. Compact the soft material with short piles or by preloading with an overburden of earth, suitably drained, or other material.

c. Compact the soft material by removal of the water content by drainage, if practicable.

d. Stabilize the soft material by chemical methods or injection of cement grout.

e. Support the load on a more stable material underneath by driving bearing piles or constructing foundation piers down to it. This will involve construction of a reinforced slab on the piles to distribute the load of the tank bottom.

f. Construct a foundation of some type which will distribute the load over a sufficiently large area of the soft material so that the load intensity will be within allowable limits, and excessive settlement will not occur.

B.6 The filling material used to replace muck or other objectionable materials or to build up the grade to suitable height should be sound and durable and at least equivalent to that used for fill in good highway practice. It should be free of vegetation and organic matter and should contain no cinders or other substances which would cause corrosion of the tank bottom. The fill should be thoroughly compacted by the best available means.

Tank Grades

B.7 It is suggested that the grade or surface upon which the tank bottom will rest be constructed at least one foot above the surrounding ground surface. This will provide suitable drainage, will help keep the bottom dry, and will compensate for some small settlement which is likely to occur.

B.8 It is further suggested that the top 3 or 4 in. of the finished grade should consist of clean sand, gravel, crushed stone (of not over 1 in. maximum size), or some similar inert material which can be readily shaped to the proper contour. During construction, the movement of equipment and materials across the grade will mar the surface of the softer materials. These irregularities should be corrected before the bottom plates are placed for welding. The finished grade may be oiled or stabilized in some manner to preserve better contour during construction and to protect the tank bottom against ground moisture. Caution should be observed, however, that the quantity or kind of material used for this purpose does not create welding difficulties or risk of galvanic corrosion.

B.9 It is suggested that the finished tank grade be crowned from the outer periphery to the center. A slope of 1 in. in 10 ft. is suggested as a minimum. This crown will partly compensate for slight settlement which is likely to be greater at the center. It will also facilitate cleaning and the removal of water and sludge through openings in the shell or from sumps situated near the shell. Since the amount of crown will affect the lengths of roof-supporting columns, it is essential that the tank manufacturer be fully informed of this feature sufficiently in advance.

B.10 If the tank bottom is built on a flat concrete slab, a similar type of finished grade is recommended, to act as a cushion and to provide the proper contour for the slope of the bottom plates.

Concrete Ring-Wall Foundations

B.11 For tanks constructed on earth grades without substructures of any sort, it is desirable to distribute the concentrated load of the shell and its attachments to produce a more nearly uniform soil loading under the tank. This may be accomplished by constructing a concrete ring wall under the shell plate similar to that shown in Fig. 47. This type of construction is recommended for all tanks and particularly for tanks with floating roofs or those with diameters of 100 ft. and greater or heights of more than 40 ft. In addition to distributing the concentrated shell load, the ring wall will:

a. Provide a level and solid starting plane for construction of the shell or for the application of insulation when required.

b. Provide a better means for leveling the tank grade and preserving its contour during construction.

c. Retain the fill under the tank bottom and prevent loss of material from erosion or adjacent excavation.

d. Act as a moisture barrier and help to keep the tank bottom dry.

B.12 When designing concrete ring walls it is desirable that they be so proportioned that the average unit soil bearing under the wall shall be approximately the same as under the confined earth at the same depth. It is recommended that the thickness of ring walls be not less than 12 in. and that the center-to-center diameter equal the nominal tank diameter. The depth of the wall will depend upon local conditions, but there appears to be no need to construct the wall to any greater depth than the soil is disturbed in constructing the fill and grade under the tank as it adds but little to the gross area and nothing to the sustaining capacity of the subsoil. The top of the wall should be smooth and level within plus or minus ⅛ in. in any 30-ft. circumferential length, and no point in the circumference should vary more than plus or minus ¼ in. from the established elevation. Recesses should be provided in the wall for flush-type cleanouts, draw-off elbows, or any other appurtenances which require recessing.

B.13 The ring wall should be reinforced against temperature and shrinkage and to resist the lateral pressure of the confined fill with its surcharge. It is suggested that the minimum reinforcing in any ring wall be 0.002 times the cross-sectional area of the wall above grade with additional reinforcement as may be required for resisting lateral earth pressure. The latest revised Building Code Requirements for Reinforced Concrete of the American Concrete Institute (ACI 318 and ASA 89.1) are recommended for stress values and material specifications.

