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22

WATER TANKS

FOR PRIVATE FIRE PROTECTION

1965

NFPA

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Official NFPA Definitions

Adopted Jan. 23, 1964. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

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SHOULD is intended to indicate recommendations or that which is advised but not required.

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AUTHORITY HAVING JURISDICTION: The organization, office or individual responsible for "approving" equipment, an installation, or a procedure.

Units of Measurements

Units of measurements used here are U. S. standard. 1 U. S. gallon = 0.83 Imperial gallons = 3.785 liters. One foot = 0.3048 meters. One inch = 25.40 millimeters. One pound per square inch = 0.06805 atmospheres = 2.307 feet of water. One pound = 453.6 grams.

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Standard for
Water Tanks for Private Fire Protection.

NFPA No. 22 — 1965

This Standard was adopted by the National Fire Protection Association in its present form at its Annual Meeting, May 17-21 1965, on recommendation of the NFPA Committee on Water Tanks, incorporating amendments summarized on page 22-143.

In 1909 the Committee on Gravity Tanks presented a set of standards on Gravity Tanks which were partly adopted with revisions in 1912. In 1913 the standards were revised to cover concrete reservoirs, valve pits and tanks. In 1914 they were adopted with amendments. Under the new name of Committee on Tanks, the committee presented in 1915 revised standards which included pressure tanks, formerly in the sprinkler standards. Amendments to the 1915 edition were made in 1917 and 1918. A new edition was published in 1919 and amended in 1922. In 1926 a complete revision of the 1919 edition superseding revisions of 1922 was adopted with a new section on tank heating. Revisions to the 1926 edition were adopted in 1928, 1930 and 1931. Revisions of the 1931 edition were made in 1933, 1936 and 1941. Further revisions were made in 1949, 1950, 1957, 1958, 1962 and 1965. The title used through 1941 was "Standards for the Construction and Installation of Gravity and Pressure Tanks." The title was changed in 1949 to "Standards for the Construction of Water Tanks for Private Fire Protection Service." The title was again changed in 1962.

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GENERAL INFORMATION AND RECOMMENDATIONS.

1. **Tank Material.** Tanks are usually built of wood or steel and are often supported on towers, ordinarily of steel although reinforced concrete towers are sometimes used. Concrete has also been employed for tanks in a few cases, where special conditions make it economical or otherwise desirable. In all such cases, however, the work should be handled only by experienced contractors who are able to give assurance that careful workmanship and expert supervision will be employed, and who will also furnish a bond guaranteeing the water-tightness of the tank for a period of years.

2. **Capacity and Elevation.**

a. The size and elevation of the tank should be determined by conditions at each individual property after due consideration of all the factors involved. It will usually be found economical to install a tank of sufficient capacity and at such height that it can be connected directly into the yard system, thus furnishing a supply for hose streams from hydrants as well as for sprinklers. Where tanks are to supply sprinklers, see separately published Standard for the Installation of Sprinkler Systems (NFPA No. 13), where they are to supply standpipes, see Standard for the Installation of Standpipe and Hose Systems (NFPA No. 14), and where they are to supply hydrants see Standard for Outside Protection (NFPA No. 24).

b. Whenever possible standard sizes of tanks and heights of towers should be used, as quicker delivery and lower prices can be thus obtained. The standard sizes of tanks are given in Articles 103 and 1503. For tanks of 40,000 gallons and larger capacities, the common standard heights of towers are 50, 75, 100, 125 and 150 feet.

3. Location.

a. The location of the structure is governed to a certain extent by local conditions. When possible, however, it is advisable to support the tank on an independent steel tower with foundations placed in the ground rather than have it carried wholly or in part on the walls of a building, thus making it an isolated structure and not subject to a failure from possible weakening of the building walls or columns.

b. The location chosen should be such that the structure will not be subject to fire exposure from adjacent buildings, but if lack of yard room makes this impracticable, the exposed steel work should be suitably fireproofed or protected by open sprinklers. (See Article 1410.) Fireproofing, when necessary, should include steel work within 20 feet of combustible buildings or windows and doors from which fire might issue.

c. If the tank or supporting trestle is to be placed on the walls of a new building, the building should be designed and built to carry the maximum loads. Old buildings should be carefully examined by a competent engineer to determine whether the tank structure can be safely installed. The preferable location is usually over masonry walls of a stair or elevator tower. The base of the tower should be designed to fit the supporting building construction accurately.

d. When steel or iron is used for supports inside the building near combustible construction or occupancy, it should be suitably fireproofed inside the building, six feet above combustible roof coverings and within 20 feet of windows and doors from which fire might issue. (See Article 1410.) Steel beams or braces joining two building columns, which support a tank structure, shall also be suitably fireproofed when near combustible construction or occupancy. Interior timber should not be used to support or brace tank structures.

e. If there is any uncertainty regarding the need of protecting tank supports against fire, advice as to the best procedure should be obtained from the authority having jurisdiction before definite designs are considered.

f. The necessity of providing foundations or footings that will furnish adequate support and anchorage for the tower cannot be overemphasized, as the safety of the entire structure is dependent upon proper attention to these features.

g. Foundations shall be located as far as practical from rivers likely to be flooded or from beaches likely to be scoured by storm waves of a hurricane.

4. Connections For Use Other Than Fire Protection. Tanks for fire protection should preferably not be used for other purposes.

The frequent filling of the tank, which is necessary when the water is used for purposes other than fire protection, is highly objectionable since the tank then becomes a settling basin resulting in a large accumulation of sediment in the bottom. When water is drawn from the tank this sediment is drawn into the yard and sprinkler systems and may cause the obstruction of the pipes and sprinklers.

In the case of a wooden tank the constantly varying water level, with consequent drying out and wetting of the lumber, may appreciably shorten the life of the tank. With a steel tank the constant refilling usually requires more frequent painting, which means not only greater expense, but more time out of service.

5. Attachments to Tank Structures. Tank structures should ordinarily not be employed to support signs, flagpoles, steel stacks, etc., as failure of any of these attachments might damage the tank structure to such an extent that its serviceability would be at least temporarily impaired.

6. Lightning Rods on Wooden Tanks.* To prevent lightning damage to wooden tanks, a lightning rod equipment is advised. The upper end of the rod should consist of a ¾-inch solid copper rod pointed at the top and extending 30 inches above the highest projection of the tank. The remainder of the rod should be a copper conductor weighing at least 6 ounces per foot or No. 00 B.&S. gauge cable. The conductor should be securely fastened to the tank and well grounded, generally to the discharge pipe, by a ground clamp. Before attaching the ground clamp, the pipe should be thoroughly scraped and cleaned and the conductor should be soldered into a lug bolted to the clamp.

7. Approved Structures. It is of the utmost importance that tank structures for fire protection be built by

*See paragraph 2210 of NFPA No. 78, Lightning Protection Code.

responsible manufacturers in accordance with the best engineering practice in order to ensure safety and reliability under all conditions.

To secure a satisfactory installation the contract should definitely specify that the entire tank equipment be designed and built in accordance with these standards.

8. **Inspection of Completed Equipment.** Immediately after the work is finished, a joint inspection of the tank equipment should be made by a representative of the tank contractor and a representative of the owner.

Written reports of these inspections should be made in triplicate and a copy signed by the contractors and the owners should be sent to the authority having jurisdiction.

This joint inspection will provide reasonable assurance that there are no defects in the work of sufficient importance to prevent the system being put immediately into commission.

9. **Care and Maintenance.**

a. A tank structure constitutes a very important part of the fire protection equipment and should be given suitable care and attention.

b. No waste material, such as boards, roofing, paint cans, etc., should be left in the tank or in the space at the top of the tank since it may get into water and obstruct the piping.

c. The hatch covers in the roofs and the door at the top of the frost-proof casing should always be kept securely fastened with substantial catches as a protection against freezing and windstorm damage.

d. Ice should not be allowed to collect in or on any part of the tank structure. Cases have been known where icicles formed from overflowing or leakage have caused failure of structures and there is always the possibility that falling ice may break some structural member or cause damage in the mill yard.

e. The bases of the tower columns should be kept free from dirt and rubbish which would otherwise permit the accumulation of moisture with consequent corrosion. The tops of foundation piers should always be at least 6 inches above the ground level and with some types of tower columns the bases should be filled with concrete, flashed with asphalt.

f. Coal or ashes or combustible material of any kind should not be piled near the columns as this may cause failure of the steel work due to fire, heating or corrosion. The tank site should be kept cleared of weeds, brush and grass.

g. Examination of all paint, including the inside of a steel tank without cathodic protection (Article 715) and the hoops and grillage of a wooden tank, should be made at least once in two years. Steel work without cathodic protection should be kept painted to prevent the formation of rust. Frequent repainting, if not protected by cathodic equipment, is necessary when the paint is exposed to conditions causing rapid disintegration.

h. Before repainting, all loose paint should be removed with scrapers and wire brushes and the surface thoroughly dried. A two-coat job is recommended, first touching up any bare spots with a red lead and oil paint. The red lead and oil paint should conform with that specified in Article 712.

i. The painters should be instructed not to allow any scrapings or other foreign material to fall down the riser. If the opening is covered for protection nothing but a few sheets of paper tied over the end of the settling-basin-stub should be used. The water pressure would then break the paper if it should be forgotten.

j. If cathodic protection is maintained in a steel tank, the tank shall be cleaned out sufficiently often to prevent sediment and scale entering the discharge pipe.

k. The authority having jurisdiction should always be notified in advance when and for how long the tank is to be out of service.

10. Workmanship. It is expected that manufacturers of approved structures will follow not only the letter but the spirit of this Standard, employing their experience and ability to make structures which will prove reliable under all conditions; also that they will replace all parts which may be found defective from faulty materials or workmanship, or that are not in accordance with the Standard.

The introduction of welding for tank structures makes impossible the simple checking in the field by an inspector, after completion of a structure, of important details at locations which with riveted construction are readily accessible and permit inspection of riveting as well as thicknesses and sizes of materials. Such details include the thickness of butt-welded plates in tanks and tubular columns; the appearance of welding in tank plates when a balcony is omitted, and in tubular columns and at struts except near the ladder and base of the structure; and the extent of inaccessible dents and out-of-roundness of tubular columns and struts.

It is therefore of utmost importance during shop fabrication and field erection that careful inspection be provided by the contractors' representatives.

11. Welding. Where acceptable to the authority having jurisdiction, steel gravity and suction tanks and steel plate risers may be of welded construction provided that the joint design and the welding fully conforms to the current edition of the American Water Works Association Standard for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage, AWWA D100, AWS D5.2, and that the tank builder presents to the authority having jurisdiction evidence fully satisfactory to the authority that said rules have been complied with. The authority may accept a written certificate from the builder as evidence that said rules have been complied with or may require a certificate from a qualified consulting engineer or commercial testing laboratory. In either case the certificate shall be supplemented with evidence satisfactory to the authority that the said rules have been complied with in the following four particulars:

1. That all welding procedures used have been qualified in accordance with the current edition of the American Water Works Association Standard for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage, AWWA D100, AWS D5.2. The evidence of such qualification should be presented in the form of a report bearing proper witness certification of a reputable testing laboratory.
2. That all welding operators employed on the job were qualified in accordance with the current edition of the American Water Works Association Standard for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage, AWWA D100, AWS D5.2
3. That welded joints have been tested by the sectioning or radiographic methods as required by the American Water Works Association Standard for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage, AWWA D100, AWS D5.2.
4. That the tank has been subjected to the required hydrostatic test.

STEEL GRAVITY AND SUCTION TANKS.

Section 1—General.

101. This Standard applies to the design, fabrication, and erection of steel gravity water tanks, including pump suction tanks.

102. Capacity. The capacity of the tank is the number of U. S. gallons available above the outlet opening. The net capacity between the outlet opening of the discharge pipe and the inlet of the overflow shall be at least equal to the rated capacity. For gravity tanks with large plate risers, the capacity shall be the number of U. S. Gallons between the inlet of the overflow and the designated low-water level line.

103. Standard Sizes. The standard sizes of steel tanks are: 5,000, 10,000, 15,000, 20,000, 25,000, 30,000, 40,000, 50,000, 60,000, 75,000, 100,000, 150,000, 200,000, 300,000 and 500,000 U. S. gallons net capacity. Tanks of other sizes are built occasionally.

104. Form. Steel tanks may be of any form desired provided they conform to this Standard throughout.

105. Strength. The material as specified shall be without defects affecting its strength or service. The workmanship shall be good, so that defects or injuries are not produced during manufacture or erection. Unit stresses as specified shall not be exceeded. The structure and its details shall possess the requisite strength and rigidity.

Section 2—Materials.

201. Plates and Shapes.

a. Plates: Plate materials shall be open-hearth or electric furnace steel conforming to any of the following ASTM specifications of the latest revision: A7, A283, Grades A, B, C, and D; except that, when plates of thickness greater than ¾ in. are used A7 and A283 Grade D steels shall not be specified; as alternatives A285, Grades A, B, and C (flange quality); A201, Grades A and B (flange quality); A131, Grades A, B, and C; or A36 may be used.

b. Shapes: Structural materials shall be open-hearth or electric furnace steel conforming to the latest revision of ASTM Specifications A7, or A36.

Copper-bearing steel with content of about 0.20 per cent copper may be used. In other particulars the steel shall conform to specifications enumerated above.

202. Basis of Furnishing Plates. Plates in the tank shell and suspended bottom shall not under-run the required thickness, based upon the specified unit stress, by more than 0.01 inch. All other plates may be furnished on the weight basis with permissible under-run and over-run according to the tolerance table for plates ordered to weight published in the applicable ASTM Specification.

203. Rivets. The steel for rivets shall conform to current Specifications A31 (Grades A and B) or A141 of the American Society for Testing Materials. If cold driving is done, properly annealed rivets of A31 shall be used.

204. Bolts, Anchor Bolts and Rods. Bolts and anchor bolts shall conform to the latest revision of ASTM Specifications A307, Grades A or B. Rods shall be open-hearth or electric furnace steel conforming to the latest revision of ASTM Specification A7, or A36.

205. Forgings. Forgings shall conform to the following current Specifications of the American Society for Testing and Materials. Steel shall be made only by the open-hearth process.

Plate Forgings—A283 and A285.
Forgings, other than plate—A235—Class C.
Forged and Rolled Pipe Flanges—A181—Grade I.

206. Castings. Castings shall conform to current ASTM Specifications A27 Grade 60-30 full annealed.

207. Reinforcing Steel. Reinforcing steel shall comply with the latest revision of the ASTM Specification A15 (structural or intermediate grade).

208. Filler Metal Electrodes. Manual arc-welding electrodes shall conform to the current requirements of the AWS and ASTM Specifications for Mild Steel Arc-Welding Electrodes (AWS Designation A5.1: ASTM Designation A233). Electrodes shall be any E60 classification suitable for the electric current characteristics, the position of welding and other conditions of intended use.

Section 3—Loads.

301. **Dead Load.** The dead load shall be the estimated weight of all permanent construction and fittings. The unit weight of steel shall be considered 490 pounds, and of concrete, 144 pounds per cubic foot.

302. **Live Load.** Under normal conditions, the live load shall be the weight of all the liquid when overflowing the top of the tank. The unit weight of water shall be considered as 62.4 pounds per cubic foot. Proper provision must be made for temporary stresses during erection. When roofs have a slope of less than 30° they shall be designed to support a uniform weight of 25 pounds per square foot on the horizontal projection.

303. **Wind Load.** Under normal conditions the wind load or pressure shall be assumed to be 30 pounds per square foot on vertical plane surfaces, 18 pounds per square foot on projected areas of cylindrical surfaces and 15 pounds per square foot on projected areas of conical and double curved plate surfaces. When designing for wind velocities over 100 miles per hour, all above mentioned unit pressures shall be adjusted in proportion to the square of the velocity assuming that the above pressures are for 100 miles per hour.

304. **Earthquake Load.** Tank structures should meet local requirements for preventing earthquake damage.

305. **Balcony and Ladder Loads.** A vertical load of 1,000 lb. shall be assumed to be applied to any 10 sq. ft. of area on the balcony floor and on each platform; 500 lb. applied to any 10 sq. ft. area on the tank roof; 350 lb. on each vertical section of ladder; and all of the structural parts and connections shall be designed to withstand such loads. The above loadings need not be combined with snow loading.

Section 4—Unit Stresses.

401. General. The maximum stresses in pounds per square inch produced by the foregoing loads or any combination of them, shall not exceed the values in the following table:

Tension: On net section, Rolled Steel	15,000
Tension: Anchor bolts	15,000
Shearing: Rivets	11,250
Bearing: Rivets in single shear	24,000
Bearing: Rivets in double shear	30,000

Bending:

Tension on extreme fibers, except column base plates	15,000
Column base plates	20,000
Compression on extreme fibers of rolled sections, and plate girders and built-up members for values of:	
$\frac{ld}{bt}$ not in excess of 600	15,000
$\frac{ld}{bt}$ in excess of 600	$\frac{9{,}000{,}000}{\frac{ld}{bt}}$

in which l is the unsupported length and d the depth of the member; b is the width; and t the thickness of its compression flange; all in inches; except that l shall be taken as twice the length of the compression flange of a cantilever beam not fully stayed at its outer end against translation or rotation.

Pins, extreme fiber	22,500
Cast steel	11,250

402. Stress Increases. When wind or earthquake loads are considered in calculating stresses, the permissible working unit stresses may be increased 25 per cent, provided that the resulting section is not less than that required for dead and live loads alone; however, in the design of concrete foundations the increase may be 33.3 per cent. Wind and earthquake loads need not be considered simultaneously.

Section 5—Details of Design.

501. Minimum Thickness. The minimum thickness for any part of the structure shall be 3/16 in. for parts not in contact and ¼ in. for parts in contact with water contents. The controlling thickness of rolled shapes for the purposes of the foregoing stipulations shall be taken as the mean thickness of the flanges, regardless of web thickness. The minimum thickness for tubular columns and struts shall be ¼ in. Round or square bars used for wind bracing shall have a minimum diameter or width of ¾ in. Bars of other shapes, if used, shall have a total area at least equal to a ¾ in. round bar.

Tanks with diameters of 120 ft. to 200 ft. inclusive shall have a minimum shell thickness of 5/16 in.; tanks more than 200 ft. in diameter shall have a minimum shell thickness of ⅜ in.

502. Thickness for Corrosion. Interior bracing, if unavoidable, shall always have 1/16-inch additional thickness added to the calculated sections. The sections shall be open to facilitate cleaning and painting. The plates of tanks to contain salt, or alkaline water shall be 1/16-inch thicker than calculated.

503. Thickness of Bottom Cylindrical Courses. The thickness of plates in the lowest cylindrical courses of tanks with suspended bottoms shall be not less than 5/16-inch for 100,000 and 150,000 gallon, ⅜-inch for 200,000 gallon tanks, and for larger tanks shall be at least 1/16-inch greater than that calculated.

504. Thickness of Flat Bottoms. The thicknesses of plates in flat bottoms shall be not less than those given in the following table.

THICKNESS IN INCHES OF BOTTOM PLATES FOR FLAT-BOTTOM TANKS.

Type of Support		Depth of Water (ft.)	10	12	14	16	18	20	22	24	26	28	30	40
Type of Support	Steel or Concrete Beams / Distance in clear between Beams in inches	12	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	3/8
		14	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	3/8	3/8	7/16
		16	5/16	5/16	5/16	5/16	5/16	5/16	3/8	3/8	3/8	3/8	3/8	7/16
		18	5/16	5/16	5/16	5/16	3/8	3/8	3/8	3/8	7/16	7/16	7/16	1/2
		20	5/16	5/16	3/8	3/8	3/8	7/16	7/16	7/16	7/16	1/2	1/2	9/16
		24	3/8	3/8	7/16	7/16	7/16	1/2	1/2	1/2	9/16	9/16	9/16	11/16
	Concrete Slab		1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4

505. Accessibility of Bottoms. Grillages shall be designed so that the tank bottom and beams will be accessible for inspection and painting.

506. Net Sections. Net sections shall be used in calculating the tensile stress in plates and members. In deducting the rivet holes their diameter shall be taken 1/8-inch larger than the undriven rivets for punched holes and 1/16-inch larger for reamed or drilled holes.

507. Rivet Size Considered. Nominal diameters shall be used in proportioning rivets in punched work. Diameters of the rivet holes may be used in drill or reamed work.

508. Edge Distance. The minimum distance from the center of any rivet hole to a sheared edge shall be at least one and one-half times the nominal rivet diameter. This distance is to be measured from the center of the bevel-sheared plates greater than 3/8-inch in thickness.

509. Spacing Between Rows. For joints where one rivet in the inner row comes midway between two rivets in the outer row, the spacing between the rivets or backpitch (p) shall have the following minimum values:

If $\frac{p}{d}$ is 4 or less, the minimum value shall be 1.75d.

If $\frac{p}{d}$ is over 4, the minimum value shall be 1.75d + 0.185 (p — 4d).

For joints where two rivets in the inner row are placed between two rivets in the outer row, the backpitch shall have the following minimum values:

If $\frac{p}{d}$ is 4 or less, the minimum value shall be 2d.

If $\frac{p}{d}$ is over 4, the minimum value shall be 2d + 0.14 (p — 4d).

510. Pitch of Rivets. The minimum distance between center of rivet holes shall be at least three diameters of the rivet.

511. Rivet Pitch for Calking. The maximum distance between centers of rivet holes along calking edges of plates, except at the column connections, shall not exceed ten times the thickness of the thinnest plate for single riveted joints or twelve times the thickness of the thinnest plate in joints having more than one row of rivets.

512. Load Location. In calculating the thickness of plates (except as specified in Article 503) stressed by the weight or pressure of the tank contents, the pressure at the lower edge of each ring shall be assumed to act undiminished on the entire area of the ring. In welded tanks the longitudinal joints in adjacent circumferential courses may be either staggered or in alignment. Welded joints crossing each other shall be grooved and welded continuously through the intersections.

513. Opening Reinforcement. All openings over 4 inches in diameter in the shell, suspended bottom, or large steel plate riser or tubular support shall be reinforced. This reinforcement may be the excess metal in the plate, the flange of a fitting or an additional ring of metal, or both flange and ring.

In computing the necessary reinforcement of an opening for particular loads, the net area of the reinforcement shall bear the same ratio to the area of the metal removed from the plate as the strength of the particular load carrying joint in the plate bears to the strength of the solid plate.

Sufficient rivets or welding shall be provided to transmit to the plate the full net strength of the reinforcing ring or flange. In computing the net reinforcing area of a fitting, such as a boiler maker's flange, or a manhole saddle, having a neck, the material in the neck may be considered as part of the reinforcing for a distance, measured from the surface of the parent plate or that of an intervening reinforcement plate, equal to four times the thickness of the material in the neck.