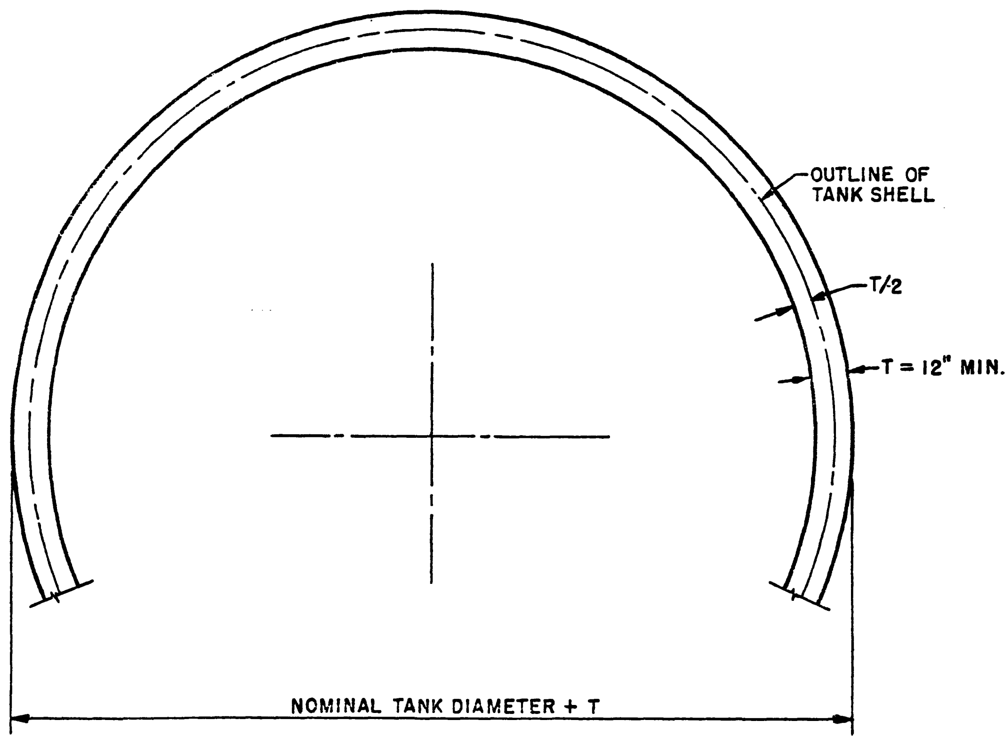
Earth Grades without Ring Walls

B.14 For tanks in locations where the construction of concrete ring walls is impracticable, suitable earth foundations may be satisfactory. The proper selection of site, investigation of soil conditions, and the preparation of the grade, however, are of equal or greater importance. The general type of foundation suggested for this purpose is shown in Fig. 48.