514. **Roof Supports.** The supports for tank roofs, not containing water, shall be designed in accordance with current steel construction specifications of the American Institute of Steel Construction except that the ratio ld/bt shall not be restricted for rafters in contact with a steel roof as it is considered that the roof sheets will provide lateral support for the rafters and except that the roof purlin depth may be less than 1/30 of the span length, and except that the maximum slenderness ratio L/R for columns supporting roof shall be 175.

515. **Roofs and Top Girders.** All tanks storing drinking water should have roofs. Tanks without roofs shall have a top girder or angle having a minimum section modulus as determined by the following formula:

$$S = \frac{HD^2}{10,000}$$

In the above formula S is the minimum required section modulus in inches cubed of the top angle or girder, including a length of tank shell equal to twenty times its thickness; H is the height of the cylindrical portion of the tank shell in feet; and D is the diameter of the cylindrical portion of the tank shell in feet.

516. **Bottom Angle.** The sides and bottom of flat bottom tanks of riveted construction over 20 feet diameter shall be connected by spliced angles calked along both legs.

517. **Welded Joints.** The types of joints used and their design shall conform to the current American Water Works Association Standard for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage, AWWA D100, AWS D5.2.

Section 6—Workmanship.

601. Plate Edges.

a. **Riveted Work**—Edges of plates which are to be calked shall be beveled either by shearing, machining, or cutting with a machine operated oxygen torch, except that plates over 5/8 in. thick shall not be sheared.

Plates 1/2 in. and less in thickness may be beveled to approximately a 60- to 70-deg. angle. Plates over 1/2 in. in thickness may be beveled to an angle of approximately 75 to 80 deg.

b. **Welded Work**—The plate edges to be welded may be universal mill edges or they may be prepared by shearing, machining, chipping, or by mechanically guided oxygen cutting, except that edges of irregular contour may be prepared by manually guided oxygen cutting.

When edges of plates are oxygen-cut, the surface obtained shall be uniform and smooth and shall be cleaned of slag accumulations before welding.

602. Rivet Holes—Rivet holes in material 5/8 in. thick and under may be punched or drilled full size. Rivet holes in material over 5/8 in. to and including 3/4 in. thick shall be either drilled from the solid or punched 1/16 in. smaller in diameter than the nominal diameter of the rivet and then reamed to size. Rivet holes in material over 3/4 in. thick shall be drilled.

The final diameter of rivet holes shall be not more than 1/16 in. larger than the rivets.

603. Removing Burrs. After drilling or reaming holes the burrs shall be completely removed.

604. Rolling. Plates shall be cold rolled to suit the curvature of the tank and the erection procedure in accordance with the following table:

Plate Thickness	Minimum Diameter for Plates Not Rolled
Plates less than 3/8 in.	40 ft.
3/8 in. to less than 1/2 in.	60 ft.
1/2 in. to less than 5/8 in.	120 ft.
5/8 in. and heavier	Must be rolled for all diameters.

All butt straps shall be formed to the proper curvature.

605. **Double Curved Plates.** Plates which are curved in two directions may be pressed either cold or hot or may be dished with a "mortar and pestle" die by repeated applications.

606. **Milling Columns.** The ends of columns shall be milled to provide a satisfactory bearing unless the design contemplates sufficient riveting or welding to resist the total calculated loads.

607. **Use of Rivets and Welding.** All joints between tank plates and all connections shall be welded or riveted. Welding shall conform to the current American Water Works Association Standard for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage, AWWA D100, AWS D5.2. (See Article 11.)

608. **Heads of Rivets.** Driven rivets over ½-inch in size shall have button, cone, or steeple heads central on the shank. The heads shall grip the assembled pieces firmly and be neat and of equal size. Heads shall be formed on the side of the plate which is calked.

609. **Assembling and Erection.** Plates shall be bolted firmly together before riveting. Drift pins should preferably not be used for bringing the parts together and shall never be used to enlarge unfair holes. High standpipes and steel plate risers shall be built on metal wedges to permit adjustments during erection, plumb lines or engineer's level being used to obtain vertical structures. The bottom plate of riveted standpipes and suction tanks shall be laid on a leveled cushion of a mixture of sand and cement about 2 inches thick. Before filling the riveted standpipe or suction tank with water, the outer foot of this cushion shall be sealed by cement mortar and the joint between steel and mortar flashed with asphalt. Cement mortar shall be forced under the bottom plate of riveted steel plate risers to obtain a uniform bearing and the joint between steel and mortar flashed with asphalt. Cement mortar and sand-cement cushions shall be mixed in the proportions of one part Portland cement to three parts clean sand.

610. **Driving of Rivets.** Rivets of greater diameter than ½ inch shall be uniformly heated to a light cherry red heat. Shop rivets shall be driven by pressure. Rivets in butt joints shall be driven with pneumatic hammers. Recupping

and calking is not allowed. Loose, burned, or otherwise defective rivets shall be cut or drilled out and replaced without injuring the adjacent metal.

611. Calking. The tank shall be made watertight by calking the edges of the plates with a round-nosed tool before painting. Foreign materials such as lead, copper filings, cement, etc., shall not be used in the joints.

612. Fitting Roofs. The roof shall fit tightly to the top of the tank to prevent circulation of air over the surface of the water. When a spider is used it shall not obstruct the flow of water into the overflow inlet.

613. Preventing Ice Damage. The contractor shall keep the tank, structure, and building roofs free of ice caused by leakage during the construction and until the tank equipment is made watertight.

614. Coatings for Bottom Plates on Soil or Concrete. (See also Article 2201.)

a. For riveted tanks, the underside of all bottom plates shall be painted two coats before being placed in position. One of these coats may be applied in the shop; in such case, a patch and over-all coat shall be applied in the field.

b. For welded tanks, the under side of all bottom plates shall be protected against corrosion by one of the following methods: (a) paint with two coats of paint after the bottom has been completely welded, (b) coat the plates with an approved rust-inhibiting high flash point grease before being placed in position or (c) erect bottom upon oil saturated sand cushion.

c. Before placing the plates on grade or foundations, when the rust-inhibiting grease is used, there shall be placed under each seam and under the shell to bottom connection a strip of asbestos felt about 6 inches wide. The asbestos felt shall be approximately 1/32 inch thick and shall be impregnated with a rust-inhibiting high flash point grease.

d. When the tank bottom is placed upon oiled sand, the sand shall be saturated to a depth of 4 inches with heavy petroleum base oil, gravity range 12°–18° Baume.

615. **Testing.**

a. **Riveted Flat Bottoms:** Riveted flat tank bottoms shall be tested on horses before being lowered to the grade. Sufficient water shall be placed in the bottom to cover the bottom angle. Any leaks shall be corrected by calking or redriving rivets, if necessary.

b. **Welded Flat Bottoms:** Upon completion of the welding of the tank bottom it shall be tested by one of the following methods and shall be made entirely tight:

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

The joints may be tested by the magnetic particle method.

c. **General:** Upon completion of the tank, before it is painted, it shall be filled with water furnished at the tank site by the purchaser at proper pressure to fill the tank to the maximum working water level. Any leaks which are disclosed in this test in the shell, bottom, or roof (if the roof contains water), shall be repaired by calking, for riveted construction, and by chipping or melting out any defective welds and then rewelding, for welded construction. No repair work shall be done on any joints unless the water in the tank is at least 2 ft. below the point being repaired.

d. **Disposal of Test Water:** The purchaser shall provide means for disposing of test water up to the tank inlet or drain pipe.

616. **Repairs.** Any leaks in the shell, bottom, or roof (if the roof contains water) shall be repaired by calking for riveted construction.

The tank shall be watertight under test, to the satisfaction of the purchaser's inspector, before painting.

Section 7—Accessories

701. **Connections.** Connections shall be provided on the tank for the necessary pipes, braces, frost-casing and walkway supports.

702. **Roof Vent.** When the steel roof is essentially airtight, there shall be a substantial vent above the maximum water level. A vent pipe shall have a cross-sectional area at least equal to one-half the area of the discharge pipe or pipes or fill pipe, whichever is the larger. A corrosion resistant screen or perforated plate with ⅜-in. holes, to exclude birds or animals, shall be provided and have a net area at least equal to the vent line. In the case of a screen, this requires a gross area at least three times the cross-sectional area of the vent pipe. The screen or perforated plate shall be protected against accumulation of sleet. The weather hood or equivalent, over the perforated plate or screen, shall be readily removable. The overflow pipe shall not be included as vent area. The vent may be combined with the roof finial. Equivalent venting may be used provided the area cannot be obstructed by sleet and the ingress of birds and animals is prevented.

703. **Roof Anchorage.** Each roof plate shall be securely fastened to the top of the tank.

704. **Roof Hatch.** An easily accessible hatch having a minimum opening dimension of 24 inches shall be provided in the roof. The hatch-cover shall be built of steel plate at least 3/16 inch thick and shall open to the right on heavy hinges with corrision resistant pins. A substantial catch shall be provided to keep the cover closed.

705. **Ladders—General.** Outside and inside steel ladders arranged for convenient passage from one to the other and through the roof hatch shall be provided. Ladders shall not interfere with opening the hatch cover and shall not incline outward from the vertical at any point. For pedestal supported tanks, the ladder should be placed inside an access tube extending through the center of the tank.

706. **Outside Fixed Shell and Roof Ladder.**

a. The outside tank ladder for suction and multiple column supported gravity tanks should be fixed at least six inches from the tank side and rigidly bolted or welded to brackets not over 12 feet apart which are riveted or welded to the tank plates. The bottom bracket shall not be more than six feet above the base of the tank cylinder, and the ladder shall extend up the tank shell and radially along the roof with the top bracket within approximately two feet of the roof hatch, and there shall be at least one foot clearance at the sides and front of the ladder at the balcony. The authority having jurisdiction may require a safety cage.

b. If a revolving roof ladder is provided (See Article 707), the fixed ladder shall have the top bracket not more than one foot below the top of the shell.

707. Revolving Roof Ladder. A revolving roof ladder attached to the roof finial with a swivel connection and equipped with rollers so that it will rotate around the roof may be provided on elevated tanks. Provision shall be made for locking the ladder in its normal position in line with the tower ladder and just to the left of the roof hatch. Revolving ladders with more than 12 feet between finial and base locking device shall be provided with intermediate locking devices not more than 12 feet apart. Other arrangements of revolving ladders may be permitted if approval is obtained from the authority having jurisdiction.

708. Inside Ladder.

a. The inside fixed ladder provided for passage between the roof hatch and tank bottom shall not be rigidly connected to the bottom plates.

b. A ladder shall extend from the top to the bottom of the inside of large steel riser pipes and shall be secured to the shell plates by brackets spaced not over twelve feet apart, the upper bracket being located at the top of the riser.

709. Ladder Bars and Rungs. Ladder side bars shall be not less than 2 inches by 5/16-inch flat steel for fixed ladders and 2½ inches by ⅜ inch for movable ladders. Side bars shall be spaced 14 inches apart. Rungs shall be at least ⅝-inch round or square steel spaced 12 inches on centers. The rungs shall be firmly riveted or welded to the side bars. Ladders and connections shall be designed to support a concentrated load of 350 pounds.

710. Painter's Trolley. Some form of trolley or other acceptable device shall be provided to facilitate repainting the outside of the tank. The connection of trolley at the top of the tank shall be substantial.

711. Painting Inaccessible Parts. Parts inaccessible after fabrication shall be protected by paint before assembling, except surfaces in watertight joints and edges or surfaces to be welded, which shall be coated with clear oil or lacquer.

712. Shop Painting. All steel, except where encased in concrete, surfaces in watertight joints and edges or surfaces to be welded shall be thoroughly cleaned and given a shop coat of red lead paint, mixed with 100 pounds of red lead paste (94% Pb_3O_4) to 2½ gallons of linseed oil (if raw oil is used add ½ pint of dryer to every gallon of paint); or an approved ready mixed red lead paint.

Paints have a tendency to soften and lose their imperviousness when submerged in water for long periods. Red lead paints resist this softening action and dry more quickly if 10 per cent by weight of litharge is added. Mix the litharge in a quart of boiled oil and add to small quantities of the paint as needed.

Other paints may be used, provided permission is first obtained from the authority having jurisdiction.

713. Field Painting. After erection, a patch coat of the same kind of paint as the shop coat shall be applied to all surfaces from which the shop coat has become removed, and to all field rivets, bolts and welds. For the inside of the tanks, an over-all field coat, preferably a red lead paint mentioned in Article 712, with litharge, shall be applied over shop and patch coats of the same material.

For outside surfaces, a patch coat of the priming paint shall be applied over all bare spots and then an over-all field coat of a good grade of metallic paint, of color specified by the purchaser, shall be applied after the tank has been made watertight.

Other paints may be used, provided permission is first obtained from the authority having jurisdiction.

714. Painting Conditions. Before painting all steel shall be thoroughly cleaned of loose mill-scale, rust, oil and grease by scraping, wire-brushing and wiping. Painting shall not be done out of doors during wet or freezing weather. The coats of paint shall completely cover the steelwork.

715. **Cathodic Protection.** In lieu of future repainting, an approved cathodic system of corrosion protection, designed to protect all wetted surfaces, including that of the riser, may be used. Anodes shall be of suitable material and construction, approved by the authority having jurisdiction. Aluminum alloy 2107-T4, and high silicon cast iron with a maximum of 14.35 per cent silicon are considered suitable materials. All anodes shall be provided with approved containment devices to prevent any portions thereof from separating and falling. All such containment devices shall be securely fastened to pin insulators hung from the roof of the tank. To insure continued reliable operation of such cathodic protection equipment, the owner shall make arrangements with the supplier for annual inspections and maintenance of the equipment.

STEEL TOWERS.

Section 8—General.

801. This standard defines the recommended practice for the design, fabrication and erection of steel towers to support water tanks.

802. **Height.** The height of tower is the vertical distance from the top of the foundations to the bottom capacity line of the tank.

803. **Strength.** The material as specified shall be without defects affecting the strength or service of the structure. The workmanship shall be good, so that defects or injuries are not produced in the manufacture or erection. Unit stresses as specified shall not be exceeded. The structure and its details shall possess the requisite strength and rigidity.

804. When a welded tower is acceptable to the authority having jurisdiction, the details shall conform to the following rules and, where not covered therein, to the current Code for Welding in Building Construction, AWS D1.0.

Section 9—Material.

901. Plates and Shapes.

a. **Plates:** Plate materials shall be open-hearth or electric furnace steel conforming to any of the following ASTM specifications of the latest revision: A7, A283, Grades A, B, C, and D; except that, when plates of thickness greater than ¾ in. are used A7 and A283 Grade D steels shall not be specified; as alternatives A285, Grades A, B, and C; A201, Grades A and B; A131, Grades A, B, and C; or A36 may be used.

b. **Shapes:** Structural materials shall be open-hearth or electric furnace steel conforming to the latest revision of ASTM Specifications A7, or A36.

Copper-bearing steel with content of about 0.20 per cent copper may be used. In other particulars the steel shall conform to specifications enumerated above. (See Article 201.)

902. Rivets. The steel for rivets shall conform to current Specifications A31 or A141 of the American Society for Testing and Materials. If cold driving is done, properly annealed rivets of A31 shall be used.

903. Bolts, Anchor Bolts and Rods. Bolts and anchor bolts shall conform to the latest revision of ASTM Specifications A307, Grades A or B. Rods shall be open-hearth or electric furnace steel conforming to the latest revision of ASTM Specification A7, or A36. (See Article 204.)

904. Pins. Pins shall comply with the latest revision of any of the following ASTM specifications; A307, Grade A; or A108, Grade 1025.

Section 10—Loads.

1001. Dead Load. The dead load shall be the estimated weight of all the permanent construction and fittings. The unit weight of steel shall be considered as 490 pounds and of concrete as 144 pounds per cubic foot.

1002. Live Load. Under normal conditions, the live load shall be the weight of all the liquid when overflowing the top of the tank. The unit weight of water shall be considered as 62.4 pounds per cubic foot. Proper provision must be made for temporary stresses during erection. When roofs have a slope of less than 30 they shall be designed to support a uniform weight of 25 pounds per square foot on the horizontal projection.

1003. Live Load—Large Risers.

a. The water directly above any riser shall not be considered as carried by the tower columns except when the riser is suspended from the tank bottom or from the tower columns.

b. If a hemispherical or ellipsoidal bottom is rigidly attached to the top of a large riser by a flat horizontal diaphragm plate and the riser is supported by a separate solid foundation or is suspended from the tower, the riser plates shall be considered as supporting the water load in a hollow cylinder having an outside radius equal to the radius of the riser at the tank bottom plus one-half the distance from the edge of the riser to the connection of the flat horizontal diaphragm plate to the hemispherical or ellipsoidal bottom plates. The inside radius of this hollow cylinder shall be considered equal to the radius of the riser at the tank bottom. This load can be deducted from the weight of the tank water when designing the tank and also when designing the tower unless the riser is suspended from the tower.

c. If the hemispherical or ellipsoidal shape is continuous to the shell of the large riser without flat horizontal diaphragm plate and the riser is supported by a separate solid foundation or is suspended from the tower, the riser plates shall be designed to carry the water load of a hollow cylinder extending from the bottom of the tank to the top of the tank. The outside radius of this hollow cylinder shall be taken as two feet greater than, and the inside radius equal to, the radius of the riser shell at the tank bottom. This load shall not be deducted from the tank water load when designing the tank and tower except that it may be deducted for the tower design of tanks with ellipsoidal bottoms of a flat shape at the connection to risers supported by a separate solid foundation.

1004. Wind Load. The wind pressure shall be assumed to be 30 pounds per square foot on a vertical plane surface. In calculating the wind load on a cylindrical surface, 18 pounds per square foot shall be applied to the total area of the vertical projection, and the point of application of the load shall be at the center of gravity of the projected area. The load on the tower shall be assumed to be concentrated at the panel points. When designing for wind velocities over 100 miles per hour, all above mentioned unit pressures shall be adjusted in proportion to the square of the velocity assuming that the above pressures are for 100 miles per hour.

1005. Balcony and Ladder Loads. A vertical load of 1,000 lb. shall be assumed to be applied to any 10 sq. ft. of area on the balcony floor and on each platform; 500 lb. applied to any 10 sq. ft. area on the tank roof; 350 lb. on each vertical section of ladder; and all of the structural parts and connections shall be designed to withstand such loads. The above loadings need not be combined with snow loading.

1006. Earthquake Load. Tank structures should meet local requirements for preventing earthquake damage.

Section 11—Unit Stresses.

1101. General. The maximum stresses in pounds per square inch produced by the above loads shall not exceed the following:

AXIAL TENSION: On net section, rods and A-7 structural steel shapes 15,000

AXIAL COMPRESSION: Gross section of columns and struts of structural shapes:

$$\frac{P}{A} = \left\{ \frac{18{,}000}{1+\frac{L^2}{18{,}000r^2}} \right\}$$ or 15,000 psi, whichever is the smaller.

For tubular columns and struts: $\frac{P}{A} = XY$, in which $X = \frac{18{,}000}{1+\frac{L^2}{18{,}000r^2}}$ or 15,000 psi, whichever is the smaller, and

$$(1)\quad Y = (2/3)\ \left(100\frac{t}{R}\right) \left[2 - (2/3)\ \left(100\frac{t}{R}\right)\right]$$

(2) Y = Unity (1.00) for values of $\frac{t}{R}$ equal to or greater than 0.015.

In the foregoing formulae, the symbols have the following meanings:

P = total axial load in pounds.
A = cross sectional area in square inches.
L = effective length in inches.
r = least radius of gyration in inches.
R = radius of the tubular member to the exterior surface in inches.
t = thickness of the tubular member in inches: minimum allowable thickness ¼ inch.

All circumferential joints in tubular sections shall be butt joints either welded for complete penetration or riveted with butt straps on both sides.

Compression on short lengths—18,000 psi. (See Article 1204)

1102. Slenderness Ratio. The maximum permissible slenderness ratio L/r for compression members carrying weight or pressure of tank contents shall be 120.

The maximum permissible slenderness ratio L/r for compression members carrying loads from wind and earthquake only shall be 175.

The maximum permissible slenderness ratio L/r for columns carrying roof loads only shall be 175.

1103. Bending:

Tension on extreme fibers, except column base plates	15,000
Column base plates	20,000
Compression on extreme fibers of rolled sections, and plate girders and built-up members for values of:	
$\frac{ld}{bt}$ not in excess of 600	15,000
$\frac{ld}{bt}$ in excess of 600	$\frac{9{,}000{,}000}{\frac{ld}{bt}}$

in which *l* is the unsupported length and *d* the depth of the member; *b* is the width; and *t* the thickness of its compression flange; all in inches; except that *l* shall be taken as twice the length of the compression flange of a cantilever beam not fully stayed at its outer end against translation or rotation.

Pins, extreme fiber	22,500
Cast steel	11,250

1104. Shearing:

Rivets	11,250
Pins and turned bolts in reamed or drilled holes	11,250
Unfinished bolts	7,500
Webs of beams and plate girders, gross section	9,750
Cast steel	7,325
Tank plates and structural connection materials	11,250

1105. Bearing:

	Double Shear	*Single Shear*
Rivets	30,000	24,000
Turned bolts in reamed or drilled holes	30,000	24,000
Unfinished bolts	18,750	15,000

Pins	24,000
Contact area of milled surfaces	22,500
Contact area of fitted stiffeners	20,250
Expansion rollers and rockers (pounds per linear inch) where d is the diameter of roller or rocker in inches	600d

1106. Combined Stresses: Members subject to both axial and bending stresses shall be so proportioned that the sum of the stresses at the critical point does not exceed the allowed axial stress.

1107. Wind and Earthquake Allowances. For stresses due to a combination of wind or earthquake with other loads, and for wind and earthquake stresses only, the above working unit stresses may be increased 25 per cent. Wind and earthquake loads need not be considered simultaneously. In no case, however, shall the resulting section be less than that required for dead and live loads alone. The above increase includes also the details at end connections, splices and anchor bolts.

1108. Fillet and Groove Welds. Welded joints shall be proportioned so that the loads specified in Section 10 shall not cause stresses therein in excess of design stresses obtained by applying to the allowable working stresses in the base material, the efficiencies in the current American Water Works Association Standard for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage, AWWA D100, AWS D5.2.

Section 12—Details of Design.

1201. Sections. Sections shall preferably be symmetrical. Members shall be built of standard structural shapes or of tubular sections. Structural shapes shall be designed with open sections to permit painting all surfaces exposed to air or moisture and subject to corrosion. Tubular sections of columns and struts shall be air tight.

1202. Minimum Thickness—General. The minimum thickness of metal shall be 1/4 inch except in the webs of channels and I-beams and in minor parts which carry no load. The minimum size of sway rods shall be 3/4 inch.