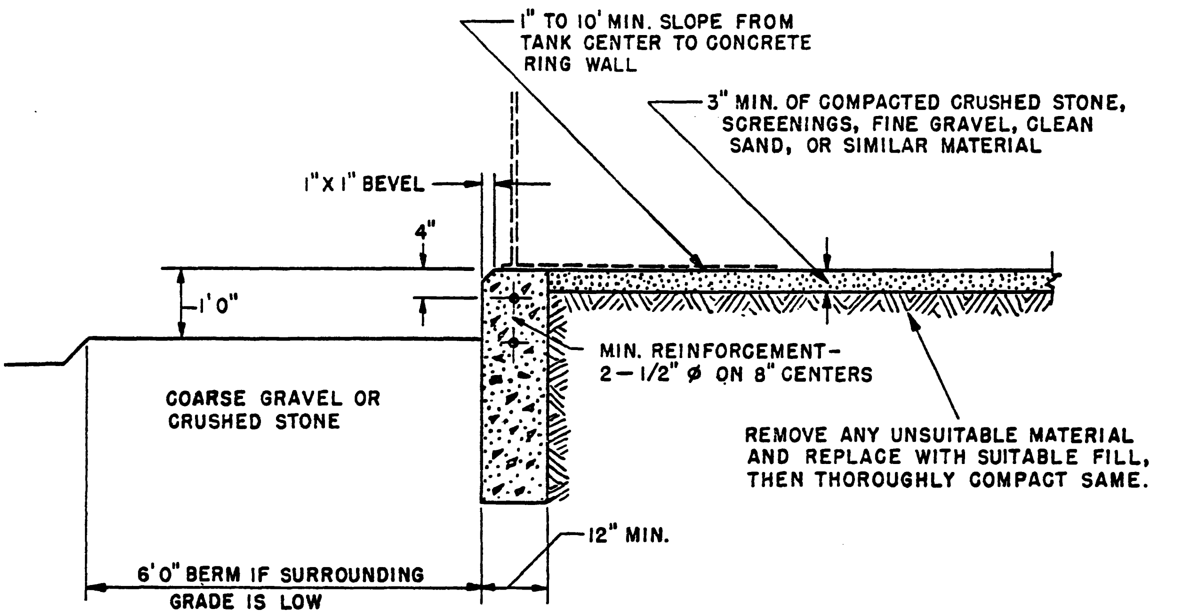
B.15 In using this type of foundation it is recommended that, if the tank is one with a floating roof or with a diameter of 100 ft. or more or height greater than 40 ft., the concentrated load of the shell and attachments be distributed by a course of annular or segmental plates. These bearing plates should be flat and at least ½ in. thick, should extend under the tank bottom for a radial distance of at least 6 in., and should extend outside beyond the shell at least 6 in. They should be firmly imbedded flush with the finished grade and should be carefully leveled and tack-welded together to maintain their alignment and position during construction. The ring of bearing plates should be interrupted where necessary to provide the required retention and supporting devices for flush-type cleanouts or similar accessories. The tolerances for leveling the bearing plates should be the same as required for the tops of concrete ring walls. After erection of the bottom tank ring, the bearing plates should be intermittently welded to the bottom sketch plates. (See Fig. 4 (d).)

B.16 For smaller tanks where the prepared grade and the subgrade are adequate to support the concentrated shell load without appreciable settlement, no bearing plates need be used. It is recommended, however, that particular care be used to prepare a smooth and level surface for the tank bottom sketch plates and that in other respects this type of foundation be similar to that shown in Fig. 48.

B.17 The finished tank grade should continue outside of the tank periphery to form a berm at least 3 ft. wide all around. This shoulder and berm should be protected against weathering and tank roof run-off by constructing it of crushed rock or covering it with some sort of paving material.