1203. **Thickness of Cover Plates.** The thickness of cover plates shall be at least $\frac{1}{4}$ inch and not less than 1/60 of the distance between rivet lines. A cover plate may be used on but one side of a column.

1204. **Net Sections.** To calculate net sections of tension members the diameters of the rivet holes shall be taken $\frac{1}{8}$ inch larger than the nominal diameters of the rivets. For compression members all ordinary bolt holes and openings other than holes for rivets or Dardelet rivet bolts or the equivalent shall be deducted from the cross sectional area. For a distance of twice the maximum width of the member from the end, the allowable unit compression on the net section may be taken as the unit compression on short lengths, Article 1101.

1205. **Rivet Sizes.** Nominal diameters shall be used in proportioning rivets. The diameters of rivets in the flanges of channels except in minor and unimportant parts shall be $\frac{1}{2}$-inch or $\frac{5}{8}$-inch for 6-inch and 5-inch channels, $\frac{5}{8}$-inch for 7-inch and 8-inch channels, $\frac{5}{8}$-inch or $\frac{3}{4}$-inch for 9-inch channels, $\frac{3}{4}$-inch for 10- and 12-inch channels, and $\frac{7}{8}$-inch or $\frac{3}{4}$-inch for larger channels. The diameters of rivets in the flanges of I-beams shall not be greater than $\frac{5}{8}$-inch for flanges less than 4 inches in width, $\frac{3}{4}$-inch from 4 to 6 inches inclusive and $\frac{7}{8}$-inch for widths greater than 6 inches.

1206. **Rivet Edge Distance.** The distance from the center of any rivet hole to an edge except rolled edges of structural shapes, shall be at least $1\frac{1}{2}$ times the nominal diameter of the rivet.

1207. **Minimum Rivet Pitch.** The distance between centers of rivet holes shall be at least three diameters of the rivet.

1208. **Maximum Rivet Pitch.** The distance between centers of rivet holes in the line of stress for members composed of plates and shapes shall not exceed 16 times the thickness of the thinnest plate but shall be not more than 12 inches. When two rows of rivets are used and the rivets are staggered, the maximum distance between rivet holes in each line shall not exceed twice the above.

1209. Riveting at Ends of Cover Plates. The pitch of rivets at the ends of cover plates in built-up compression members shall not exceed four diameters of the rivet for a length equal to $1\frac{1}{2}$ times the maximum width of the member.

1210. Lattice. The open sides of compression members shall be provided with lattice. The thickness of lattice bars shall be at least 1/40 of their length between the centers of end rivets for single and 1/60 for double latticing. The minimum width of lattice bars shall be as follows:

For 15-inch channels or built sections with $3\frac{1}{2}$-inch or 4-inch angles—$2\frac{1}{4}$-inch ($\frac{3}{4}$-inch rivets) or $2\frac{1}{2}$-inch ($\frac{7}{8}$-inch rivets).

For 12-inch and 10-inch channels or built sections with 3-inch angles—$2\frac{1}{4}$ ($\frac{3}{4}$-inch rivets).

For 9-inch channels or built sections with 3-inch or $2\frac{1}{2}$-inch angles—$2\frac{1}{2}$-inch ($\frac{3}{4}$-inch rivets), or 2-inch ($\frac{5}{8}$-inch rivets).

For 8-inch and 7-inch channels or built sections with $2\frac{1}{2}$-inch angles—2-inch ($\frac{5}{8}$-inch rivets).

For 6-inch and 5-inch channels or built sections with 2-inch angles—$1\frac{1}{2}$-inch ($\frac{1}{2}$-inch rivets), or $1\frac{3}{4}$-inch ($\frac{5}{8}$-inch rivets).

The inclination of lattice bars with the axis of the member shall not be less than 45 degrees. Lattice bars shall be so spaced that the ratio L/r of one flange of the member included between two adjacent connections of lattice bars is not over $\frac{3}{4}$ of that of the unsupported length of the member as a whole.

1211. Batten Plates. Batten plates shall be provided where lattice is discontinued at ends or intermediate points of members. Batten plates shall be as near the latticing and the ends of members as practicable. In main members carrying calculated stress the end batten plates shall have a length not less than the distance between the lines of rivets connecting them to the flanges and intermediate batten plates a length of at least one-half of this distance. The thickness of batten plates shall not be less than 1/50 of the distance between the lines of rivets connecting them to the flanges of the members, and the rivet pitch shall not be more than four diameters of the rivets.

1212. **Columns.**

a. **Splices.** Column splices shall be designed to withstand the maximum possible uplift or at least 25 per cent of the maximum compression whichever is greater. The abutting joints of welded tubular columns may be either butt welded with a backer strip or spliced by plates welded to both sections being joined. Where a horizontal plate minimum thickness of 1/4 in. is used to seal the top and bottom of a column section the backing strip or splice plate may be omitted.

Riveted columns shall be milled to give a uniform bearing over the entire section and, if channels, shall be spliced on four sides. The number of rivets in spliced parts of channel columns shall be proportioned as nearly as practicable in accordance with the respective sectional area of the parts. If H sections, only the flanges need to be spliced.

b. **Strength Diaphragm in Tubular Columns.** A substantial diaphragm or equivalent resistance to local tube distortion shall be provided at all panel points, points of concentrated loading and at the top diagonal wind rod connections. When a horizontal plate (minimum thickness 1/4 in.) is used to seal the top and/or bottom of a column section and is located within 18 in. of the panel point a diaphragm plate is not necessary.

1213. **Combined Shapes.** The rivet pitch in members consisting of structural shapes in contact shall not exceed 12 inches. The shapes shall be separated at least 3/8 in. if they are not in contact. For tension members, the component parts of which are separated by washers, the rivets shall be spaced not over 3 feet 6 inches apart.

1214. **Starred Angles.** Compression members built of two angles in a star section shall have pairs of tie plates or angles spaced not over 20 inches on center for 3-inch, 24 inches for 4-inch, 36 inches for 5-inch, 42 inches for 6-inch, and 48 inches for 8-inch angles. The tie plates or angles shall be connected to each of the angles of the compression members by not less than two rivets and at least three rivets shall be used in 6-inch or 8-inch angles.

1215. **Connections—General.** The strength of connections shall be sufficient to transmit the full stress in the member. A group of rivets at the end of any member, transmitting stress into that member should have its center of gravity in the line of the center of gravity of the member; if not, provision shall be made for the effect of the resulting eccentricity. Connections between the columns, struts and tension members shall be made by gusset plates which may also serve as splice plates. Diagonal bracing shall, when possible, be connected to the same gusset plates that connect the columns and struts. Rivets shall not be subjected to tensile stress.

1216. Pins. Adjustable tension members shall be connected to gusset plates by finished or cold-rolled steel pins. Pins shall either be headed on one end and threaded on the other or be threaded on both ends, the threaded ends being fitted with nuts. Threads shall be burred outside the nuts to prevent easy removal of the nuts.

1217. Net Area of Pin-Plate. The net area of the gusset-plate section ahead of a clevis pin shall not be less than 62.5 per cent of the net area of the tension member.

1218. Clevises, Forked Ends, Turnbuckles.

a. Bar or plate clevises, forged clevis-nuts, or forked ends shall be used to connect adjustable tension members to the clevis-pins. The strength of clevises shall not be less than that of the tension member. The minimum sectional area through forked ends shall not be less than the area of the tension member at its smallest section.

b. Clevis plates may be fusion welded to wind rods. There shall be two plates at each end of the rod. The plates shall be symmetrical. There shall not be any open spaces between rod and clevis plates. The plates shall be bent in easy lines to reduce to a minimum the stretch under load, or they shall be flat with filler plates on the pin. In any case, the clevis pin shall be designed to carry the maximum stresses, including bending, without overstressing. An acceptable clevis is shown in Fig. 1.

c. Turnbuckles shall be of the open type and shall have a strength not less than that of the tension member. A turnbuckle shall not be used when the outer ends of the member and threaded unless outer ends are prevented from turning Turnbuckles shall be prevented from turning by a ¼-inch lock bolt in an unstressed end of a rod in the turnbuckle.

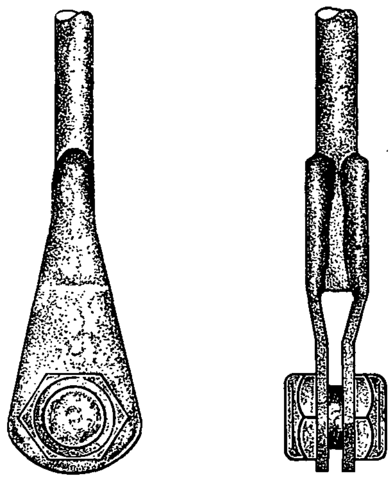


Fig. 1. Welded Clevises for Diagonal Wind Rods.

d. Two holes at 90° shall be provided for the lock bolt. The ends of the lock bolt shall protrude sufficiently to effectively prevent the turnbuckle from turning. Threads of the lock bolt shall be burred. Equivalent construction, including Dardelet or similar self-locking threads without the lock bolt will be satisfactory.

1219. Tank Connection. The center of gravity lines of the column, circular girder, and lowest plate of the tank cylinder shall meet at a point or the columns shall be designed for the eccentricity. The combined axial and bending stress in the detail connecting the top of the column to the tank plate shall not be more than 33⅓ per cent in excess of the allowable axial working-stress which in the case of compression, is that allowed for short lengths. The outward hydrostatic pressure on the tank plate directly behind the hitch-angles may be considered as opposing inward bending of the hitch-angles.

1220. Tie Plates. The main constituent parts of columns shall be solidly tied together at points of connection of tension or compression members.

1221. Length of Tension Members. The horizontal projection of the unsupported length in inches of a nonadjustable tension member in a horizontal or inclined position shall not exceed 200 times the radius of gyration about the horizontal axis.

1222. Column Bases and Caps.

a. Columns shall have bases built of steel plates and structural shapes. The lower end of each column shall be faced and must bear fully on the base plate. The base plate and its connection to the column shall be designed to load the foundation uniformly and also to transmit the net uplift from the column when subjected to the greatest possible wind stress to the foundations with the tank empty. Parts used in footings shall bear against the base plates and be braced rigidly against lateral movement. Footings shall be designed without pockets or else shall be filled with concrete and flashed with asphalt to prevent the collection of dirt and moisture inside.

b. When the tower supports a flat bottom tank, the columns shall have steel caps designed to transmit the load from the grillage I-beams concentrically to the columns. The upper ends of the columns shall be faced and bear fully on the cap plates. Parts used in the caps shall bear against the cap plates and be braced rigidly against lateral movement. The tops and bottoms of column shapes may be welded to the cap and base plates respectively provided that approval of design is obtained from the authority having jurisdiction. If the batter of columns exceeds 1.8 inches horizontal to twelve inches vertical, the footings shall be riveted throughout or rigid ties provided between the column bases.

1223. Circular Girder with Inclined Columns. Tops of inclined columns shall be connected by a continuous, horizontal circular girder if the tank bottom is suspended. The outer flange should preferably be symmetrical about the web plate, but if eccentric, the allowable working stresses for the flanges shall be reduced 25 per cent. The bending moment shall be considered as carried entirely by the flanges, the shear by the web, and the compression by the flanges and web in proportion to their areas at the section considered. Splices shall be designed to transmit the load in the spliced member. The horizontal component of the maximum column load shall be transmitted to the girder without subjecting the rivets to tension. The circular girder may be used as a balcony. Drain holes shall be provided in the web place.

1224. Circular Girder with Vertical Columns. If the columns are vertical and the tank bottom suspended, the circular girder shall be as stated in Article 1223 or else shall be a structural shape connected to the tank by the rivets of the joint between the shell and bottom, the shape extending as close as possible to the columns.

1225. Interior Bracing. Bracing inside the tank shall be avoided if possible but if used, 1/16-inch additional thickness shall be added to the calculated sections to provide for corrosion. The sections shall be open to facilitate cleaning and painting.

1226. Top Struts. The thrust from battered columns supporting a flat bottom tank shall be resisted by struts connected to the extreme top of the columns or to the cap plates on all sides of the tower.

1227. Grillage. When the tower supports a flat bottom tank all of the supporting beams shall be steel and shall be riveted or bolted to the post cap girders. The latter shall be riveted or bolted to the column caps and shall be braced to prevent overturning. When drop beams are used between the girders no other bracing is necessary. For tanks of over 30,000 gallons capacity, the drop beams, if used, shall be fully riveted in place. The load on the outside grillage beams shall be considered as increasing from zero at the ends to a maximum at the center.

1228. Base Braces. When the tower is supported by a building, insecure earth, or foundations extending more than about one foot above grade, rigid members shall be placed between the adjacent column bases or foundations. Rigid members shall be provided between adjacent column bases when the columns are welded to the base plates and the batter exceeds 1.8 horizontal to 12 vertical.

1229. Web Stiffeners. Web stiffeners consisting of pairs of angles shall be provided at points of concentrated loading on beams and girders when necessary to prevent buckling of webs.

1230. Large Risers. Water Spheres.

a. Large steel plate pipes three feet or more in diameter shall be designed to withstand stress caused by the weight or pressure of the tank and riser contents and also the load imposed upon the top of the riser pipe by the tank bottom or by members supporting the tank bottom as specified in Article 1003. If the design of the riser plates is controlled by hoop tension, 0.3 of the compressive stress in the vertical direction shall be added to the full calculated tensile stress in the horizontal direction in determining the thickness. If the design of the riser plates is controlled by vertical compression, 0.3 of the tensile stress in the horizontal direction shall be added to the full calculated compressive stress in the vertical direction in applying the formulae in Article 1101.

The thickness of the bottom ring of the steel plate shall be sufficient so that the specified unit stresses shall not be exceeded when combined with bending, or other stress around the manhole or other openings.

b. For the design of water spheres and conical frustum at the base of the sphere, the symbol R representing the radius in Article 1101 shall be taken as the radius of the sphere, or the radius of the cone perpendicular to the conical surface.

The surface of the conical frustum supporting the sphere shall not be inclined to the horizontal at an angle less than 30°. If compression reinforcing is required at the junction of the conical frustum and the tubular support, the effective width in inches of each plate at the joint that may be considered as contributing to this required reinforcing shall be limited to the square root of the product of each plate thickness in inches and its respective inside radius in inches.

1231. Anchor Bolts. In earthquake locations there shall be at least two anchor bolts per column.

Section 13—Workmanship.

1301. Shearing. All shearing shall be done neatly, and material over $\frac{3}{4}$ inch thick, except base plates or other plates not carrying actual stress, shall have $\frac{1}{8}$ inch planed from the sheared edges.

1302. Punching. Punching shall be accurately done. The diameter of the punch shall not be more than 1/16-inch larger than that of the rivet, and the diameter of the die not more than 3/32-inch larger than that of the punch.

1303. Subpunching and Drilling. Material more than $\frac{3}{4}$-inch thick, except base plates or other plates not carrying actual stress, shall be subpunched and reamed or drilled from the solid.

1304. Straightening and Fitting. The several pieces forming built sections shall be straight and shall fit close together. Riveted members shall have all parts firmly drawn together with bolts, before riveting is commenced.

1305. Use of Rivets, Bolts and Welding. Members shall be riveted or welded throughout, except in field connections of non-adjustable tension members carrying wind stress only, and of compression members and grillages in towers supporting tanks of 30,000 gallons or less capacity, where unfinished bolts may be used. The threads of unfinished bolts shall be burred outside of the nuts. Dardelet rivet-bolts or the equivalent may be used in field connections of towers supporting tanks of 100,000 gallons or less capacity. Where machined bolts are needed, the bolt holes shall be reamed parallel and the bolts machined to a driving fit, burring the threads outside the nuts unless special approved locking devices are provided.

1306. Heads of Rivets. Button heads shall be used except where countersunk heads are necessary. The height of a button head shall be not less than 6/10 times the rivet diameter and the diameter of the head not less than $1\frac{1}{2}$ times the rivet diameter plus $\frac{1}{8}$-inch.

1307. Driving of Rivets. Rivets of greater diameter than $\frac{1}{2}$ inch shall be uniformly heated to a light cherry red heat. Shop rivets shall be driven by pressure. Recupping and calking is not allowed. Loose, burned, or otherwise defective rivets shall be cut or drilled out and replaced without injuring the adjacent metal.

1308. Drifting. Drift pins shall not be used to enlarge unfair holes. If the holes must be enlarged to admit the rivet, they shall be reamed. Poor matching of holes will be cause for rejection.

1309. Lattice Bars. Lattice bars shall have neatly rounded ends, unless otherwise called for.

1310. Bearing Surfaces. Compression joints depending upon contact bearing shall have the bearing surfaces accurately faced after the members are completely shop riveted and when perfectly aligned.

1311. Threads and Nuts. Screw threads on rods shall be cut or rolled to the United States Standard or shall have Dardelet threads or similar self-locking threads, and shall make tight fits in nuts and turnbuckles. All threads in nuts and turnbuckles shall be engaged. Machined bolts shall have threads entirely outside the holes, and washers not less than 1/8 inch thick shall be used under the nuts. Nuts on all bolts shall be drawn tight and threads burred outside the nuts.

1312. Grouting of Base Plates. During field erection the columns shall be built on thin metal wedges which, after the structure is completed, shall be driven to equal resistance so that all columns will be loaded equally and then the spaces beneath the base plates and the anchor bolt holes completely filled with portland cement mortar, consisting of one part portland cement to three parts clean sand. After the mortar has set, any remaining spaces under the base plates shall be filled with neat cement grout. Joints between steel and mortar shall be flashed with asphalt.

1313. Assembly.

a. Component parts of built-up members shall be held in firm contact by adequate clamps or other means. Spaces in which inaccessible corrosion can form shall not be left between component parts of members.

b. Erection bolts or other positive devices imparting sufficient strength and stiffness to resist all temporary weights and lateral loads, including wind, shall be used for temporarily fastening the members together and bracing the framework.

1314. Alignment. Members and all component parts shall be straight and free from appreciable buckles or warping.

1315. Tubular Column Distortion. The column axis shall not deviate from a straight line more than 1/1000 of the laterally unsupported length. At no cross-section shall the difference between the maximum and minimum outside diameters exceed 2 per cent of the nominal outside diameter. Local dents shall be no deeper than the plate thickness.

Section 14—Accessories.

1401. Connections. Connections shall be provided on the tower for the necessary pipe and frostproof casing braces.

1402. Ladders—General. A steel ladder shall be placed on one of the tower columns extending from a point within easy reach of the ground to the balcony around the tank or to the revolving tank ladder. The ladder shall not incline outward from the vertical at any point. When the tower supports a wooden tank or when the balcony is not used as a circular girder, the ladder may pass through an opening in the balcony not less than 18 x 24 inches in the clear. The ladder shall be securely fastened at its upper end. Welding of ladders and their connections is permitted.

1403. Ladders—Details.

a. The ladder shall have not less than 2 x 5/16-inch flat side bars spaced at least 14 inches apart and at least ⅝-inch round or square rungs, spaced 12 inches on centers. The rungs shall be firmly riveted or welded to the side bars. The sections of the ladder shall be connected by lap or butt joints. If joints are bolted, at least two ½-inch bolts shall be used on each side of each splice.

b. The ladder shall be connected to the tower column by flat bar brackets spaced not over 12 feet apart. The brackets shall be rigidly connected to the column and designed to support a load of 350 pounds on the ladder.

c. Other arrangements of tower ladders may be permitted provided approval is first obtained from the authority having jurisdiction. Such arrangements are not recommended, however, unless made necessary by a special design of tower, and with distances greater than 12 feet between supports, the side bars of the ladder should be made of angles not lighter than 1¾ x 1¾ x ¼ inches or their equivalent.

1404. Walkway.

a. A walkway at least 18 inches wide, extending from a point accessible from the tower ladder to the expansion joint under the tank and terminating in a platform giving at least 20 inches clearance around the enlarged portion of the frost-proof casing, shall be provided when the tower is 30 feet or more in height. Walkway flooring shall be 2 in. dressed plank spaced ½ in. apart, or ¼ in. steel plate with drain holes. The walkway and platform shall be rigidly supported and braced laterally to prevent swinging.

b. All supports shall be of steel and shop connections shall be riveted or welded. Ends of threads shall be burred on all bolted connections. A railing 36 in. high shall be placed on each side of the walkway and around the outer edge of the platform and shall be rigid. The top rail and posts shall be of not less than 1 in. pipe or of angles not lighter than 1¾ x 1¾ x 3/16 in. An intermediate rail shall be provided or diagonal latticing used.

1405. Balcony. Towers over 20 feet high, and having a horizontal circular girder at the top of the inclined columns, Article 1223, to resist the inward thrust from the columns, shall be provided with a balcony at least 24 inches wide around the base of the cylindrical portion of the tank. A rigid railing at least 36 inches high shall be provided around the outside of the balcony. The top rail and posts shall be not lighter than 1¾ x 1¾ x 3/16 inch angles or their equivalent. An intermediate rail or latticing shall be provided.

A balcony shall not be required for pedestal or tripod supported tanks. For inclined column tower supported tanks without a cylindrical shell, a balcony shall not be omitted without the approval of the authority having jurisdiction.

1406. Painting Inaccessible Parts. Parts inaccessible after fabrication shall be protected by paint before assembling, except surfaces in watertight joints and edges or surfaces to be welded, which shall be coated with linseed oil.

1407. Shop Painting. All steel, except where encased in concrete, and edges or surfaces to be welded shall be thoroughly cleaned and given a shop coat of red-lead paint, mixed with 100 pounds of red-lead paste (94% Pb_3O_4) to 2½ gallons of linseed oil (if raw oil is used add ½ pint of dryer to every gallon of paint); or an approved ready mixed red-lead paint.

Other paints may be used, provided permission is first obtained from the authority having jurisdiction.

1408. Field Painting. After erection, a patch coat of the same kind as the shop coat shall be applied to all surfaces from which the shop coat has become removed, and to all field rivets, bolts and welds. An over-all field coat of a good grade of metallic paint of color specified by the purchaser shall be applied after the tank has been made watertight.

Other paints may be used, provided permission is first obtained from the authority having jurisdiction.

1409. Painting Conditions. Before painting all steelwork shall be thoroughly cleaned of loose mill scale, rust, oil and grease by scraping, wirebrushing and wiping. Painting shall not be done out of doors during wet or freezing weather. The coats of paint shall completely cover the steelwork.

1410. Fireproofing Tank Towers. (See Article 3 for locations where fireproofing is needed.)

a. Fireproofing, when necessary, is usually not installed by the tank contractor. The best fireproofing of steel columns consists of poured concrete, 2 in. outside of all projecting steel. One method of construction is to wind No. 5 B & S gage steel wire spirally at a pitch of 8 in. around the section and then to erect wooden forms about 6 ft. high, filling and tamping before erecting the next 6-ft. section.

b. The best coarse aggregates arranged in order of preference are limestone or calcareous gravel, trap rock, granite, sandstone, and hard coal cinders, less than 1 in. in size. A 1:2:4 mixture of portland cement, clean sand, and one of the above coarse aggregates should be used.

c. Another method of construction consists of winding 4 or 5 ft. lengths of expanded metal around the section, the mesh taking the place of wooden forms and wire ties. The concrete should be of relatively dry consistency, however, so that it will not escape from the mesh. The mesh should be kept about 1 in. away from the steel by means of spacers so that the concrete will completely surround the steel. Ends of the mesh should be lapped and securely wired together. After the concrete has set, a 1-in. layer of portland cement mortar is trowelled on the outside of the mesh.

d. Ordinarily columns are so nearly vertical that the weight of concrete fireproofing does not cause significant bending stresses. The vertical load is carried by the foundations. If columns are considerably inclined, reinforcing bars should be placed in the concrete so designed as to make the fireproofing self-supporting.

e. Fireproofing should extend continuously through floors and roof of a building. The extreme top of the concrete should be thoroughly flashed with asphalt, including all exposed junctions between steel and concrete. Concrete surfaces exposed to freezing temperatures should be coated with special waterproof paint suitable for concrete surfaces, to prevent spalling.

f. Horizontal struts and compression portal braces should also be encased in solid concrete 2 in. outside of all projecting steel. Wooden forms and wire ties are necessary, and reinforcing rods should be located near the bottom of the section so designed as to make the fireproofing self-supporting. Care should be taken in designing the supports for the forms, as compression members are not usually of sufficient strength to safely resist bending. If any of the struts are used for supporting forms, their strength shall be carefully investigated by a consulting structural engineer.

g. Cement plaster on metal lath has not been satisfactory out of doors or in moist locations, due to unobserved corrosion of the steel sections.

h. Diagonal wind rods or tension portal members are not usually fireproofed, being less subject to failure when heated than the compression members. Where very severe exposure exists, 1-in. asbestos covering over heavily painted rods, with exterior covering of painted 8-oz. canvas may be used, but removal and repainting of the steel at about eight-year intervals, is advisable. Special care is needed to make such fireproofing watertight at turnbuckles and clevises. Concrete has been used occasionally but wire ties or coarse rectangular mesh are necessary to prevent serious cracking and deterioration of the fireproofing.

i. Wooden frostproof casings are not usually fireproofed. A few casings have completely burned away from steel tanks without damaging the tower or tank but necessitating replacement of the riser pipes. Grillage beams under a wooden tank might possibly fail in case of a serious fire involving the frostproof casing. Wooden casings, unless given a preservative treatment, usually rot seriously and need replacement at from eight- to fourteen-year intervals. This period would probably not be lengthened by the presence of cement plaster fireproofing.

j. Non-combustible frostproof casings are desirable for wooden tanks. For steel tanks, 3-ft. diameter steel risers are satisfactory, and do not require fireproofing. In case of high risers, it is necessary to strengthen the valve pit roof.

k. Alternate protection for tank towers in lieu of concrete may consist of open sprinklers if water supplies are sufficient and watch service and other conditions are satisfactory to the authority having jurisdiction.

WOODEN WATER TANKS.

Section 15—General.

1501. This Standard defines the recommended practice for the design, manufacture, and erection of wooden water tanks.

1502. Capacity. The capacity of the tank is the number of U. S. gallons available above the outlet opening. The net capacity between the outlet opening of the discharge pipe and the inlet of the overflow shall be at least equal to the rated capacity.

1503. Standard Sizes. The standard sizes of wooden tanks are 5,000, 10,000, 15,000, 20,000, 25,000, 30,000, 40,000, 50,000, 60,000, 75,000, and 100,000 gallons net capacity. Tanks of other sizes are built occasionally.

1504. Form. A wooden tank shall be circular in section with vertical sides.

1505. Strength. The materials as specified shall have no defects other than those permitted by the grading rules for the lumbers listed in Article 1602. The use of second-hand materials, including hoops, lumber, etc., is not permitted. The workmanship shall be good so that defects or injuries are not produced during manufacture or erection. Unit stresses, as specified in Article 1801, shall not be exceeded except where additionally reinforced. (See Article 2003—Chime.) The structure and its details shall possess the requisite strength and rigidity.

Section 16—Material.

1601. Lumber—General. All lumber shall be well seasoned and free from rot, sap, loose or unsound knots, worm holes and shakes.

1602. Lumber—Staves and Bottom.

a. Untreated lumber in the staves and the bottom shall be thoroughly air dried "all heart" or "tank stock" without any sapwood after shaping, and shall bear the grade-mark and trade-mark of the association under whose rules it is manufactured, or otherwise be acceptably identified or certified. Acceptable untreated species are red cypress (coast type), redwood, western red cedar, southern white cedar (Dismal Swamp), and Douglas fir (coast type), the varieties being arranged in the order of preference.

b. Cypress, redwood or southern white cedar (Dismal Swamp) are advised as the increased serviceability will ordinarily more than offset the slightly greater cost of the complete installation. Fir deteriorates rapidly if the water is overheated during the heating season. (See Article 3524.)

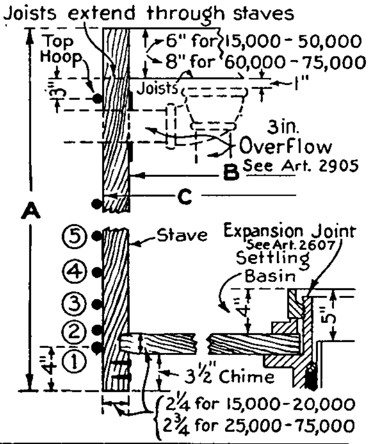
c. Acceptable treated species are Douglas fir (coast type) "tank stock" without sapwood restriction, and Southern yellow pine, "square edge and sound, clear, free of edge knots and unsound through knots" or "B and Better Finish." Treatment shall consist of an eight-pound per cubic foot retention of creosote applied after shop fabrication, according to the standard specifications of the American Wood Preservers' Association (Washington, D. C.) by the empty-cell process.

1603. Timber—Supports. Wooden dunnage beams, when used, shall be a dense grade of Southern pine or Douglas fir or a structural grade of redwood or red cypress (Coast type) except that structural grades of other species may be used if treated with a six- to eight-pound per cubic foot retention of creosote applied according to the standard specifications of the American Wood Preservers' Association (Washington, D. C.) by the empty-cell process. (See Articles 1801 and 1908.) Dunnage beams, if of wood, shall be at least 4 x 6 inch nominal size, laid on edge. Board or timber shims shall not be used beneath the tank supports, 1:3 portland cement mortar or iron being used if necessary.

1604. Hoops. Hoops shall be round bars of iron or steel. Iron bars shall conform to current specifications A84 or A189 of the American Society for Testing and Materials. Steel bars shall conform to A306 Grade 65. Steel shall be made only by the open hearth or electric furnace processes.

WOODEN TANKS

Dimensions are for cylindrical Tanks. If tapered tanks are used, diameters in table are at one half depth.



TANK DIMENSIONS

Net Capacity (Gallons)	Stave Length A	Inside Diam. B	Outside Diam. C	Approx. Outside Circ.
15,000	14'-0"	14'-2½"	14'-7"	45'-9¾"
20,000	16'-0"	15'-3½"	15'-8"	49'-2¾"
25,000	16'-0"	17'-0½"	17'-6"	54'-11¾"
30,000	18'-0"	17'-6½"	18'-0"	56'-6½"
40,000	20'-0"	19'-1½"	19'-7"	61'-6¼"
50,000	20'-0"	21'-6½"	22'-0"	69'-1½"
60,000	20'-0"	23'-6½"	24'-0"	75'-4¾"
75,000	24'-0"	23'-10½"	24'-4"	76'-5¼"

DISTANCES BETWEEN HOOPS (Inches)

Number of Hoop starting at bottom	Net Capacity (U.S. Gallons) 15,000	20,000	25,000	30,000	40,000	50,000	60,000	75,000
29								
28								3
27								21
26								21
25								19
24								18
23							3	14
22					3	3	21	12
21					21	21	20	12
20					21	21	18	12
19				3	19	18	15	12
18				21	15	18	15	10
17				18	15	15	14	10
16				18	12	15	12	10
15		3	3	15	12	12	11	9
14		21	21	15	10	12	10	9
13	3	18	18	14	9	10	9	8
12	21	18	18	12	9	10	9	8
11	21	15	15	11	9	9	8	8
10	19	15	15	10	9	9	8	7
9	15	15	15	9	9	8	7	7
8	13	12	12	9	9	8	7	7
7	12	12	12	8	9	8	7	7
6	11	11	10	8	8	7	7	6
5	10	10	10	8	8	7	6	6
4	9	9	9	7	8	7	6	6
3	9	9	9	7	7	6	6	6
2	8	8	8	7	6	4	6	6
1	7	6	7	6	2	2	3	2
Bottom of Stave	4	4	4	4	4	4	4	4

Hoops: 15,000: 13-¾ in. Hoops; 20,000: 10-⅞ in. Hoops, 5-¾ in.; 25,000: 11-⅞ in. Hoops, 4-¾ in.; 30,000: 15-⅞ in. Hoops, 4-¾ in.; 40,000: 12-1 in. Hoops, 10-⅞ in. Hoops; 50,000: 18-1 in. Hoops, 4-⅞ in.; 60,000: 19-1 in. Hoops, 4-⅞ in.; 75,000: 21-1⅛ in. Hoops, 7-1 in. Hoops.

N. B. Top distance is measured from the top hoop to the underside of the joists.

Fig. 2. Hoop Schedules for Wooden Tanks.

1605. Hoop Lugs. The lugs shall be of malleable iron, conforming to current Specification A-47 of the American Society for Testing and Materials.

1606. Steel Shapes. The steel for structural shapes shall conform to current Specification A-7 structural steel of the American Society for Testing and Materials.

Section 17—Loads.

1701. Dead Load. The dead load shall be the estimated weight of all permanent construction and fittings.

1702. Live Load. Under normal conditions, the live load shall be the weight of all the liquid when overflowing the top of the tank. The unit weight of water shall be considered as 62.4 pounds per cubic foot. Proper provision must be made for temporary stresses during erection. When roofs have a slope of less than 30 they shall be designed to support a uniform weight of 25 pounds per square foot on the horizontal projection.

1703. Wind Load. Under normal conditions the wind load or pressures shall be assumed to be 30 pounds on vertical plane surfaces, 18 pounds on projected areas of cylindrical surfaces and 15 pounds per square foot on projected areas of conical and double curved plate surfaces. When designing for wind velocities over 100 miles per hour, all above mentioned unit pressures shall be adjusted in proportion to the square of the velocity assuming that the above pressures are for 100 miles per hour.

1704. Earthquake Load. Tank structures should meet local requirements for preventing earthquake damage.

1705. Balcony and Ladder Loads. A vertical load of 1,000 lb. shall be assumed to be applied to any 10 sq. ft. of area on the balcony floor and on each platform; 500 lb. applied to any 10 sq. ft. area on the tank roof; 350 lb. on each vertical section of ladder; and all of the structural parts and connections shall be designed to withstand such loads. The above loadings need not be combined with snow loading.

Section 18—Unit Stresses.

1801. General. The following stresses in pounds per square inch apply particularly to wooden tanks and shall not be exceeded. (Unit working stresses for steel supporting construction are given in Section 11.)

a. Tension Hoops. The unit stress for tension hoops of A84 iron shall be 12,500, of A-189 and A306 steel shall be 15,000 (use with hydrostatic load and neglect initial tension).

b. Timber. The allowable working stresses for timbers mentioned in Articles 1603 and 1908 shall be as follows:

WORKING STRESSES FOR TIMBER (Select Grade)

Species	Allowable Stress Lb. per Sq. In.: Bending — In extreme fiber	Horizontal Shear	Compression perpendicular to grain	Compression parallel to grain; short columns
Cedar, western red	900	80	200	700
Cedar, northern and southern white	750	70	175	550
Douglas fir (Western Washington and Oregon)	1600	90	345	1175
Douglas fir (Western Washington and Oregon), dense grade	1750	105	380	1290
Douglas fir (Rocky Mountain type)	1100	85	275	800
Pine, southern yellow	1600	110	345	1175
Pine, southern yellow, dense	1750	120	380	1290
Pine, white, sugar, western white, western yellow	900	85	250	750
Pine, Norway	1100	85	300	800
Redwood	1200	70	250	1000
Spruce, red, white, Sitka	1100	85	250	800

1802. Wind and Earthquake Allowance. For stresses due to a combination of wind or earthquake with other loads, the above working unit stress may be increased 25 per cent. Wind and earthquake loads need not be considered simultaneously. In no case shall the strength of the member be less than that required for dead and live loads alone.

Section 19—Details of Design.

1901. Lumber Thickness. The lumber in the staves and the bottom shall be at least 2½ in. (nominal) dressed to not less than 2⅛ in. thickness for tanks not exceeding 16 ft. in depth or diameter and for larger tanks at least 3 in. (nominal) dressed to not less than 2⅝ in. thickness.

1902. Hoop Sizes. Hoops shall be not smaller than the pitch diameter of ¾ in. thread. Not more than two sizes of hoops shall be used on a tank.

1903. Hoop Schedules. A hoop is assumed to support one-half of the length of the stave to the two adjacent hoops. Typical hoop schedules for standard size tanks are shown in Figure 2, based upon the area at the root of cut threads. Other schedules are satisfactory provided the unit stress as stated in Article 1801 is not exceeded.

1904. Hoops at Bottom.

a. One hoop shall be placed approximately at the center of the bottom planks of tanks with diameters of 19 ft. or less. The stress in this hoop shall not exceed one-half the allowable unit tension, the excess strength being provided to take care of the swelling of the bottom planks.

b. Two hoops of equal size shall be placed opposite the tank bottom on tanks with diameters of over 19 ft. The stress in the upper hoop shall be limited as stated above.

1905. Hoops at Top. The top hoop shall be placed 3 in. below the bottom of the flat cover joists or 3 in. below the top of the staves if the flat cover is omitted. The maximum spacing of hoops shall not exceed 21 in.

1906. Hoop Lugs. The ends of the hoop sections shall be connected by malleable iron lugs of design similar to that shown in Figure 4. The lugs shall have an ultimate strength of not less than 9700 lbs. for the ¾ in.; 13,500 lbs. for the ⅞ in.; 17,700 lbs. for the 1 in.; and 22,300 lbs. for the 1⅛ in. sizes. The lugs shall be designed so that water will not be pocketed. The hoops shall be so located on the tank that the lugs come in fairly uniform spiral lines.

1907. Main Supports. Steel I-beams or reinforced concrete beams shall be used for the main supports on which the dunnage beams rest.

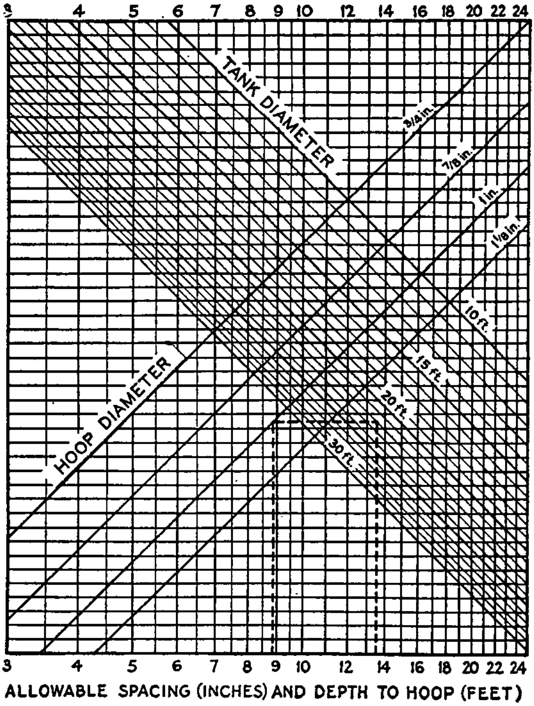


Fig. 3

Hoop Spacing Diagram for Wooden Tanks.

Note: "Hoop spacing" is one-half the distance from the hoop next above to the one next below the one being considered; "tank diameter" is the average outside diameter; "depth" is the distance from the hoop being considered to the top of the stave or if the staves are notched for flat cover joists, to the bottom of the notch.

The diagram is computed by the following formula assuming plain threaded ends using the area at the root of the thread.

$$\text{Spacing (inches)} = \frac{12{,}500 \times \text{area of hoop (sq. in.)}}{2.6 \times \text{tank diam. (ft.)} \times \text{depth (ft.)}}$$

Example: A 1 in. hoop 13.5 ft. down from the top of a 22 ft. diameter tank. What is the allowable spacing? Enter table at 13.5 ft. depth, follow the dash line vertically to 22 ft. diameter, then horizontally to 1 in. hoop, then vertically out of the diagram at 8.9 in. spacing. One-half the sum of the actual distances to the next hoop above and below should not exceed 8.9 in. plus the tolerance.

Tolerances: Design spacing may exceed computed spacing a maximum of ½ in. Spacing as installed may exceed computed spacing a maximum of 1 in.

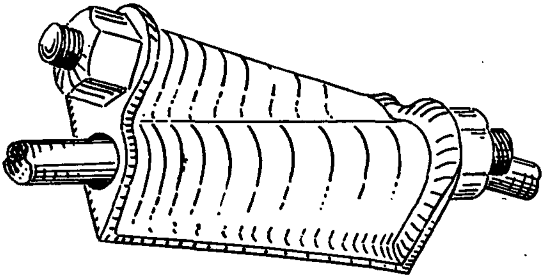


Fig. 4. Hoop Lugs.

1908. Dunnage Beams. The dunnage beams on which the tank bottom rests shall ordinarily be steel I-beams. If the main beams on which the dunnage beams rest are placed directly on the building walls, the dunnage beams may be timber (See Article 1603), at least 4 x 6 in. in nominal size, laid on edge. When the tank is erected over a concrete tower, reinforced concrete dunnage and supporting beams may be used.

1909. Spacing of Supports. The maximum distance in the clear between the beams on which the tank bottom rests shall not exceed 18 in. The maximum distance between the outer edge of the outer dunnage beam and inside surface of the tank staves measured on a line perpendicular to the beam at its mid-point shall not exceed 14 in.

1910. Accessibility of Bottoms. Tank supports shall be designed to make both the tank bottom and the supports accessible for inspection and painting and to allow a free circulation of air under the tank bottom and about the ends of the staves.

Section 20—Workmanship.

2001. Lumber Edges and Surfaces. Planks for staves and bottom shall be planned on both sides with the outer surface of staves preferably curved to the radius of the tank. The edges of staves and bottom planks shall be machine planed or sawed. Edges of staves should preferably be cut to obtain full bearing at joints. A fore plane may be used for smoothing up the edges. The last stave to be placed in the tank shall be carefully planed to the required size.

2002. Croze. The croze shall be cut at right angles to the center line of the staves and on an arc corresponding to the radius of the tank. The edges of the bottom planks shall be beveled on the under side and smoothed off on the upper side by planing to obtain a tight joint at the croze. The depth and width of the croze shall be at least ¾ in. and 2½ in., respectively, for 2⅝ in. standard dressed staves and ⅝ in. and 2 in. for 2⅛ in. staves.

2003. Chime. The chime shall be of uniform depth and not less than 3½ in. Before erection, the chimes of staves shall be nailed with at least three nails with staggered spacing, 2 in. nails with 3 in. staves and 1½ in. nails with 2½ in. staves. Nails shall be coated with zinc or copper, or shall be of other material highly resistant to corrosion.

2004. Dowels. The edges of each bottom plank shall be bored with holes not over 5 feet apart for wooden dowels not less than ⅝-inch in diameter.

2005. Splices. Splices should not be made in staves or bottom planks. However, where staves or bottom planks exceeding 16 ft. in length are required and where conditions warrant special consideration, one approved finger joint splice may be used in a stave or bottom plank if permitted by the authority having jurisdiction. Such joints in adjacent staves or bottom planks shall be staggered a minimum of 4 feet.

2006. Joints at Bottom. The joints between staves shall not come nearer than ½-inch to a joint between the bottom planks.

2007. Extra Staves. One or more extra staves shall be shipped with each tank.

2008. Lumber Storage. The finished tank lumber shall not be exposed to the weather before erection.

2009. Marking of Staves. The proper hoop spacing shall be plainly marked on at least every twelfth stave before shipment.

2010. Clearance at Supports. The distance between the ends of dunnage beams and the inside surface of the staves shall be not less than 1 inch or more than 3 inches. The supports shall be of such depth that the clearance beneath the ends of staves is not less than 1 inch at any point.

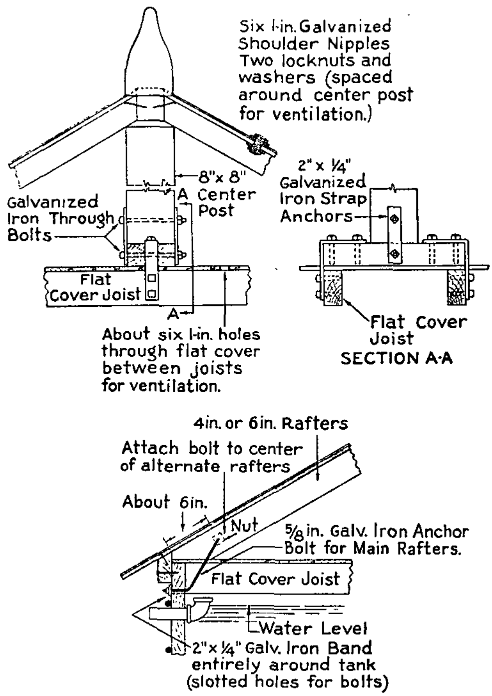


Fig. 5. Details of Tank Roof Construction.

2011. Hoop Forming. Hoops shall be cut to proper length and bent in the shop to the radius of the tank. The sections of a hoop shall be of approximately equal length.

2012. Hoop Threads. The threads shall have a tight fit in the nuts and shall be U. S. Standard.

2013. Hoop Tightening. Care shall be taken in setting up the nuts on the hoops to prevent an excessive initial stress in the hoops. The threads of the nuts shall be fully engaged.

2014. Removal of Rubbish. All waste lumber and rubbish shall be removed from inside of the tank and from the flat cover, if provided, before filling to prevent possible obstruction of piping.

Section 21—Accessories.

2101. Roof—General. When the tank is located out of doors it shall have a flat wooden cover over the top and above this a conical roof, except that the flat cover may be omitted and the conical cover made self-supporting provided that approval of the detailed design is first obtained from the authority having jurisdiction. Roofs shall be constructed as shown by Figure 5 or in accordance with other designs approved by the authority having jurisdiction.

Roof boards shall be not less than 1 in. nominal thickness and laid without spacing between. Ship lap or matched joints shall be used in the flat cover, but only ship lap joints are advised in the conical cover. The joint between the tank staves and roof shall be tight. Nails shall be heavily galvanized.