PLAN OF CONCRETE RING WALL

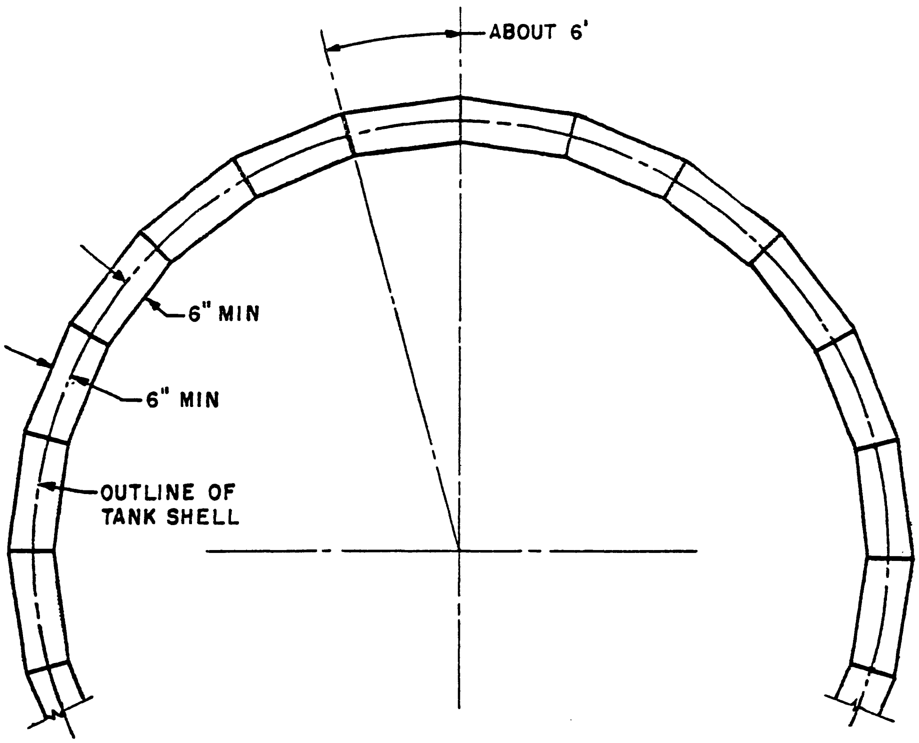


NOTE: TOP OF CONCRETE RING WALL SHOULD BE SMOOTH AND LEVEL. CONCRETE- 3000 PSI. AT 28 DAYS. LAP REINFORCEMENT SPLICES TO DEVELOP FULL STRENGTH IN BOND

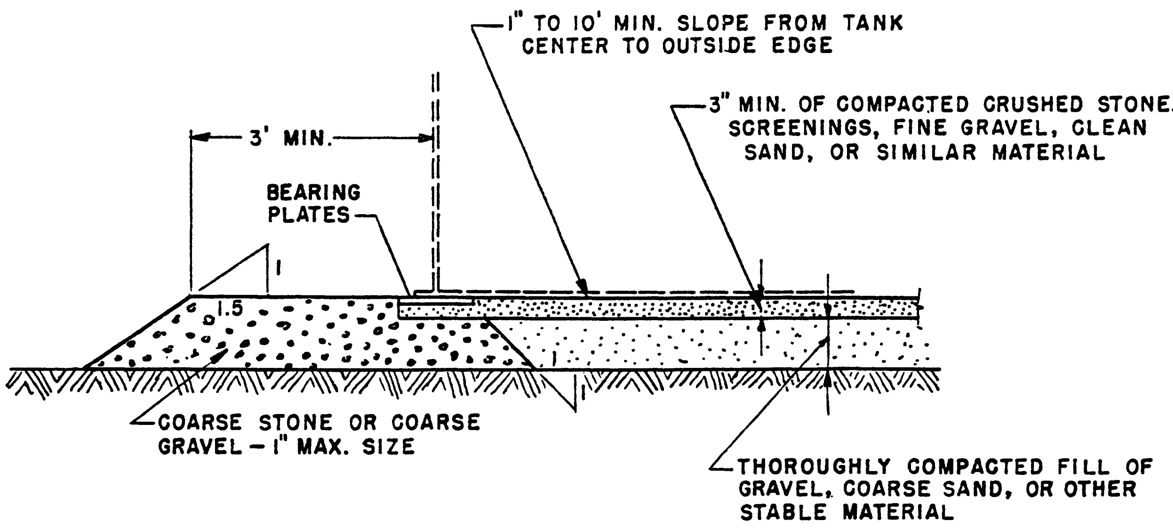
12C-44

FIG. 47

EXAMPLE OF CONCRETE RING-WALL FOUNDATION



PLAN OF BEARING PLATES



12C–45

NOTE: BOTTOM OF EXCAVATION SHOULD BE LEVEL. REMOVE MUCK, VEGETATION, AND UNSTABLE MATERIALS TO WHATEVER DEPTH IS NECESSARY

FIG. 48
EXAMPLE OF EARTH FOUNDATION

APPENDIX C

FLOATING ROOFS

NOTE: *Requirements on floating roofs are tentative and applicable only if agreed upon between the purchaser and the manufacturer. The API monogram may not be applied to a floating roof nor to a name plate attached thereto. Further, the API monogram applied to a floating roof tank, shall apply only to the open-top portion of the tank.*

C.1 SCOPE

C.1.1 The requirements given herein are minimum and, unless otherwise qualified in the text, apply to pan-type, pontoon-type, and double-deck type floating roofs. It is intended to limit only those factors that affect the safety and durability of the installation, and as considered to be consistent with the quality and safety requirements of Std 12C. There are numerous alternative details and proprietary appurtenances for which agreement between the purchaser and the manufacturer is necessary.

C.2 MATERIAL

C.2.1 Material requirements as set forth in Sect. 2 of Std 12C shall apply, except as specifically covered herein.