2102. Flat Cover. The flat cover, if provided, shall rest on parallel joists, spaced not over 36 in. on centers. The nominal size of joists shall be at least 2 x 6 in. for lengths up to 18 ft., 3 x 6 in. for lengths up to 22 ft., and 3 x 8 in. for

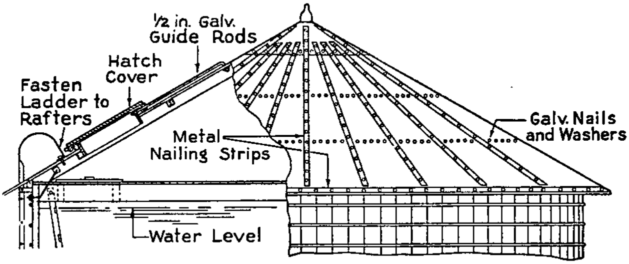


Fig. 6. Section of Conical Roof.

lengths up to 30 ft. Two joists of the above specified dimensions shall be placed at the center of the tank to support the center post. The full section of all joists at their ends shall be solidly supported by resting in slots cut entirely through the staves or by other means approved by the authority having jurisdiction. Supporting posts below joists are not permitted.

2103. Conical Roof. (Figure 6.)

a. The conical roof should preferably be supported by 2 x 4 in. rafters spaced not over 36 in. apart around the top of the tank.

b. Although the rafter and header type of construction is considered preferable, other types of roof construction may be acceptable provided approval of design is first obtained from the authority having jurisdiction.

c. The roof shall be covered with galvanized iron, two-ply asphalt, asbestos or equivalent fire-resistive roofing, securely fastened in place. Prepared asphalt roofing shall be laid with at least 2½ in. laps, properly cemented, and using ¾ in. galvanized roofing nails with at least ½ in. heads and large washers spaced not over 3 in. on centers, or the equivalent. Rows of nails shall be spaced not over 2 ft. apart vertically and horizontally.

2104. Roof Anchorage. All parts of the roof and cover shall be securely fastened together and anchored to the tank staves to prevent extreme winds from blowing them loose.

2105. Roof Hatches.

a. A hatch not less than 20 in. by 22 in. shall be built in the conical roof, accessible from the tank ladder. The hatch shall be placed high enough up the conical roof to make entrance to the flat roof reasonably easy when the cover for the flat roof hatch is in place.

b. The four sides of the hatch shall be of not less than 1½ in. dressed stock and shall be raised not less than 3 in. above the roof boards. The top of the hatch cover shall be made of not less than 1-in. dressed and matched boards and shall be covered with the same material as specified for the roof. The edges of the hatch cover shall be of not less than 1½ in. dressed stock and shall lap down over the raised sides of the hatch. The hatch cover shall be arranged to open freely by sliding upward on two ½ in. guide rods securely bolted to the roof, one on each side of the cover. A substantial handle shall be bolted to the lower side of the cover.

c. Other forms of hatch covers may be acceptable provided approval is first obtained from the authority having jurisdiction.

d. A hatch not less than 20 in. by 22 in. shall be built in the flat cover, if provided, located directly beneath the hatch in the conical roof. The hatch cover shall be made of 1 in. dressed and matched boards and shall be of sufficient size to prevent its falling through the hatch.

2106. Ladders—General. Inside and outside ladders arranged for convenient passages from one to the other and through the roof hatch shall be provided. Ladders shall not interfere with opening the hatch cover.

2107. Outside Ladders.

a. A steel ladder shall be provided on the outside of the tank extending from the balcony to the roof. The sides of the ladder shall extend 18 in. above the top of the tank and thence downward in an arch to the roof or cover where the ends shall be securely fastened. The ladder shall be placed at least 3 ft. to one side of the tower ladder if a balcony is provided. See Article 2109.

b. The outside ladder shall have not less than 2 x ¼ in. flat side bars, spaced at least 14 in. apart and at least ⅝ in.

round or square rungs, spaced 12 in. on centers. The rungs shall be firmly riveted or welded to the side bars. The ladder shall be securely fastened at least 6 in. from the side of the tank by brackets not over 12 ft. apart. The upper brackets shall be placed not more than 12 in. below the top of the tank staves and the lower end of the ladder shall be securely fastened to the balcony (Article 2109) or, in the absence of a balcony, to the tower ladder. The brackets shall be designed to support a load of 350 lbs. on the ladder.

2108. Inside Ladder.

a. A wooden ladder shall be provided on the inside of the tank extending from the hatch to the tank bottom with a slope of about 10° from the vertical.

b. The inside ladder shall have 2 x 4-in. side pieces spaced at least 14 in. apart and 1 x 2-in. rungs, spaced 12 in. on centers, securely spiked into slots so as to be flush with the sides. The ladder shall be securely fastened at the upper and lower ends.

2109. Balcony—General. A wooden or steel balcony shall be placed around the base of the tank when the tank bottom is elevated more than 20 ft. above the main building roof. For tanks of diameter in excess of 15 ft. 6 in., the width of balcony shall be 24 in. and for smaller tanks not less than 18 in.

2110. Balcony Floor. If the balcony is of wood, the plank shall be at least 1½-in. dressed lumber of good, sound quality spaced ½-in. apart. The planks may be laid crosswise on stringers or lengthwise on cross beams, spaced not over 4 ft. apart; if of steel it shall be built of at least ¼-in. plate and shall be provided with drain holes.

2111. Balcony Clearance. A clearance of not less than 3 in. nor more than 5 in. at any point shall be provided between the balcony and the tank staves. The clearance in the inside angles of polygonal balconies with plank laid lengthwise, shall be limited to a maximum of 5 in. by means of properly supported filler pieces.

2112. Balcony Supports. The balcony supports shall be built of structural steel shapes except that reinforced concrete supports may be used when the tank is located on a concrete tower.

2113. Balcony Railing. A railing 36 in. high shall be placed around the balcony and shall be rigid. The top rail and posts shall be of not less than 1-in. pipe or of angles not lighter than 1¾ x 1¾ x 3/16-in. or 2 x 1½ x ¼-in. An intermediate rail shall be provided or diagonal latticing used.

2114. Balcony Opening. When a hole is cut in the balcony for the tower ladder it shall be at least 18 in. by 24 in.

2115. Painting Inaccessible Parts. Portions of steelwork inaccessible after erection shall be painted before assembling.

2116. Shop Painting. All steel work, except where encased in concrete, and threads at ends of hoops, shall be given a shop coat of red lead paint mixed with 100 lbs. of red lead paste (94% Pb_3O_4) to 2½ gallons of linseed oil (if raw oil is used add ½ pint of dryer to every gallon of paint); or an approved ready mixed red lead paint.

2117. Field Painting—Steel Work. After erection, a patch coat of the same kind of paint as the shop coat shall be applied to all steel surfaces from which the shop coat has become removed and also to the thoroughly cleaned hoop threads. An over-all field coat of a good grade of metallic paint of color specified by the purchaser shall be applied to all steel work after the tank has been made watertight.

2118. Painting Conditions. All steel shall be thoroughly cleaned of mill scale, rust, and grease before painting by scraping, wire brushing and wiping. Painting shall not be done out of doors during wet or freezing weather. The coats of paint shall completely cover the steelwork.

2119. Painting—Woodwork. Exposed woodwork such as balcony, stringers, and supporting beams shall be given at least two coats of a good grade of paint. While the painting of a wooden tank is usually desirable from the standpoint of appearance, its value in increasing the life of the tank has not been definitely determined.

2120. Lightning Protection. See Article 6.

FOUNDATIONS.

General. Tanks and tank towers rest on foundations in the ground or on building walls or framework. Careful design and good workmanship are essential to properly safeguard life and property.

Section 22—Foundations in the Ground.

2201. Material.

a. Concrete foundations shall be built of concrete with a 28-day compressive strength of not less than 2,500 psi. The cement and aggregates shall conform with the current American Concrete Institute Building Code Requirements for Reinforced Concrete (ACI 318). The maximum aggregate size for unreinforced concrete shall be 3 in., and 1½ in. for reinforced concrete.

b. Pump suction tanks shall be set upon crushed stone, sand or concrete foundations. For good soil conditions, at least 6 in. of crushed stone or sand shall be provided. This should be saturated with oil and laid on moistened and compacted gravel after removing soft surface.

c. A concrete ring wall at least 2½ feet deep and 6 in. thick shall surround the tank foundation. This ring shall project 4 in. above grade and shall include reinforcing steel equal to .25 per cent of the cross-sectional area. If the ring wall is outside of the tank shell, asphalt flashing shall be provided between the tank and the ring wall at the ground level.

d. For poor soil, an 8-in. reinforced concrete slab with concrete ring wall directly beneath the tank sides and extended below the frost line is advised. For riveted construction, a 1½-in. layer of a dry mixture of sand and cement should be placed on top of the concrete slab. For welded construction, no sand cushion is needed on the concrete slab. Piles should be used in addition to the reinforced concrete slab when soil conditions are very poor.

2202. Form.

a. The tops of foundations shall be level and at least 4 in. above ground. The tops of foundation piers for towers shall be located accurately at the correct elevations. The bottom of foundations shall be located below the frost line, and in the case of piers, at least 4 ft. below grade, and shall rest on thoroughly tamped soil or rock.

b. Piers shall ordinarily be made pyramidical in form with smooth or stepped sides. If supporting a tower their center of gravity should preferably lie in the continued center of gravity line of the tower column. The height of piers shall not be less than the mean width. The top surface shall extend at least 3 in. beyond the bearing plates on all sides and shall be chamfered at the edge.

c. Tops of ring wall foundations shall be level within ¼ inch (plus or minus ⅛ inch) in one plate length (34 feet more or less), and no two points on the wall shall differ by more than ½ inch (plus or minus ¼ inch).

2203. Design. The details of design shall conform with the current requirements of the American Concrete Institute.

2204. Anchorage.

a. The weight of piers shall in all cases be sufficient to resist the maximum net uplift occurring with the tank empty and wind loads on the structure, as specified in previous sections. The wind shall be considered blowing in a direction diagonal to the tower. The weight of earth directly above the base of the pier may be included.

b. Anchor bolts shall be arranged to securely engage a weight at least equal to the net uplift with the tank empty and the wind blowing in a direction diagonal to the tower. Their lower ends should preferably be hooked or fitted with anchor plates.

c. Anchor bolts shall be accurately located with sufficient free length of thread to fully engage their nuts. Expansion bolts are not acceptable. The minimum size of anchor bolts shall be 1¼ in. when not replaceable.

2205. Grouting and Flashing. Bearing or base plates shall have complete bearing on the foundation or be laid on cement grout to secure a complete bearing. The stressed portion of anchor bolts shall not be exposed except where necessary. If the stressed portions of anchor bolts must be exposed, they shall be protected from corrosion by encasing them in cement mortar unless they are accessible for complete cleaning and painting. If structural shapes, plates, and bolts enter or are supported by masonry or concrete, the joint between the metal and masonry or concrete shall be flashed with asphalt. (This does not refer to base plates under columns.)

2206. Bearing on Foundations. The pressure in pounds per square inch of column base plates or steel footings on foundations shall not exceed the following:

Portland Cement Concrete 2500 lbs.	625
Portland Cement Concrete 3000 lbs.	750

2207. Soil Bearing Pressures.

a. Foundations are normally designed for a bearing pressure of 4,000 lbs. per sq. ft. If reliable soil data or experience is not already available, or if the bearing pressure is to be more than 4,000 lbs. per sq. ft., the conditions beneath the foundations shall be determined by adequate subsoil investigation. Such investigations shall include test borings made by or under the supervision of an experienced soils engineer or soils testing laboratory, and to the depth necessary to determine the adequacy of the support (usually 20 to 30 ft. minimum).

b. The foundations shall be designed to carry the maximum loads without excessive settlement. If wooden piles are used above permanent low ground water level, they shall be creosoted by the empty cell process with a 12-lb.-per-cu.-ft. retention of creosote applied to the standard specifications of the American Wood Preservers' Association.

c. Foundations shall not be constructed over buried pipes or immediately adjacent to existing or former deep excavations unless the foundation bases go below the excavation. The soil pressure in tons per square foot shall not exceed the following:

Ordinary clay or sand	2
Compact dry clay or coarse sand	4
Compact sand and gravel	5
Shale rock	8
Hard rock	20

2208. Center Pier. In addition to the weight of the water in a large plate riser, the weight of the column of water directly above the riser in the tank, and the weight of the steel plate, the center pier shall be considered as supporting a hollow cylinder of water in the tank. If the hemispherical or ellipsoidal bottom is rigidly attached to the top of the large riser by a flat horizontal diaphragm plate, the hollow cylinder shall have an outside radius equal to the radius of the riser at the tank bottom plus one-half the distance from the edge of the riser to the connection at bottom plates. The inside radius of the hollow cylinder shall be equal to the radius of the riser at the tank bottom. If the hemispherical or ellipsoidal shape is continuous to the large riser, without a flat horizontal diaphragm plate, the outside radius of the hollow cylinder shall be 2 ft. greater than the radius of the riser at the tank bottom.

Section 23—Supporting Buildings.

2301. General.

a. When the tank is erected over a building, it shall be supported by the walls of a stair or elevator tower when possible, otherwise it may be supported on the building walls and interior building columns. Supporting buildings shall be reinforced concrete, steel frame, or brick or stone masonry, carefully designed to resist all loads resulting from the tank structure.

b. The adequacy of an existing building to carry the tank and wind loads shall be determined by a competent local consulting engineer. Frequently the tank contract excludes all responsibility for the strength of the supporting building and soil or pile carrying capacities.

c. In addition to the vertical load due to dead and live loads and overturning forces due to wind, the horizontal load shall be carefully considered. This includes the total horizontal shear at the base of the structure due to wind.

d. Bearing plates shall be of sufficient thickness to distribute the load to the masonry without overstressing. The method of calculation used in the current "Steel Construction" handbook of the American Institute of Steel Construction is suggested.

2302. Concrete Building. The design of a reinforced concrete building supporting a tank structure should preferably conform with the specifications of the American Concrete Institute.

2303. Steel-Frame Building. The design of a steel building (not exposed steel towers) supporting a tank structure should preferably conform to the current Building Specifications of the American Institute of Steel Construction. Steel columns used as supports for a tank and the beams directly connected to the columns shall be fireproofed throughout their length with not less than 2 inches of concrete.

2304. Brick Supporting Walls.

a. Brick walls supporting tank structures shall be adequately designed to carry all loads to the soil. They shall be not less than 12 in. in thickness and free from cracks. The bricks shall be laid in portland cement mortar. "T" or angle walls shall not be used for tank supports, the recommended construction being rectangular walls with well-bonded corners. Each column-base or beam shall rest on a footing consisting of steel or reinforced concrete beams.

b. For steel footings two or more I-beams, not smaller than 6-inch, securely tied together, should ordinarily be used. The footing shall be carefully levelled on a layer of unset portland cement mortar thicker than any projecting metal so as to give a uniform and complete bearing on the parts of the wall to be loaded. The space between footing beams shall be filled with portland cement mortar. If the footings are placed over openings in brick walls, when the opening is of such dimensions or so located that there is a possibility of the wall cracking under the footing, the beams on top of the walls shall be of sufficient strength and length to transmit the entire load to the walls on each side. Cement mortar shall consist of one part portland cement to three parts clean sand.

2305. Anchorage.

a. The anchorage of tank towers to supporting buildings shall be designed to resist the maximum net uplift in the column under consideration with the tank empty and the wind load on the structure, as specified in previous articles.

b. Anchors shall engage a weight of not less than 1½ times the maximum net uplift and shall be designed to prevent movement of the tower in any direction.

c. If located on brick walls the tower column shall be anchored to the wall either by bolts deeply embedded and connected at the lower end to a plate or beam, or by structural shapes extending down the sides of the walls and connected thereto by through bolts. If desired, the column base plates may be bolted to steel footings and the latter to the brick walls as specified.

d. The minimum size of anchor bolts, when not replaceable, shall be 1¼-in. Expansion bolts are not acceptable.

2306. Bearing Pressures. The pressures in pounds per square inch of column base-plates or steel footing-beams on supports shall not exceed the following:

Portland Cement Concrete	2000 lbs.	500
" " "	2500 lbs.	625
" " "	3000 lbs.	750
Sandstone (first class)		400
Limestone (first class)		500
Granite (first class)		600
Brickwork with Portland Cement mortar		175

APPROVAL.

Section 24—Approval.

2401. **Plans.** The contractor shall furnish stress sheets and plans required by the purchaser and the authority having jurisdiction for approval or for obtaining building permits and licenses for erection of the structure.

2402. **Facilities for Inspection.** Material and workmanship shall at all times be subject to the inspection of engineers representing the purchaser.

2403. **Engineer's Authority.** The engineer shall have the power to reject materials and workmanship which do not conform to this standard, but in case of dispute, the contractor may appeal to the authority having jurisdiction.

2404. **Rejection.** The acceptance of any material or finished members by the engineer shall not be a bar to their subsequent rejection if they are found to be defective. Rejected material and workmanship shall be replaced promptly or made good by the contractor.

2405. **Liability.** Upon completion of a tank construction contract, and having tested the tank and made it watertight, the tank manufacturer should notify the authority having jurisdiction so that the tank can be inspected and given the formal approval necessary.

2406. **Cleaning Up.** Upon completion of the work, the contractor 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.

PIPE CONNECTIONS AND FITTINGS.

Section 25—General Information.

2501. Watertight Intersections at Roofs and Floors.

a. The intersections of all tank pipes with roofs and concrete or waterproof floors of buildings shall be watertight. Where tank pipes pass through concrete roofs a watertight intersection shall be obtained by fittings calked with oakum or by pouring the concrete solidly around the pipes each of which has first been wrapped with two or three thicknesses of building paper. If concrete is used, the upper side of the intersection should then be well flashed with asphalt. Wooden roofs shall also be built tightly around the pipes and made watertight by fittings calked with oakum or by adequate flashing.

b. Where tank pipes pass through a concrete or waterproof floor, a watertight intersection, as described above, shall be obtained so that water from above cannot follow down the pipe to lower floors or the basement.

2502. Rigid Connections. Rigid connections to steel tanks should be made by means of threaded flanges riveted or bolted to the tank plates or by couplings welded to the plates. Couplings welded to the tank plates shall be of extra heavy weight. Adequate welding shall be applied to both sides of the tank plate. A rigid connection to a wooden tank should be made by means of a running nipple or by threaded flanges, one inside and one outside the tank, bolted together through the wood with movable nuts outside. Lead washers shall be placed under bolt heads, and rubber gaskets under flanges, except for hot-water or steam pipes, which shall have lead gaskets.

2503. Placing Tank in Service. All tank piping should be done immediately after completion of the tank and tower so that the tank can be filled and placed in service promptly. Wooden tanks may be greatly damaged by shrinkage if left empty after being erected.

2504. The Contract. To ensure installation of an adequate equipment the contract should definitely specify that the finished work shall conform with this standard in all respects.

2505. Approval of Layouts. Complete information regarding the tank piping on the tank side of the connection to the yard or sprinkler system shall be submitted to the authority having jurisdiction for approval. This should preferably be by a sketch submitted in quadruple, but may, if the arrangement is standard as illustrated in this Standard, be in written form. In either case the information submitted should include the size and arrangement of all pipes; the size, location and type of all valves, tank-heater and other accessories; the steam pressures available at the heater; the arrangement of, and full information regarding the steam supply and return systems together with pipe sizes; and the details of construction of the frost-proof casing.

2506. Inspection of Completed Equipments. Immediately after the work is finished, a joint inspection of the tank piping should be made by a representative of the contractor and a representative of the owner.

Written reports of these inspections should be made in triplicate and a copy signed by the contractor and the owner should be sent to the authority having jurisdiction.

This joint inspection will provide reasonable assurance that there are no defects in the work of sufficient importance to prevent the system being put immediately into service. It will also make the owner's representatives more familiar with the system.

2507. Care and Maintenance. A tank and its piping constitute an important part of the fire protective equipment and should be carefully maintained to ensure reliability. Weekly inspections should be made to determine that controlling valves are wide open and sealed. A thorough annual inspection of the entire equipment, tank and tower, piping, controlling valves, check valve, heating system, mercury gage, expansion joint and all other accessories should be made to make sure that everything is in good repair. At times of cleaning or painting the tank or making repairs it should be ascertained that the tank is free of foreign material and all piping clear of obstructions before placing the tank in service again. The heating system should be given daily supervision during freezing weather. The expansion joint should be repacked and adjusted if it binds or develops leaks. Ice should not be permitted to form either inside or outside of the equipment.

2508. **Precautions During Repairs.** Whenever the tank is drained the authority having jurisdiction should be notified well in advance and the following precautions should be observed:

(1) Plan work carefully to enable completion in the shortest possible time.

(2) If available a second reasonably reliable supply with constant suitable pressure and volume, usually public water, should be connected to the system.

(3) If such a supply is not available, the fire pump, if any, should be turned over constantly, preferably using an automatic governor, to maintain suitable pressure in the system and a man should be constantly prepared to operate the pump at full capacity in case of fire.

(4) Additional fire pails and extinguishers should be placed in buildings where protection is impaired and extra, well-instructed watchmen should be continuously on duty.

(5) The members of the private fire brigade as well as the public fire department should be familiar with conditions.

2509. **Heater Thermometer.** One of the chief advantages of the gravity circulation system of heating tanks is the fact that it permits convenient observation of the temperature of the coldest water at a thermometer located in the cold-water return-pipe near the heater. Failure to provide an accurate thermometer at this point or to observe it daily and keep it registering the proper temperature is to forfeit this advantage and may result in freezing the equipment.

a. For a gravity circulating heating system (Figures 8, 9, 10, 11, 15, 16 and 18A) an accurate thermometer shall be located as specified in Article 3515.

b. For a tank containing a radiator steam heater or with an independently fired water heater, an accurate socket thermometer shall be located as specified in Article 3523.

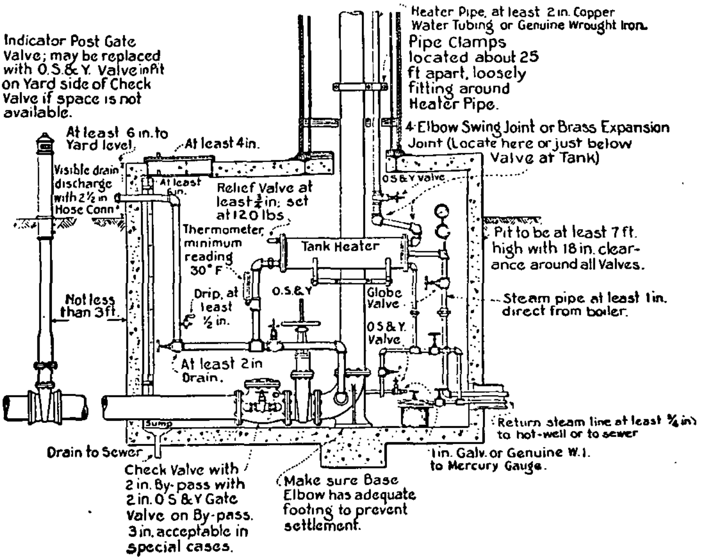


Fig. 8. Valve Pit and Tank Connections at Base of Riser.

2510. Connections For Use Other Than Fire Protection. Water for other than fire protection purposes should not ordinarily be drawn from the tank. Circulation of water through the tank causes an accumulation of sediment that may obstruct the piping or sprinklers and moreover, such circulation causes corrosion of steel tanks and rotting of wooden ones. A leak or break in a pipe for use other than fire protection may seriously impair the fire protection by partly or completely draining the elevated tank.

2511. Filling. The tank should be kept well filled, never allowing the water level to be lower than 3 or 4 in. below the overflow. The filling bypass should be kept closed when not in use even if the tank is filled by a fire pump since in case of fire an open bypass would result in loss of water otherwise needed.

2512. Mercury Gage. The approved mercury gage is considered the most reliable water-level indicator for elevated tanks. The gage should be carefully installed and adjusted and then properly maintained as described in Section 32. A mercury catcher should be provided at the top of the gage glass if there is any probability that mercury may be blown out because of fluctuating water pressure.

2513. Frost-Proof Casing. The frost-proof casing should be kept in good repair and air-tight throughout. Its insulating qualities are greatly impaired if joints spring open or if the casing settles away from the tank or if rotting occurs around the base.

2514. Tanks with Large Risers. Large steel plate riser pipes, three feet or more in diameter without frost-proof casing, are acceptable if properly heated. (See Article 3523.) The fire hazard and upkeep of the frost casing and provision of an expansion joint or walkway are avoided. On the other hand, painting and heating of the large riser and building of the stronger and larger valve pit costs more than for equipments with the smaller risers.

The check valve and gates in the discharge pipe, filling arrangement, overflow, drain and mercury gage are generally provided and sometimes a blow-off valve is furnished near the base of the large riser. A manhole at least 12 in. by 16 in. shall be provided with its lower edge level with the discharge piping protection specified in Article 2515.

2515. Discharge Piping Protection. For tanks with a large steel plate riser (3 ft. diameter or larger), the inlet to the vertical discharge pipe located within the large riser shall be protected against entry of foreign material. This may be done with an American Standards Association 125 lb. flanged Tee with the "run" of the reducing Tee placed horizontal and with horizontal outlets one pipe size smaller than the discharge pipe or with a fabricated plate extending at least 4 in. beyond the outside diameter of the pipe. The plate shall be supported by at least three supporting bars 1½ in. x ¼ in., ⅝ in. round rods or equivalent which elevate all portions of the plate a distance at least equal to the pipe diameter above the discharge pipe inlet. Attachments of the supports to the discharge pipe may be directly by welding or bolting or by a ¼ in. thick tightly fitting sectional clamp or collar having ⅝ in. bolts in the outstanding legs of the clamps or collar. A clearance of at least 6 in. shall be provided between all portions of the flanges of a Tee or fabricated plate and the large riser plate.

Section 26—Discharge Pipe.

2601. At Roofs and Floors. The intersection of the discharge pipe, as well as all other tank pipes, with the roof or waterproof or concrete floors shall be watertight. (See Article 2501.)

2602. Size. Conditions at each individual plant influence the size of discharge pipe needed. The diameter, however, shall not be less than 6 in. for tanks up to and including 25,000 gallons capacity and generally not less than 8 in. for 30,000 to 100,000 gallons inclusive or 10 in. for greater capacities.

Smaller pipe than specified above (not less than 6 in.) may be permitted in some cases if conditions are favorable and large flows of water not needed. On the other hand, larger pipe may be required because of the location and arrangement of piping, height of buildings or other conditions. In all cases approval of the pipe sizes shall be obtained from the authority having jurisdiction.

2603. Kind of Pipe and Gaskets. The discharge pipe shall be flanged cast-iron or steel pipe, welded steel, or of approved corrosion-resistant materials with flanged or welded connections except that for steel-plate risers, standpipes, or suction tanks the short length of vertical pipe from the base elbow through the bottom plate may be of cast-iron with spigot at the lower end. If flanges are used, copper, lead, or good-quality rubber gaskets shall be placed between the flanges.

2604. Braces. The pipe and/or large steel plate riser pipe shall be braced laterally by rods not less than 5/8 in. in diameter, connected to the tower columns near each panel point. End connections of braces shall be by eyes or shackles; open hooks are not permitted.

2605. Support. The discharge pipe shall be supported at its base by a double-flanged base elbow resting on a concrete or masonry foundation, except that for tanks with steel plate risers or for suction tanks or standpipes the base elbow may have bell ends. A leaded joint at the connection of yard piping to the base elbow shall be strapped or the base elbow adequately backed up by concrete. If the discharge pipe is offset inside of a building, it shall be supported at the offset by suitable hangers from the roof or floors, in which case the base elbow may not be required. Large steel riser pipes shall be supported on a reinforced concrete pier designed to support the load specified in Article 3304. Concrete grout shall be provided beneath the large riser to give uniform bearing when empty.

2606. Offsets. The discharge pipe outside of buildings shall extend vertically to the base elbow or building roof without offsets if possible. If an offset is unavoidable it shall be supported at the offsetting elbows and at intermediate points not over 12 ft. apart and shall also be rigidly braced laterally. The supports shall consist of steel beams across the tower struts or of steel rods from the tower columns so arranged that there will be no slipping or loosening.

2607. Expansion Joint. Tanks with flanged or welded pipe risers (12 in. diameter and under) shall have an approved expansion joint on the fire-service discharge pipe, when the tank is on a tower which elevates the bottom 30 ft. or more above the base elbow or any offset in the discharge pipe. Expansion joints should be built to conform to Section 27.

2608. Rigid Connection.

a. When the distance between the tank bottom and the base elbow or supporting hanger is less than 30 ft. the discharge pipe may be connected rigidly to the tank bottom by means of riveted or bolted flanges, or by welded coupling of extra heavy weight with adequate welding both sides of the tank plate. If bolts are used, the nuts shall be placed on the outside of the tank and lead washers and approved packing shall be used under bolt heads and flanges, respectively. The top of the pipe (or fitting attached to the top) shall extend above the inside of the tank bottom or base of a steel plate riser to form a settling basin.

b. The top of a steel plate riser shall be connected rigidly to the suspended bottom of the tank. The discharge pipe from a steel plate riser of a tank over a building shall be connected rigidly to the base of the large riser. A rigid flanged connection or welded joint or a leaded joint may be used between the discharge pipe and the bottom of a suction tank or standpipe or the base of a steel plate riser of a tank on an independent tower, but if a rigid connection is contemplated, special approval of details shall be obtained from the authority having jurisdiction. When the base of a steel plate riser is in its final position on a concrete support, it shall be grouted to obtain complete bearing.

2609. Swing Joints. If the vertical length of discharge pipe below an offset either inside or outside of a building is 30 ft. or more, a four-elbow swing joint, of which the offset forms a part, shall be provided in the pipe.

2610. Settling Basin. The depth of the settling basin in the tank bottom shall be 4 in. for a flat-bottom tank and 18 in. for a suspended-bottom tank. The settling basin at the base of a large steel plate riser shall be at least 3 ft. deep.

2611. Check Valve. An approved check valve shall be placed horizontally in the discharge pipe and shall be located in a pit under the tank when the tank is on an independent tower. (See Figure 8.) When the tank is located over a building, the check valve shall ordinarily be placed in a pit, preferably outside the building. (See Figure 9.) When yard room is not available, the check valve may be located on the ground floor or in the basement of a building provided that it is adequately protected against breakage. The check valve should ordinarily be bossed, drilled and tapped for a filling bypass.

2612. Controlling Valves.

a. An approved gate valve, generally with an indicator post, shall be placed in the discharge pipe on the yard side of the check valve between the check valve and any connection of the tank discharge to other piping. (Figure 8.) If yard room for an indicator post is not available, an approved outside screw and yoke gate valve similarly arranged, but inside of the valve pit or room, may be used.

b. An approved outside screw and yoke gate valve shall be placed in the discharge pipe on the tank side of the check valve. (Figure 8.) If the tank is on an independent tower this valve shall be placed in the pit with the check valve preferably on the yard side of the base elbow. If the tank is located over a building the valve shall be placed under the roof near the point where the discharge pipe enters the building. (Figure 9.)

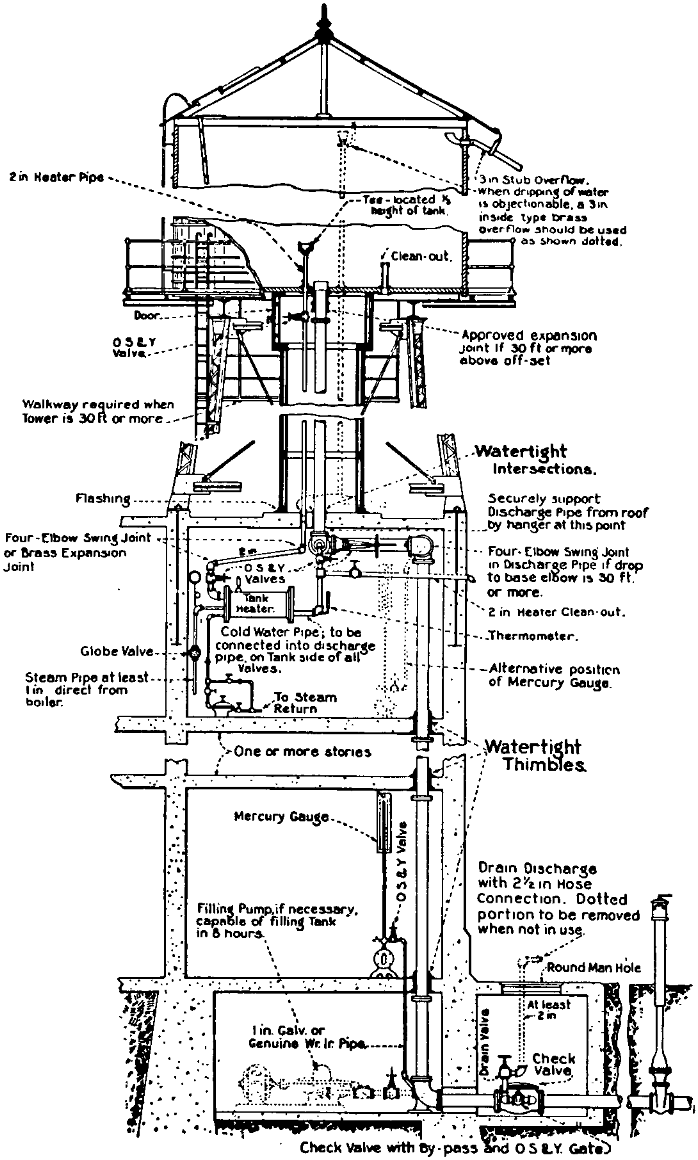


Fig. 9. Connections for Tank Located Over Building.

Section 27—Expansion Joint.

2701. **Connection to Tank.** An approved expansion joint shall be connected to the tank bottom when required by Article 2607, using bolts or rivets for a steel tank and bolts or a special screw fitting for a wooden tank. The connection shall be permanently watertight using lead washers under bolt heads and a lead gasket between the flange and steel tank plate if bolts are used. Rubber gaskets may be used between the flanges and the bottom of a wooden tank if a special screw fitting is used. Riveted connections must be made watertight by calking. The movable nuts on bolts shall be on the outside of the tank.

2702. **General Design.** The design shall be such that the joint will operate reliably over periods of years without attention and shall be of adequate strength to resist the stresses and corrosion to which it will be subjected. One or both of two parts that slide, one upon the other, shall be brass or other noncorrodible metal of ample strength and wearing qualities.

2703. **Clearances.** At least 1/16-in. clearance shall be provided around all movable parts to prevent binding and at least ½-in. between the cast-iron body and an iron or steel slip-tube.

2704. **Body Casting.** The body shall be cast iron with a settling-basin extension of proper length (See Article 2610); preferably cast integrally. Provision shall be made for a packing space of adequate size. (See Article 2707.)

2705. **Gland.** The adjustable gland shall be brass or iron and must be connected to the body casting preferably with four standard bolts at least ⅝-in. in size and of sufficient length to permit full adjustment.

2706. **Slip-Tube.** The sliding tube at the top of the discharge pipe shall be brass or iron with triple plated brass outer surface, if the gland is iron. If the gland is brass, the slip-tube may be cast-iron or wrought pipe, but in this case the top of the packing space shall be formed with brass and a clearance of at least ½-inch must be provided at all points between the cast-iron body and the slip-tube. The upper part of the slip-tube shall be machined over a length such that the top of the gland can be dropped to 6 inches below the bottom of the body casting so as to permit repacking. The top of the slip-tube shall be located about 5 in. below the top of 4-in. settling-basin extensions and 12 in. below the top of 18-in. settling-basin extensions.

2707. **Packing.** The packing shall consist of asbestos wicking saturated with rape oil and graphite or an equally suitable material. Packing at least 2 in. deep and one-half inch thick shall be provided in the packing space.

2708. **Connections For Use Other Than Fire Protection.** Connections for use other than fire protection should preferably not be made but when unavoidable, they shall be connected rigidly to the tank bottom and a standard expansion joint if needed shall be provided in each such pipe below and entirely independent of the tank.

Section 28—Filling.

2801. **Bypass Around Check Valve.** When the tank is to be filled from the fire protection system under city or fire-pump pressure, the filling pipe shall preferably be a bypass around the check valve. (Figures 8 and 9.) The bypass shall be connected into tapped bosses on the check valve or into the discharge pipe between the check valve and all other valves. The bypass should ordinarily be 2 in., but 2½-in. and 3-in. sizes may be permitted under special conditions provided that approval is first obtained from the authority having jurisdiction. An approved outside screw and yoke gate valve shall be placed in the bypass and kept closed except when the tank is being filled.

2802. **Filling Pumps.** When the tank is to be filled by a special filling pumps, the pump and connections shall be of such size that the tank can be filled in 8 hours. The filling pipe shall be at least 2 in. in diameter and may, except as noted in Article 2803, be connected directly into the tank discharge pipe, in which case an approved outside screw and yoke gate valve and a check valve shall be placed in the filling pipe near the tank discharge pipe, the check valve being on the pump side of the gate valve. The filling-pump suction-pipe shall not be connected to a fire-service main supplied from the tank. The filling valve should be open only when the tank is being filled.

2803. **Filling from Drinking-Water Supply.** When the water in the fire protection system is not suitable for drinking purposes, and the tank is filled from a drinking-water supply, the filling pipe shall be extended up separately inside the frost-proof casing to discharge through a return bend above the maximum water level. If the pipe extends through the bottom of the tank, the portion inside the tank shall be of brass securely braced. An approved outside screw and yoke gate valve, a check valve and a drip valve shall be placed in the filling pipe.

2804. **Filling Pipe at Roof and Floors.** The intersection of a separate filling pipe with a roof or waterproof or concrete floors shall be watertight. (See Article 2501.)

2805. **Corrosive Water.** If the tank is filled with water which corrodes steel pipes rapidly, the filling pipe shall be of brass or genuine wrought iron.

Section 29—Overflow.

2901. **Size.** The overflow pipe shall be of adequate capacity for operating conditions and shall be not less than 3 in. in diameter throughout.

2902. **Inlet.** The inlet of the overflow pipe shall be located at least 1 in. below the bottom of the spider-rod holes in a steel tank or the flat-cover joists in a wooden tank, but never closer than 2 in. to the top of the tank, and shall consist of a special funnel or reducing coupling at least 5 in. in largest internal diameter. The inlet shall be arranged so that the flow of water is in no way retarded by the tank spider or other obstruction.

2903. **Stub Pipe.** When dripping of water or small accumulation of ice is not objectionable, the overflow may, by the choice of the owner, pass through the side of the tank near the top. (Figures 10 and 11.) The pipe shall be extended with slight downward pitch to discharge beyond the tank or balcony and away from the ladders, and shall be adequately supported. Vertical extensions of the pipe to the balcony or below are not recommended because they often become plugged with ice.

2904. **Inside Pipe.** When a stub pipe is undesirable, the overflow pipe shall extend down through the tank bottom and inside the frost-proof casing or steel plate riser, discharging through the casing near the ground or roof level. The section of the pipe inside the tank shall be of brass except in the case of tanks with steel plate risers, where overflow pipes 3½ in. or larger may be of extra heavy genuine wrought iron or of flanged cast-iron pipe. Inside overflow pipes shall be braced at points not over 25 ft. apart to tank and riser plates by substantial clamps. The discharge shall be visible and the pipe pitched to drain. If the discharge is exposed the exposed length shall not exceed 4 ft. and shall avoid the entrance to the valve pit or house.

Section 30—Clean-Out and Drain.

3001. **Handhole.** A standard handhole with a minimum dimension of 3 in. or a manhole shall be provided in the saucer plate, outside of the frost-proof casing, at the bottom of an elevated steel tank with a suspended bottom (Figure 11), unless the tank has a large riser pipe 3 ft. or more in diameter.

3002. **Shell Manhole.** A circular manhole 24 in. in diameter or an elliptical manhole 18 by 22 in. minimum size, with cover hinged to shell, shall be furnished in the first ring of the suction tank shell at a location to be designated by the purchaser.

3003. **For Elevated Flat Bottom Tanks.** At least a 2-in. clean-out shall also be provided outside of the frost-proof casing, in the bottom of a wooden tank or a flat bottom steel tank, when elevated. For wooden tanks, the clean-out connection should consist of a special screw fitting with gasket or a pair of 2 in. flanges. The fitting inside the tank should be installed with its top flush with the top surface of the bottom planks. For steel tanks, the connection should consist of an extra-heavy coupling welded to the tank shell, with its top flush with the inside surface at the bottom plates. The coupling should be welded to both sides of the tank plates. A piece of 2 in. brass pipe about 5 in. long, capped at the top with a brass cap, shall be screwed into the inner fitting or flange. The clean-out shall be watertight. (See Figure 10.)

3004. **Riser Drain.**

a. A drain pipe at least 2 in. in diameter fitted with a reliable controlling valve and a ½-in. drip valve shall be connected into the tank discharge-pipe near its base, and when possible on the tank side of all valves. If the outlet is an open end it shall be fitted with a 2½-in. hose connection unless it discharges into a funnel or cistern piped to a sewer. If the drain is piped directly to a sewer, a sight glass or a ¾-in. test valve on the underside of the pipe shall be provided. If the drain pipe is to be used for a hose stream the controlling valve shall be an approved gate or angle valve.

b. When a circulation tank-heater is located near the base of the tank riser the drain pipe shall, if possible, be connected from the cold-water return-pipe between the cold-water valve and the heater to permit flushing water from the tank through the hot-water pipe, heater and drain for clean-out purposes. (See Article 3515 and Figure 8.)

Section 31 — Connections For Other Than Fire Protection.

3101. Dual Service Tanks. The use of an elevated tank in part for other than fire protection purposes is not advised. Frequent circulation of the water results in an accumulation of sediment which may obstruct the piping or sprinklers and a fluctuating water level hastens decaying of wood and corrosion of steel. In the few cases where dual service is necessary an adequate supply of water shall be constantly and automatically reserved in the tank for fire protection purposes.

3102. Pipe For Other Than Fire Protection Purposes. The pipe for other than fire protection purposes shall be entirely separate from fire service pipes and shall extend to an elevation inside the tank below which an adequate quantity of water will be constantly retained for fire protection. The pipe for other than fire protection purposes inside the tank shall be brass except that genuine wrought iron may be used if the pipe is larger than 3 in. or cast iron if 6 in. or larger. The pipe inside the tank shall be braced near the top and at points not over 25 ft. apart. The expansion joint, if there is one, shall be of standard type, below the tank without connection to the tank plates. (See Article 2708.)

3103. At Roofs and Floors. Just as for other tank piping the intersection of a pipe for other than fire protection purposes, with a building roof or waterproof or concrete floor, shall be watertight. (See Article 2501.)

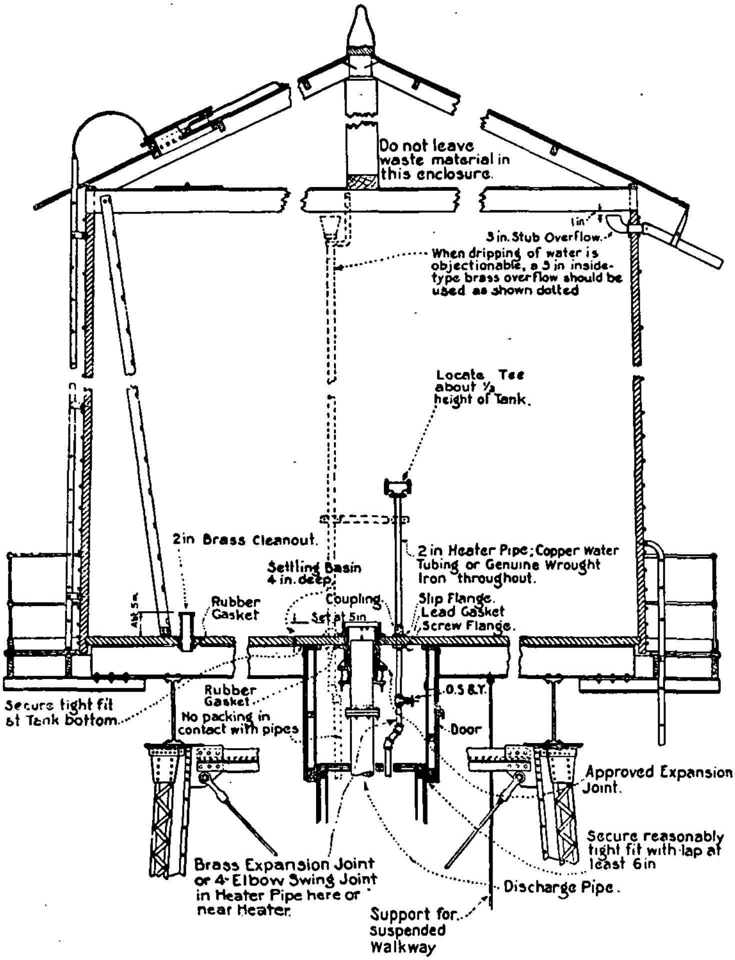


Fig. 10. Typical Tower-Supported Wooden Tank.