C.3 DESIGN

C.3.1 **General.** Design and construction of the roof and accessories shall be such as to permit the tank to overflow and then return to a liquid level that floats the roof well below the top of the tank shell without damage to any part of the roof, tank, or appurtenances. During such an occurrence, no manual attention shall be required to protect the roof, tank, or appurtenances. If a wind skirt or top shell extension is used for the purpose of containing the roof seals at the highest point of travel, overflow drainage openings shall be provided to prevent rise of the liquid level in the tank above the designed capacity height.

C.3.2 **Joint Design.** Sect. 3.1 of Std 12C shall apply.

C.3.3 **Decks.** In corrosive service, such as sour crude oil, it is suggested that roofs be of the contact type designed to eliminate the presence of any air-vapor mixture under the deck.

C.3.4 **Plate Thickness.** Unless otherwise specified on the purchase order, all deck plates shall have a minimum nominal thickness of $\frac{3}{16}$ in.

C.3.5 Deck plates shall be joined by continuous full-fillet welds on the top side. On the bottom side where flexure is anticipated, adjacent to girders, support legs, or other relatively rigid members, full-fillet welds not less than 2 in. long on 10-in. centers shall be used on any plate laps which occur within 12 in. of any such rigid support or member.

C.3.6 Top decks of double-deck roofs and of pontoon sections which are designed with a permanent slope for drainage shall have a minimum slope of $\frac{3}{16}$ in. in 12 in., and preferably shall be lapped to provide the best drainage. Plate buckles shall be kept to a minimum.

C.3.7 **Pontoon Volume.** The minimum pontoon volume of a single-deck pontoon roof shall be sufficient to keep the roof floating on a liquid with a specific gravity of 0.7 if the single deck and any two pontoon compartments are punctured. The minimum pontoon volume of a double-deck roof shall be sufficient to keep the roof floating on a liquid with a specific gravity of 0.7 if any two pontoon compartments are punctured and the primary drainage is inoperative. In either type of roof the pontoon volume and emergency drainage, either in combination or separately, shall be such that a 10-in. rainfall over the entire area during a 24-hr. period will not cause the roof to sink if the primary drainage is inoperative (with no compartments or decks punctured).

C.3.8 **Pontoon Openings.** Each compartment shall be provided with a manway with a rain-tight cover. The manway covers shall be provided with suitable hold-down fixtures or other means to prevent wind from removing the covers. The top edge of manway necks shall be at an elevation to prevent water entering the compartments under the conditions set forth in Par. C.3.7.

C.3.9 **Bulkhead Plates.** All internal bulkhead plates shall be single fillet welded along their bottom and vertical edges for liquid tightness. When specified by the purchaser the top edge of the bulkhead shall also be provided with a single continuous fillet weld for liquid tightness.

C.3.10 **Ladders.** The floating roof shall be supplied with a ladder which automatically adjusts to any position of the roof in such manner as always to provide access to the roof. The ladder shall be designed for full roof travel regardless of normal setting of roof leg supports. If a rolling ladder is furnished, it shall have full-length hand rails on both sides and shall be designed for a 1,000-lb. midpoint load with the ladder in any operating position.

C.3.11 **Roof Drains.** Primary drains shall be of the hose, jointed, or siphon type as specified on the purchase order. A check valve shall be provided near the roof end of the hose and jointed-pipe drains on single-deck and pan-type roofs to prevent backflow of stored product in case of leakage. Provisions shall be included to prevent kinking of the hose or pinching under the deck legs. Hose drains shall be designed to permit replacement without entering the tank. The swing joints of pipe drains shall be packed against leakage. The installation of either type drain shall include the installation of the proper shell fittings for its operation and, if necessary, its removal. The minimum size primary drain shall be equivalent in capacity to one 3-in. drain for roofs up to and including 120 ft. in diameter and to one 4-in. drain for roofs over 120 ft. in diameter.

C.3.12 Vents. Suitable vents shall be provided to prevent over-stressing of the roof deck or seal membrane. It is advisable for the purchaser to specify liquid withdrawal rates so that the fabricator may size the vacuum vents. These vents, or bleeder valves, or other suitable means, shall be adequate to evacuate air and gases from underneath the roof during initial filling.