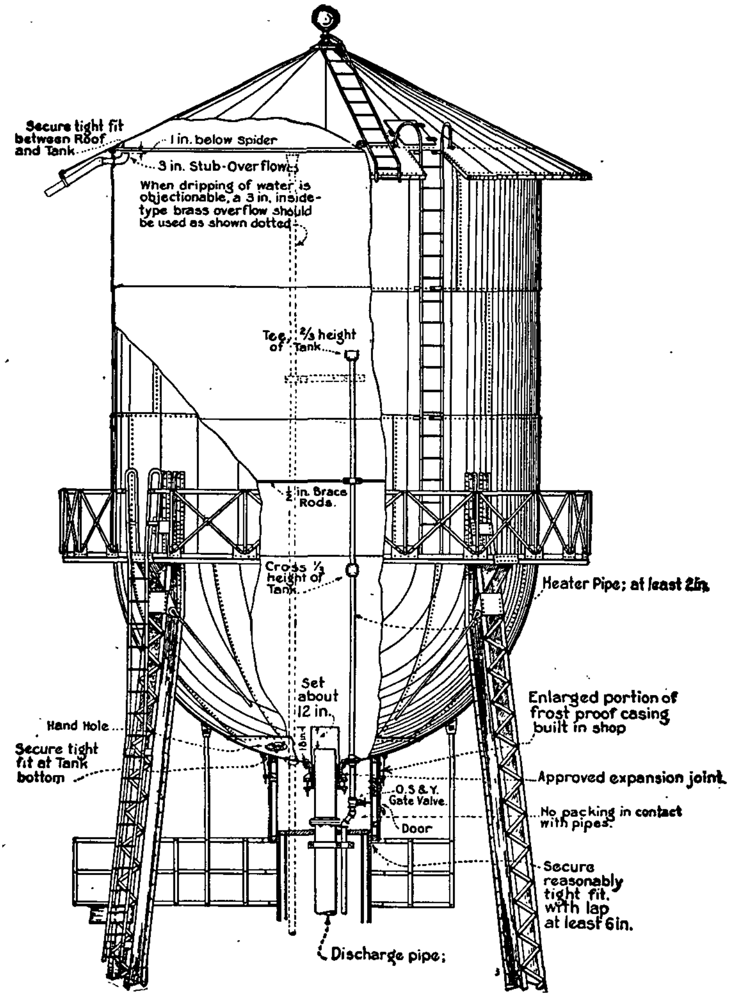


Fig. 11. Typical Tower-Supported Hemispherical-Bottom Riveted Steel Tank.

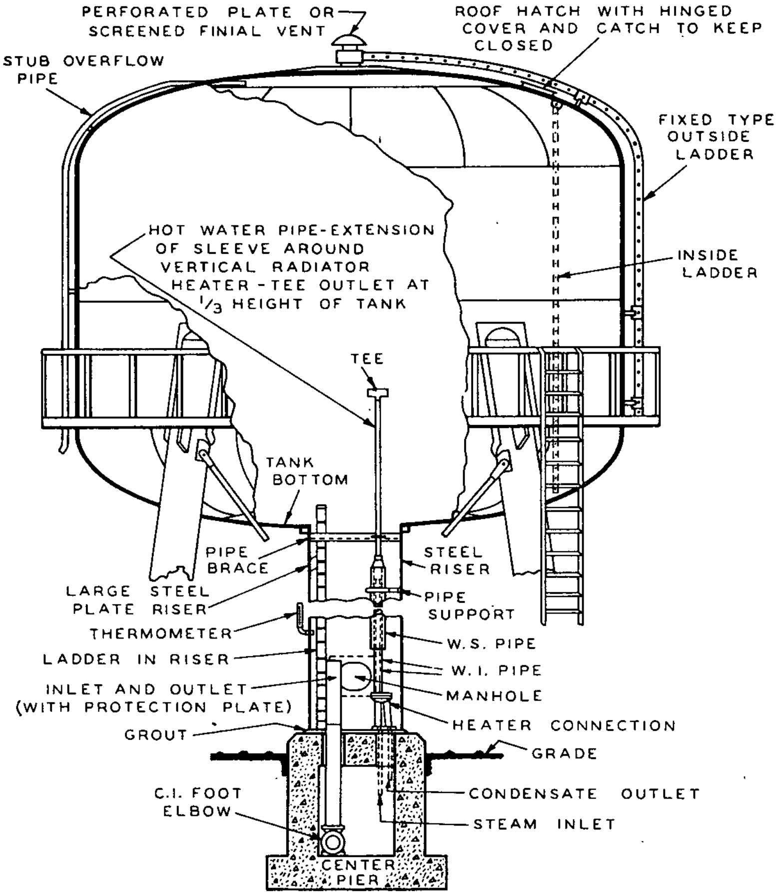


Fig. 11a. Typical Tower-Supported Double Ellipsoidal Tank.

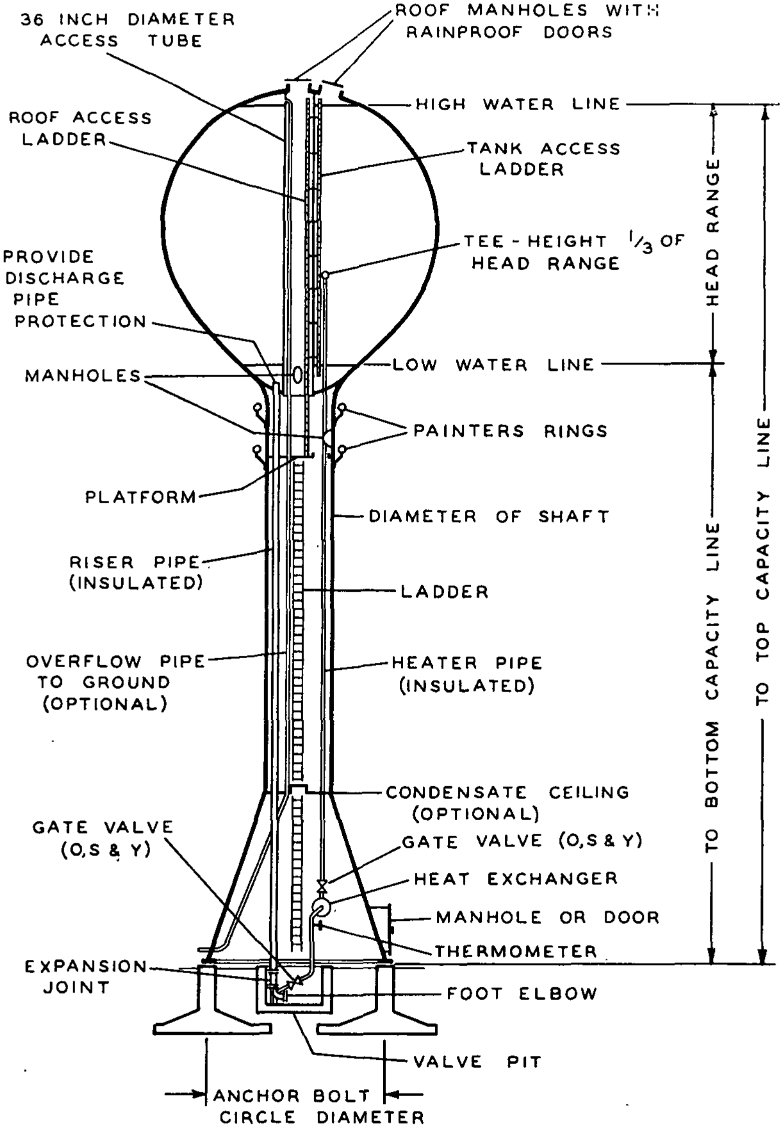


Fig. 11b. Typical Pedestal Tank.

Section 32—Telltale.

3201. **General.** An approved mercury gage constructed as shown in Figure 12 shall be provided to indicate the depth of water in the tank, except that an approved closed circuit, high and low electrical alarm may be required by the authority having jurisdiction in place of the mercury gage, in which case the standard for protective signaling systems shall be followed.

3202. **Mercury Gage Materials.** Pipe and fittings containing mercury shall be iron or steel. Brass, copper or galvanized parts, if in contact with mercury, are amalgamated and leaks will result.

3203. **Water Pipe.** The water pipe to the mercury gage shall be 1-in. galvanized throughout, and connected into the discharge pipe on the tank side of the check valve. If possible the pipe shall be short and run with a continual upward pitch toward the tank piping without air pockets to avoid false readings. The pipe shall be buried well below the frost line, or be located in a heated conduit.

3204. **Valves.** The valve at the mercury gage shall be an approved outside screw and yoke gate valve. An additional approved outside screw and yoke gate valve shall be installed close to the discharge pipe when the distance to the mercury gage exceeds 50 feet.

3205. **Mercury Catcher.** Occasionally, fluctuating water-pressures require a mercury catcher at the top of the gage glass as shown in Figure 12, to prevent loss of mercury. The catcher is not a standard part of the equipment and is not furnished by the gage manufacturer unless especially ordered.

3206. **Extension Piece.** If the mercury catcher is not needed it can be replaced by about a 3-foot extension of ⅛-inch pipe, vented at the top.

3207. **Water-Drain Plug.** A plugged Tee shown at "G" in Figure 12 shall be provided in the mercury pipe between the mercury pot and the gage glass to permit draining off water which sometimes accumulates on top of the mercury column.

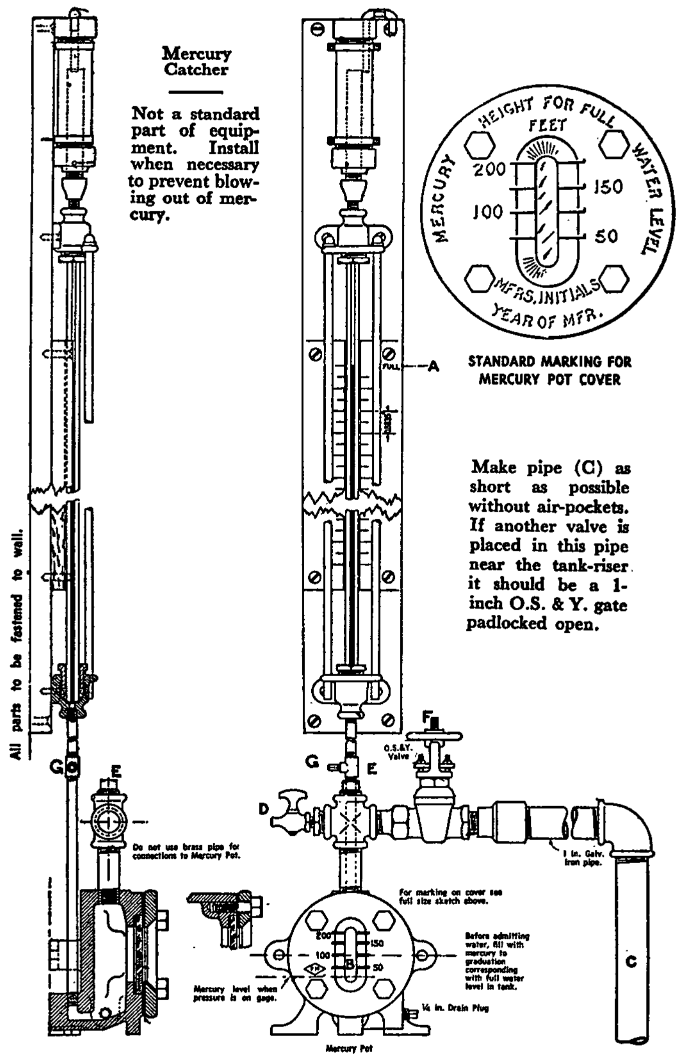


Fig. 12. Mercury Gage.

3208. Location. The gage shall be installed in a heated room such as a boiler-room, engine-room or office, where it will be readily accessible for reading, testing and maintenance. It shall be so located that it is not liable to become injured or broken.

The column of mercury from the mercury pot to the top will be roughly one-thirteenth the height from the mercury pot to the top of the tank. This fact should be borne in mind when planning a location for the instrument.

3209. Cleaning. Before installing the gage, remove all grease, dirt and moisture from the pot and piping that will contain mercury and be sure that the mercury itself is clean. Carbon tetrachloride or warm water containing a small amount of washing soda are good cleaning materials.

3210. Installing. The gage shall be accurately installed so that when the tank is filled to the level of the overflow, the mercury level is opposite the "FULL" mark on the gage board. The following procedure is advised.

a. Choose a suitable location as explained in Article 3208. The height of the top of the scale above the center of the mercury pot will be approximately the height of the top of the tank above the pot, divided by 13.6 (the specific gravity of mercury). About three additional feet of clearance should be allowed over the top of the scale.

b. Having located the top of the scale as above, set up the instrument as indicated in Figure 12 and so oriented that test cock "D" will be in a convenient position for testing with the scale board in plain sight and so that a little water from the test cock will not do any harm. Complete the water connections.

c. Remove plug "E" and with valve "F" closed, fill the pot with mercury to the mark on the cover corresponding to the height above the pot of the full water-level in the tank. Replace plug "E."

d. Being sure that the tank is full to the top of the overflow open cock "D" then valve "F" leaving cock "D" open until all air is blown out and water flows freely. Then close cock "D."

e. Finally, adjust the scale board so the "FULL" mark comes opposite the top of the mercury column, the tank being full to the top of the overflow. Secure the scale board firmly in place. Leave valve "F" open unless the gage is subjected to heavy fluctuations of pressure.

3211. Testing. To determine that it is accurate, the instrument should be tested occasionally as follows: *(References are to Fig. 12.)*

a. Overflow the tank.

b. Close valve "F." Open test cock "D." The mercury should quickly drop into the mercury pot. If it does not there is an obstruction which must be removed from the pipe or pot between the test cock and the gage glass.

c. If the mercury does lower at once as it should, close cock "D" and open valve "F." If the mercury responds immediately and comes to rest promptly opposite the "FULL" mark on the gage board the instrument is all right.

d. If the mercury column does not respond promptly and read correctly during the above test, there are probably air-pockets or possibly obstructions in the water-connecting pipe. Open cock "D." Water should flow out forcibly. Permit water to flow through cock "D" until all air is expelled and rusty water from the tank riser appears. Then close "D." The gage should now read correctly. If air separates from the water in the 1-in. pipe due to being enclosed in a buried tile conduit with steam pipes, the air can be automatically removed by installing a ¾-in. air trap at the high point of the piping. The air trap can usually be best installed in a Tee connected by a short piece of pipe at "E," with a plug in the top of the Tee so that mercury can be added in the future if necessary, without removing the trap. If there are inaccessible pockets in the piping, as below grade or under concrete floors, the air can be removed only through petcock "D."

e. If in test (d) the water does not flow forcibly through cock "D" there is an obstruction which must be removed from the outlet of the test cock or from the waterpipe between the test cock and the tank riser.

f. If there is water on top of the mercury column in the gage glass it will cause inaccurate readings and must be removed. First lower the mercury into the pot as in test (b). Close cock "D" and remove plug "G." Open valve "F" very slowly causing mercury to rise slowly and water above it to drain through "G." Close valve "F" quickly when mercury appears at "G" but have a receptacle ready to catch any mercury that may drain out. Replace plug "G." Replace any escaped mercury in the pot as in 3210 (c).

g. After testing leave valve "F" open, except as noted in Article 3212.

3212. **Excessive Water Pressures.** If found necessary, to prevent forcing mercury and water into the mercury catcher, the controlling valve marked "F" may be closed when filling the tank, but should be left open after the tank is filled, except when the gage is subjected to continual fluctuation of pressure, when it may be necessary to keep the gage shut off except when reading. Otherwise it may be necessary to frequently remove water from the top of the mercury column as in Article 3211 (f).

VALVE ENCLOSURES AND FROST PROTECTION.

Section 33—Valve Pit or House and Heater House.

3301. General. When the tank is on an independent tower, a valve pit or house shall be built at the base of the discharge pipe to house the valves, tank heater and other fittings. If a large valve pit below grade is provided it can contain all equipment, including the check valve in the horizontal run. If a house above grade, with no large pit beneath it, is used it becomes necessary to place the O.S. & Y. gate valve in the vertical part of the tank discharge pipe and to construct a small brick or concrete pit or well to contain the check valve in the horizontal pipe below the frost line.

3302. Materials. The valve pit below grade shall be built of portland cement concrete with a clean aggregate. Reinforced concrete should be a 1:2:4 mixture. Plain concrete, when low stresses permit its use, may be a 1:3:5 mixture. A valve house above grade shall be constructed of concrete, brick, cement plaster on metal lath or other noncombustible material with suitable heat insulating properties.

3303. Dimensions. A valve pit or house shall be of sufficient size to provide a clearance of 12 in. and preferably 18 in. around all contained equipment. A valve pit shall extend at least 6 in. above grade and far enough below grade to place the base-elbow below the frost line and at such an elevation that connection to the system can be conveniently made. The necessary size of pit shall be carefully planned in advance for each equipment, but ordinarily a pit 7 ft. deep and 6 ft. by 9 ft. horizontally inside will be of sufficient size. A valve house containing only the O.S. & Y. gate in the discharge pipe and the heater can usually be made smaller.

3304. Design of Valve Pit.

a. All parts of the pit and soil beneath shall be adequate to resist all loads including the frost-casing or large steel riser and contained water. This requires reinforced 1:2:4 concrete for the roof. The walls and floor should also be reinforced 1:2:4 mixture if subjected to appreciable bending stresses from ground water pressure or other loads. The walls and floor may be plain 1:3:5 concrete, usually not less than 8 inches thick, when bending stresses are insignificant.

b. The load considered in designing the pier and its bearing which supports a large steel plate riser, when the hemispherical or ellipsoidal shape is continuous to the shell of the large riser without flat horizontal diaphragm plate, shall be the weight of the water column from the pier to the tank bottom plus the weight of a cylinder of water 4 ft. greater in diameter than the large riser and extending from the bottom to the top of the tank. If a hemispherical or ellipsoidal bottom is rigidly attached to the top of a large riser by a flat horizontal diaphragm plate, the weight considered acting on the pier shall be the weight of the water column from the pier to the tank bottom plus the weight of a cylinder of water whose radius equals the radius of the riser at the tank bottom plus one-half the distance from the edge of the riser to the connection of the flat horizontal diaphragm plate to the hemispherical or ellipsoidal bottom plates, and extending from the bottom to the top of the tank. The pier shall adjoin a pit containing the usual valves and accessories. An adequate slip-joint shall be provided between the pier and the valve pit if the soil is incapable of sustaining a load of two tons per square foot without negligible settlement.

3305. **Pit Manhole.** A standard round manhole with cover at least 24 in. in diameter, a square metal manhole with substantially hinged cover at least 20 in. on a side, or a raised hatch of equivalent size with a cover built of 2-ply matched boards with tar-paper between, shall be provided in the roof of the valve pit. Where there is no heater in the pit the manhole shall have a properly fitted inside cover of 2-in. plank or its equivalent located at least 4 in. below the outer cover.

3306. **Pit Ladder.** A steel ladder, rigidly secured shall extend from the manhole to the floor.

3307. **Waterproofing Pit.** If the pit is below drainage level the outside surface shall be thoroughly waterproofed. Waterproofing may be done either by painting with asphalt and then covering with at least two layers of felt and asphalt alternately, felt to be lapped 18 in., or by other suitable methods.

3308. **Pit Drain.** A sump and drain shall be provided wherever a sewer is available or soil conditions make the ar-

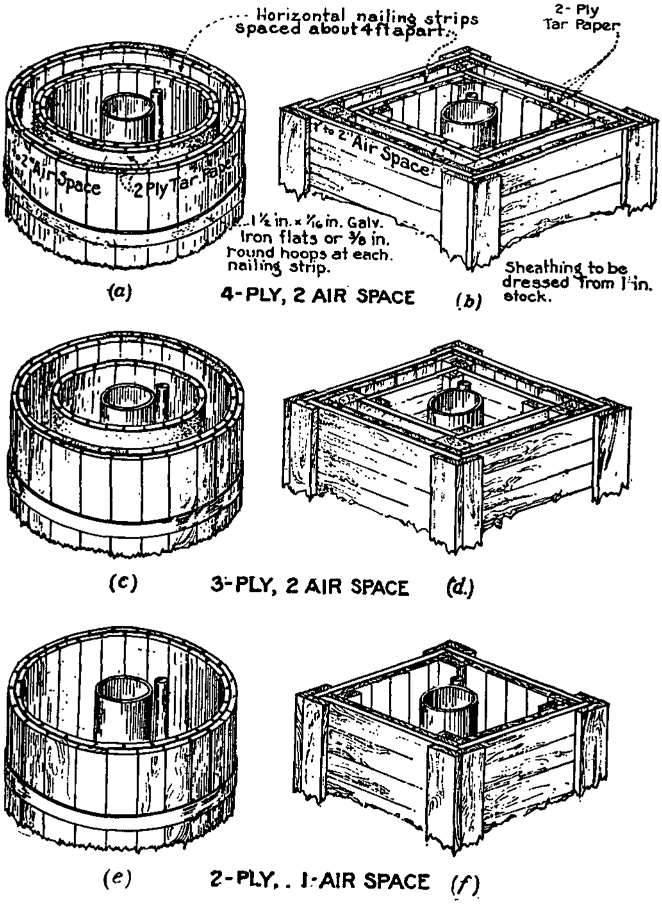


Fig. 13. Wooden Frostproof Casings.

rangement possible. If suitable drainage cannot be obtained an injector is sometimes advisable.

3309. Heater House.

a. A heater house above grade shall be substantial and the roof shall be strong enough to support the frostproof casing, if provided, and other loads without excessive deflection. A tight-fitting double door of sufficient size for admittance of persons or equipment shall be provided.

b. If the house contains a heater which burns oil or a gas which is heavier than air, and is located over a valve pit below grade, the entrance to the pit shall be outside of the heater house. The portion of the floor of the heater house which is over the pit shall be continuous concrete, tightly calked around all pipes.

c. If the house contains a fuel burning heater, louvers above the maximum snow level or a vent shall be provided to furnish sufficient fresh air for combustion of fuel in addition to the vent to exhaust the products of combustion from the house.

3310. **Heating Valve House or Pit and Heater House.** The valve or heater house above grade, as well as the valve pit, shall be heated sufficiently to maintain a temperature of at least 40°F. during most severe weather.

Section 34—Frostproof Casing.

3401. **General.** An approved frostproof casing shall be placed around all exposed tank-piping in localities where the lowest mean atmospheric temperature for one day as shown by the Isothermal Map, Figure 20, is 20°F. or lower. Tank piping subjected to temperatures below freezing within unheated buildings shall also be adequately protected. Combustible frostproof casings subjected to serious fire exposure shall be protected by at least 1 in. of cement plaster or metal lath. The casing or discharge pipe shall be braced as specified in Article 2604, and bracing shall be provided between the frostproof casing and the discharge pipe. Noncombustible construction is preferred throughout as indicated in Figure 14 or equivalent.