C.3.13 Supporting Legs. The floating roof shall be provided with supporting legs. Legs fabricated from pipe shall be notched or perforated at the bottom to provide drainage. Length of legs shall be adjustable from the top side of the roof. The operating and cleaning position levels of the supporting legs shall be as specified on the purchase order and the manufacturer shall make certain that all tank appurtenances, such as mixers, interior piping, fill nozzle, etc., are cleared by the roof in its lowest position.

C.3.14 Legs and attachments shall be designed to support the roof and a live load of at least 25 lb. per sq. ft. Where possible, roof load shall be transmitted to the legs through bulkheads or diaphragms. Leg attachments to single decks shall be given particular attention to prevent failures at the points of attachment. Steel pads or other means shall be used to distribute the leg loads on the bottom of the tank. Pads, if used, shall be continuously welded to the bottom.

C.3.15 Roof Manways. At least one roof manhole shall be provided for access to the tank interior and for ventilation when the tank is empty. The number of roof manholes shall be as specified by the purchaser. These manholes shall be at least 24-in. inside diameter and shall have tight gasketed and bolted covers equivalent to the roof manholes shown in Fig. 12 of Std 12C.

C.3.16 Centering and Anti-Rotation Device. Suitable devices shall be provided to maintain the roof in a centered position and to prevent its rotation. These appurtenances shall be capable of resisting the lateral forces imposed on them by the roof ladder, unequal snow loads, wind loads, etc.

C.3.17 Seals. The space between the outer periphery of the roof and the tank shell shall be sealed by a flexible device which shall provide a reasonably close fit to the shell surfaces. If the sealing device employs steel shoes in contact with the shell, such shoes shall be made from galvanized sheet conforming to ASTM A 93, with a minimum nominal thickness of 16 ga. and a class 1.25 (commercial) coating, except that if uncoated shoes are specified, they shall be made of sheet steel of a thickness and quality as specified on the purchase order. An adequate but minimum number of expansion joints shall be provided. Any fabric or non-metallic material used as a seal or a seal component shall be durable in its environment and shall not discolor or contaminate the product stored.

C.3.18 Gaging Device. Each roof shall be provided with a gaging hatch or gage well with a tight cap of a design as specified on the purchase order.

C.4 FABRICATION, ERECTION, WELDING, INSPECTION, AND TESTING

C.4.1 Applicable fabrication, erection, welding, and inspection requirements of Std 12C shall apply.

C.4.2 Deck seams and other joints which are required to be liquid or vapor tight shall be tested for leaks by penetrating oil or by any other method consistent with Std 12C methods for testing cone-roof seams and tank-bottom seams.

C.4.3 The roof shall be given a flotation test while the tank is being filled with water and emptied. During this test, the upper side of the lower deck shall be examined for leaks. The appearance of a damp spot on the upper side of the lower deck shall be considered evidence of leakage.

C.4.4 The upper side of the upper decks of pontoons and of double-deck roofs shall be visually inspected for pinholes or defective welding.

C.4.5 Drain-pipe and hose systems of primary drains shall be pressure tested with water at 50 psi. During the flotation test, the roof drain valves shall be kept open and observed for leakage of tank contents into the drain lines.

APPENDIX D

COMPOSITE TANKS

NOTE: *API Std 12G, referred to in the following paragraph, is "tentative." Therefore the API monogram may not be applied to steel tanks constructed with aluminum-alloy top rings and roofs.*

D.1 SCOPE

D.1 These requirements apply to tanks, all parts of which are constructed in accordance with the requirements of API Std 12C, except the top ring, roofs, and roof supports, which are constructed of aluminum-alloy.

D.2 The aluminum-alloy portion of such tanks shall conform to the requirements of API Std 12G: Specification for Welded Aluminum-Alloy Storage Tanks.

D.3 The circumferential joint between the aluminum-alloy top shell ring and the supporting ring shall be either riveted or bolted, in accordance with the applicable requirements of API Std 12A: Specification for Riveted Oil-Storage Tanks. For composite joints of steel and aluminum alloy, the faying surfaces shall be protected from galvanic corrosion by use of one of the following:

a. Zinc chromate paint on contacting surfaces.

b. Suitable calking material.

c. Suitable gasket material.

APPENDIX E

USE OF API MONOGRAM

The foregoing specification is for the use of all manufacturers desiring to use it.

Manufacturers desiring to warrant that articles manufactured or sold by them conform with this specification 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 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 of 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.

CANCELLATION OF MONOGRAM RIGHTS

The right to use the monogram is subject to cancellation for the following causes:

1. Using the monogram on material that does not meet the specification.
2. Failure to report on use of monogram. Each authorized manufacturer is required to report annually regarding his use of the monogram on the products covered by his authorizing certificates. Report forms will be provided by the Institute.
3. Failure to use the monogram on material produced to 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.

FORM OF CERTIFICATE OF AUTHORITY TO USE THE API MONOGRAM

No.............................

AMERICAN PETROLEUM INSTITUTE

CERTIFICATE OF AUTHORITY TO USE OFFICIAL MONOGRAM

THE AMERICAN PETROLEUM INSTITUTE hereby grants to

....

....

the right to use the official monogram on..................

....

under the conditions specified in the official publication of the American Petroleum Institute entitled

....

with the understanding that the use of this monogram shall constitute a representation that the material so marked complies with the latest edition of said specification, and with the further understanding, that material which fails to comply will not be so marked.

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

Issued to New York,.., 19.........

AMERICAN PETROLEUM INSTITUTE,

(SEAL)

Secretary.

AMERICAN PETROLEUM INSTITUTE

DIVISION OF PRODUCTION

300 CORRIGAN TOWER BLDG.

DALLAS 1, TEXAS

STATEMENT OF MANUFACTURER'S QUALIFICATIONS TO USE API MONOGRAM

The information indicated below, when requested by the Institute, must accompany all applications to use the API monogram. All such information is subject to investigation and applications must be rejected if the information supplied so warrants.

Material:________________________
(List here the equipment on which applicant desires to apply the monogram)

API specification designation:________________________

1. Name of applicant:________________________
2. Location of principal office:________________________
3. Where will equipment be manufactured?________________________
4. Class of ownership:________________________
   (Corporation, partnership or individual)
5. Capital invested:____________ 6. Year organized:____________
7. Is the applicant thoroughly familiar with all stipulations give in the API specification covering this material?________________________
8. Is the applicant actually manufacturing this material now?________________________
   a. State the length of time applicant has made the material and supplied it to the oil industry:____________
   ____
   (Years and Months)
   b. State the approximate percentage of production of this material to applicant's total production:______
   ____
9. Give the names and address of five representative users in the oil industry to whom applicant has sold this material (give name of company, complete street address, and name of company representative to whom inquiries should be addressed):
   ____
   ____
   ____
   ____
   ____
   ____
   ____

10. If applicant has not supplied this material to the oil industry and cannot furnish the five references under item 9, give the names and addresses of five representative users in other industries to whom applicant has sold similar equipment (give name of company, complete street address, and name of company representative to whom inquiries should be addressed):

____

____

____

____

____

11. If the applicant is not now manufacturing this material, when does he expect to begin production? ________

____

12. If the applicant has not previously made this material, state fully (on an attached sheet) the experience of any members of applicant's present organization in the manufacture of this material, giving names of organizations where such experience was obtained.

Questions 13, 14, and 15, need be answered only if the specification requires testing, or the possession of API reference master gages.

13. Does the applicant now possess the necessary equipment and personnel for conducting all tests required in the API specification covering this material? ____________________

14. Does the applicant now possess such API reference master thread gages as required by the specification covering this material? ____________________

If applicant possesses such gages, give full information (on separate sheet) on types, sizes, certifying agency and certification dates.

15. If the applicant does not now possess such gages, have they been ordered? ____________

If so, give full information (on separate sheet) on types, sizes and from whom ordered.

16. Give names of five responsible business men as references regarding applicant's general character, integrity, and reputation. (Give complete mailing address and name of organization with which each is affiliated.)

____

____

____

____

____

17. Name and address of applicant's representative to whom API correspondence should be directed:

____

____

(Signature and title of authorized officer)

Date ________________ ________________________

(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,
50 WEST 50th ST.,*
NEW YORK 20, N. Y.

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 ____________________ } ss.:

Acknowledged and sworn to before me

this ________ day of ____________, 19____.
Notary Public

*If the specification named in the application is a Division of Production specification, the application should be sent to the American Petroleum Institute, Division of Production, 300 Corrigan Tower Bldg., Dallas 1. Texas.