3402. Wood.

a. When special permission is obtained from the authority having jurisdiction, frostproof casings may be wooden, built as shown in Fig. 13. (See Article 3404.) All lumber must be sound and free from large or loose knots. Sheathing shall be matched stock, dressed from a nominal thickness of at least 1 inch to a finished thickness not less than ⅝ inch. One thickness of heavy nonabsorbent or saturated building paper shall be wrapped around all, except the outer courses of sheathing. Air spaces shall be not less than 1 in. nor more than 2 in. Horizontal nailing strips shall be provided not over 4 ft. apart.

b. Effective fire stops shall be provided in all air spaces about 6 ft. and 10 ft. above the base of the casing, except that for prefabricated casing, the lower fire stop may be at the base of the casing. If the casing contains only water pipes, noncombustible insulating material at least 4 in. thick supported on 2-in. planks, or the equivalent, shall be used for these fire stops. The insulating material shall be packed tightly in any spaces between planks and pipes. If the casing contains a steam pipe, an approved noncombustible material shall be used instead of the 2-in. planks. The pipes shall be protected against corrosion at these fire stops by liberal application of red lead paint with litharge added, as covered in Article 712, after careful cleaning of the pipes with wire brushes and scrapers. At least 1½ in. x 1/16 in. galvanized iron flats or ⅜ in. round hoops shall be placed around circular casings over each nailing strip. Bracing between the frostproof casing and the discharge pipe shall be spaced at intervals of not over 4 ft. except that prefabricated casing shall be braced to the discharge pipe at the ends of the sections, not over 16 ft. long.

3403. Insulation.

a. Layers of approved insulation consisting of mineral, vegetable or animal material may be constructed as follows: First, remove all rust from the pipes with wire brushes and apply two coats of red lead paint using the mixture as stated in Article 712 or an approved paint; second, wrap all pipes together with waterproof building paper applied over hard wood cleats equal in thickness to the projections of pipe flanges or couplings; third, apply alternate wrappings of 1 in. insulation and waterproof building paper using the

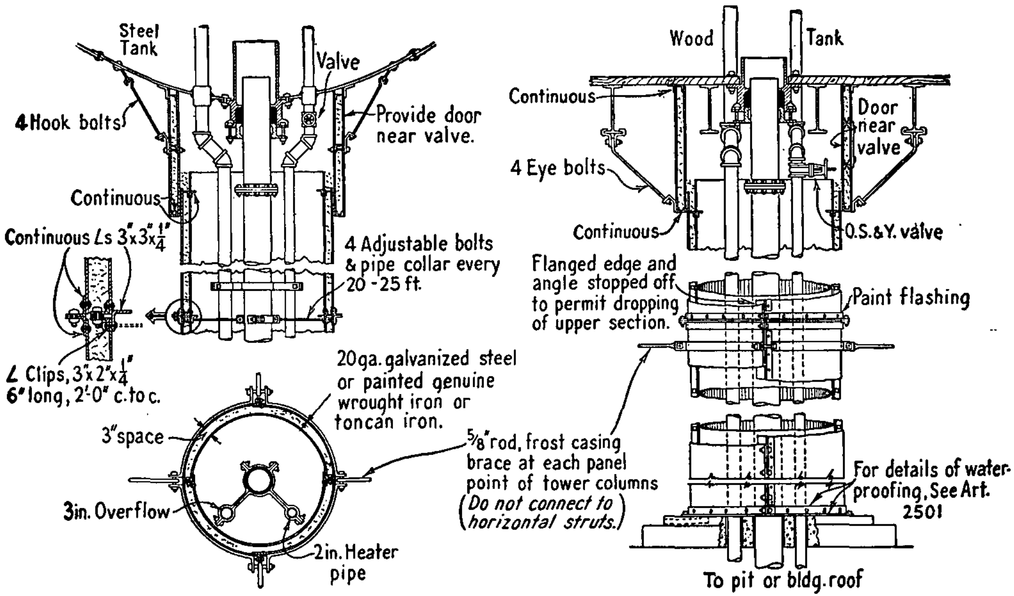


Fig. 14. Suggested Insulated Metal Frostproof Casings.

number of layers equivalent in insulating value to the wooden casings specified in Article 3404 and finishing with building paper; finally, provide an outer covering of painted 8 oz. canvas securely bound with No. 16 copper wire with windings not over 1 ft. apart or by sewing. This type of casing is likely to settle and expose the pipes at the top of the insulation unless adequately secured to the pipes and the tank bottom. Approval of use of insulating materials should be obtained from the authority having jurisdiction.

b. Insulating materials between inner and outer layers of wood or metal may be used after obtaining approval of details from the authority having jurisdiction. Such casings shall be watertight and conform with other Articles in this Section so far as applicable. Suggestions for insulated metal casings are shown in Figure 14. Absorbent insulating materials should not be placed in direct contact with iron or steel pipes.

c. For low towers, brick casings with 1 in. air spaces between four 4-in. walls and bonded together with frequent headers, supported on concrete foundations have given satisfactory experience in very cold climates.

3404. **Required Thickness.** In localities where the lowest mean temperature for one day as shown by the Isothermal Map, Figure 20, is minus 20°F. or lower, the wooden casing shall be not less than four-ply with two air spaces (Figure 13, a and b). Similarly for minimum one-day mean temperatures between 0° and minus 20°F. the casing shall be three-ply, two air-space (Figure 13, c and d), and for points further south at least two-ply, one air-space (Figure 13, e and f) except that no casing is needed where the minimum one-day mean temperature is above 20°F.

Inside of buildings where freezing may occur a two-ply, one air-space wooden casing or at least the equivalent in other types of insulation applied as specified in Article 3403 will usually suffice.

3405. **Top.**

a. When the casing is wooden or metal an enlarged section shall be provided directly under the tank bottom and shall fit over the main portion of the casing with a slip joint lapping at least 6 in. to provide for expansion or settlement of the tower. This section shall have the same insulating qualities as the main casing and shall be tightly and securely fitted to the tank bottom. For a tank with a hemispherical or other suspended bottom it shall be built in the shop. A tightly fitting, hinged door of the refrigerator type with handle and catch shall be provided and so located that the valve in the hot-water pipe just beneath the tank bottom can be operated. Hardware for the door including hinges, clasp and handles shall be attached to wood by through bolts or to metal casings by rivets or welding.

b. When the frostproofing consists of insulating material as specified in Article 3403 it shall be carried in full thickness over the body of the hot water valve at the tank bottom and fitted tightly and securely around the stem of the valve and to the bottom of the tank. The stem and handwheel of the valve shall be covered with a waterproof building paper, then with a one-inch layer of insulating material and finally with the outer covering of painted canvas securely bound on but in such a manner that it can be readily cut away in case of emergency. A disc of distinctive color and the word "Valve" should be painted on the canvas over the valve.

3406. Bottom. The casing shall be substantially supported at the bottom by the roof of the valve pit or building, using beams if necessary. The joint around the bottom shall be watertight to prevent leakage from outside and when the tank is over a building the joint between the roof and pipes inside the casing shall also be watertight to keep water from draining into the building in case of a broken pipe. (See Article 2501.) The lower end of the casing shall be protected from absorption of moisture.

3407. Paint. Unless the lumber used in a wooden casing has been suitably treated with a preservative, all exposed parts shall be given at least two coats of a good grade of paint. If a metal casing is used, all surfaces shall be given two coats of paint as specified in Articles 712 and 713.

3408. Wood Preservatives. The lumber used in wooden frostproof casings is subject to rotting. Treatment of the lumber with a suitable preservative such as sodium fluoride, creosote or even zinc chloride is advised.

TANK HEATING EQUIPMENTS.

Including Method of Determining Necessary Heater Capacities.

Adequate heating of tank equipments ranks next to structural design in importance. An ice plug in the riser pipe may make the tank water unavailable in case of fire and may break the pipe. Ice in or on tank structures has been the direct cause of collapse in several cases.

The heating system must therefore be reliable and must allow convenient, judicious and economical operation. It must be of sufficient capacity and properly arranged to prevent ice in any part of the tank or piping. It should not, however, be so operated as to cause overheating which is seriously detrimental to wooden tanks and to the paint in steel tanks. Icicles, which will form on the structure in cold climates if the tank is allowed to overflow or leak, shall be avoided.

Section 35—Heating.

3501. **Approval of Plans.** Complete information regarding the heating system and its layout shall be submitted for approval before work is commenced, as explained in Article 2505. The information should preferably be incorporated in a sketch, but may be given by letter if the layout conforms with one of those illustrated in these specifications.

3502. **General Requirements.** Tanks located where the water may freeze shall be adequately heated even if the tank water is circulated by being used, in part, for purposes other than fire protection. The heating system shall be of such capacity that the temperature of the coldest water can be maintained during coldest weather at 42°F. There shall be a low water temperature alarm connected to an approved central station supervisory service or adequate local proprietary alarm set at 40°F.

Caution. Frequently the fire pump, filling pump or city supply creates a pressure at the water heater at times of filling the tank, considerably in excess of the normal static pressure from the tank. The allowable working pressure of the heater and the setting of the water relief valve shall be not less than the maximum filling pressure.

3503. Gravity-Circulating Systems. The heating system shall be of the gravity-circulating type except as noted in Articles 3520, 3521 and 3522. Gravity Circulation permits convenient observation of coldest water temperatures at a thermometer in the cold-water return-pipe and is dependable and economical if correctly planned. Cold water received through a connection from the discharge pipe or from near the bottom of a suction tank or standpipe is heated and rises through a separate hot-water pipe into the tank.

A circulating water pump may be used in a bypass line to improve the efficiency of the gravity circulating system. However, the heater size shall be based on gravity circulation to provide the heat loss as determined by Table 4, 5 or 6. The circulating water pump should be controlled by an outside thermostat designed to start the pump when the outside temperature reduces to 40°F.

NOTE: Water has its maximum density at 39.2°F. When the temperature of the water falls below 39.2°F., there is a water inversion so that the warmer water settles to the bottom of the tank while the colder water rises. Therefore, if the circulation heater is to be fully effective, sufficient heat must be provided so that the temperature of the coldest water will be maintained safely above 42°F.

3504. Steam Water Heaters. A steam water heater may consist of a cast iron or steel shell through which water circulates around steam tubes or coils of brass or copper. Galvanized steel or iron steam tubes are permitted but are not advised because of their more rapid depreciation and poorer heat-transfer qualities. The shell and tubes shall be designed to withstand a test pressure of at least two and one-half times the permissible working pressure and not less than 300 lbs. per sq. in. and shall be so tested before shipment. Heaters shall have a bolted flange on at least one end to facilitate taking apart for inside cleaning.

Heaters designed so that water passes through the tubes or coils surrounded by steam are practical for ease of cleaning. However, such heaters should be well insulated unless it is desired to use the heat loss for heating the valve pit or other housing.

3505. **Coal-burning Water Heaters.** A coal-burning water heater of sufficient strength to resist the water pressure may be used. Water circulates through a chamber or series of chambers or through brass pipe-coils around and over the fire. The heater and accessories shall be installed in accordance with the manufacturer's recommendations and provided with approved combustion safeguards.

3506. **Gas-Fired Water Heaters.** A gas-fired water heater of sufficient strength to resist the water pressure may be used. The heater shall be of a type listed by a recognized testing laboratory and shall have a permanent marking showing the input ratings in Btu per hour. The heater and accessories shall be installed in accordance with the manufacturer's recommendations and provided with approved combustion safeguards.

The gas-fired water heater shall be equipped to prevent abnormal discharge of gas, in event of ignition failure or accidental flame extinguishment, by automatic means specifically approved for the heater.

A high-limit switch shall be provided in the hot water pipe close to the heater, to shut off the gas supply automatically when the water temperature exceeds 190°F.

Thermostatic control of the burner with temperature response element shall be located in the coldest water affected by atmospheric temperature, maintaining a minimum water temperature of at least 42°F.

3507. **Oil-Fired Water Heaters.** An oil-fired water heater of sufficient strength to resist the water pressure may be used. The heater shall be of a type listed by a recognized testing laboratory and shall have a permanent marking showing the input rating in Btu per hour.

The heater and accessories shall be installed in accordance with the manufacturer's recommendations and provided with approved combustion safeguards.

The heater shall be equipped to prevent abnormal discharge of oil at the burner, in event of ignition failure or accidental flame extinguishment, by automatic means specifically approved for the heater.

A high limit switch shall be provided in the hot water pipe close to the heater to shut off the oil supply automatically when the water temperature exceeds 190°F.

Thermostatic control of the burner with temperature response element shall be located in the coldest water affected by atmospheric temperature, maintaining a minimum water temperature of at least 42°F.

The oil tank shall be buried outside the heater house.

3508. Electric Water Heaters. An electric water heater of sufficient strength to resist the water pressure may be used. A water circulating pump should be used in conjunction with electric heating elements. A single water heater or boiler of adequate capacity may be used. However, it may be desirable to avoid sudden peak demands on the electric service by installing multiple heaters, in parallel (see Article 3512), with the various thermostatic controls set at different temperatures. With all of the heater elements in operation, the system shall have adequate capacity to maintain a minimum water temperature of at least 42°F. Thermostatic control with temperature response element shall be located in the coldest water affected by atmospheric temperature.

In the hot water pipe close to the heater, there shall be a manual reset high-limit control thermostat that disconnects all ungrounded electrical conductors to the heater in the event that the water temperature exceeds the temperature of the high-limit thermostat (approximately 190°F.).

Electric heaters and accessories shall be of a type listed by a recognized testing laboratory, shall have a permanent marking showing the kilowatt capacity, and shall be installed in accordance with the manufacturer's recommendations. The installation of all electrical wiring shall comply with the standards of the National Electrical Code.

3509. Marking of Heaters. All tank heaters shall be plainly marked with a plate or cast lettering giving the size and type of heater and the manufacturer's name.

3510. Relief Valve. A dependable relief valve shall be provided in the water chamber or pipe between the hot and cold-water valves of any water heater. The relief valve shall be carefully adjusted to open at a pressure of 120 pounds per square inch except that the opening pressure shall be not greater than the allowable working pressure of the heater nor less than the maximum static or filling pressure to which it may be subjected. If the heater is close to stock that might be damaged by water the relief shall be piped to a safe point.

3511. Location. The heater shall be located in a valve pit, special heater-house or in a nearby building at or near the base of the tank structure. When the tank is over a building the heater may be located in the top story.

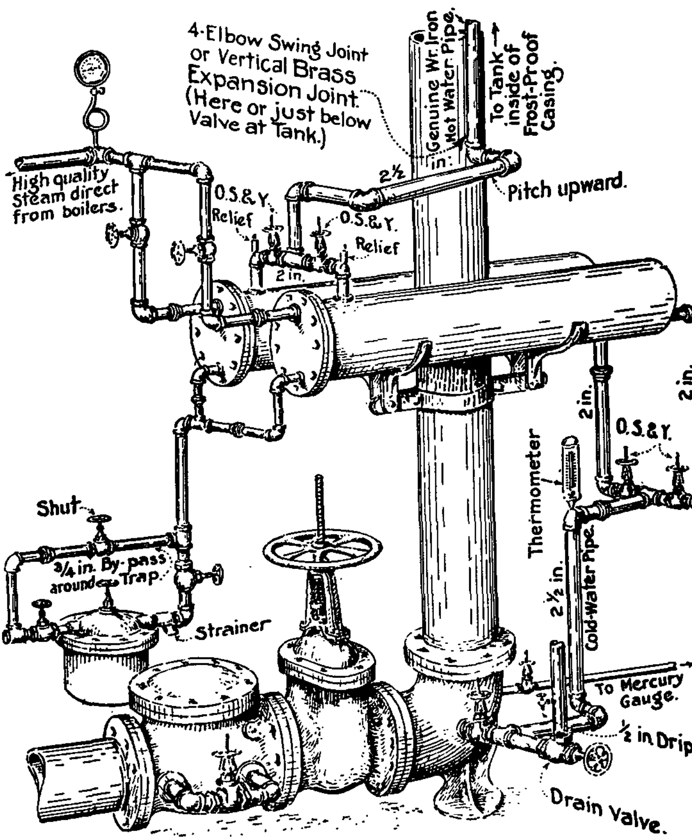


Fig. 15

3512. Multiple Heaters. If two or more heaters are used, they shall be placed at one level and shall be connected in parallel with symmetrical piping and with a relief valve and controlling valves in the water lines of each. A globe valve shall be placed in each steam-supply line. A typical arrangement of two steam heaters correctly connected is shown in Figure 15. Similar arrangements should be used for other water heaters.

3513. Heat Insulation. Heaters should be insulated to prevent excessive heat losses. When the tank heater is the only source of heat in a valve pit or other heater room enough of the heater or steam pipe should be left bare to keep the temperature of the air above freezing.

3514. Hot-Water Pipe. The size of the hot-water pipe shall be as specified in Article 3516. Copper water tubing, genuine wrought iron, or brass (85% copper) pipe should be used throughout. If the tank is elevated the hot-water pipe shall be placed near the discharge pipe inside of the frostproof casing. The pipe shall pitch upward at all points and shall have a four-elbow swing-joint or adequately supported, brass expansion-joint located either just above the heater or just below the gate valve near the tank bottom. The hot water shall discharge inside the tank through a Tee fitting of the nominal pipe size, at about one-third the height of the tank. The pipe shall be adequately braced, where required, inside the tank and also at points not over 25 ft. apart throughout its length, providing, however, enough play to allow for expansion. An approved outside screw and yoke gate valve of the nominal pipe size shall be placed in the pipe near the heater.

3515. Cold-Water Pipe. The size of the cold-water return-pipe shall be as specified in Article 3516 at least 2 inches in diameter and, if the tank is elevated shall be connected into the discharge pipe on the tank side of all valves, at a point such that there will be circulation throughout the entire portion of the discharge pipe subject to freezing. An accurate thermometer graduated at least as low as 30°F. shall be placed in the cold-water pipe at a point where it will register the temperature of the coldest water in the system. A recording thermometer instead of an ordinary mercurial socket-thermometer is often advisable as a continual temperature record permits more careful operation of the heating system. An approved outside screw and yoke gate valve of the nominal pipe size shall be placed in the cold-water pipe. A 2-inch drain pipe discharging at a visible point shall be connected into the cold-water return-pipe between the heater and the cold-water controlling valve to permit flushing water from the tank through the hot-water pipe, heater and drain for clean-out purposes. The drain pipe shall be arranged as specified in Article 3004 and as shown in Figures 8 and 9.

3516. Water-Circulating Pipes—General.

a. The size of water-circulating pipes for wooden tanks shall be at least 2 in. For steel tanks the size shall be in accordance with the following table but not less than 2 in.

Minimum One-Day mean Temp. Degrees F.	Size in Inches of Circulating Pipes Required for Elevated Steel Tanks. Tank Capacity (U. S. Gallons)									
	15,000	20,000	25,000	30,000	40,000	50,000	60,000	75,000	100,000	150,000
+10	2	2	2	2	2	2	2	2	2	2½
+ 5	2	2	2	2	2	2	2	2	2	2½
0	2	2	2	2	2	2	2	2	2½	2½
— 5	2	2	2	2	2	2	2	2	2½	2½
—10	2	2	2	2	2	2	2	2½	2½	2½
—15	2	2	2	2	2	2	2½	2½	2½	3
—20	2	2	2	2	2	2½	2½	2½	2½	3
—25	2	2	2	2	2½	2½	2½	2½	3	3
—30	2	2	2	2	2½	2½	2½	2½	3	3
—35	2	2	2	2½	2½	2½	2½	3	3	3
—40	2	2	2	2½	2½	2½	2½	3	3	3

b. Long runs of nearly horizontal circulating-pipe and pockets, or excessive number of fittings, should be avoided as far as possible. The relief valve, mentioned in Article 3510, shall be located in the water chamber or pipe between the hot and cold-water valves. A typical arrangement of a steam water heater and piping in a valve pit is shown in Figure 8. For a tank over a building the usual layout is shown in Figure 9. The hot water circulating pipes for typical tanks are indicated in Figures 10, 11, 11a and 11b. The arrangement of the circulation piping for other heaters is similar to that for steam water heaters. If the circulating pipes pass through the roof or waterproof or concrete floors, the intersections must be watertight. (See Article 2501.)

c. Caution. *Explosion hazard should always be avoided by shutting off or removing the source of heat when both valves in the circulating-pipes are shut for any reason. This precaution should be taken even though a relief valve is correctly located.*

3517. Steam Supply. Steam water heaters shall be connected to a reliable steam supply with a pressure preferably not less than 10 pounds per square inch and ordinarily not over 50 pounds per square inch. The steam pipes shall have an area at least equivalent to that of 1-in. nominal size

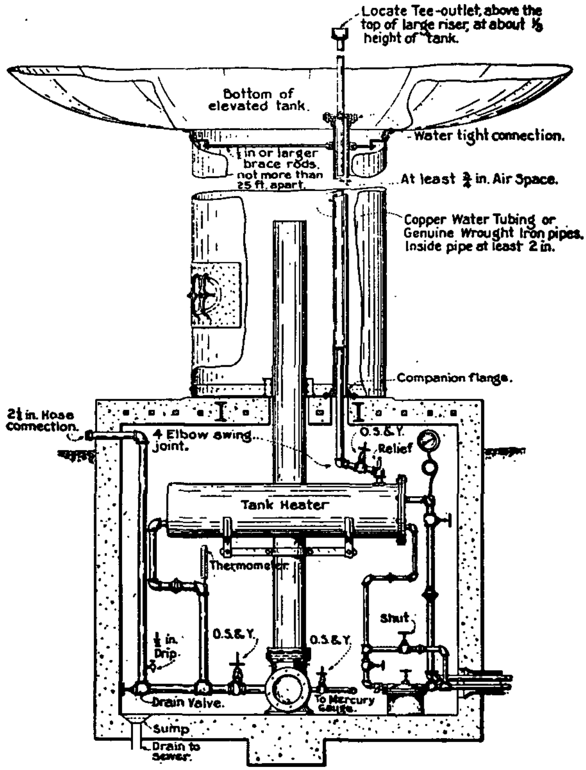


Fig. 16. Arrangement of a Circulation-Heater for a Tank with a Large Riser.
(For alternate arrangement of heater pipes in large riser, see Art. 3523)

pipe for each heater supplied, and shall run direct from the boiler header if possible. A globe valve shall be placed in the line near the heater and a steam gage shall be provided preferably between the valve and the heater. When the heater is connected to a vacuum system the layout shall have the approval of the makers of the heating specialties and in all cases a final approval shall be obtained from the authority having jurisdiction.

3518. Steam Return.

a. The steam return shall be arranged to quickly relieve the heater of condensate. The area of the return-pipe shall be at least equivalent to the area of ¾-inch nominal size pipe for each heater served. A reliable steam-trap of adequate size and equipped with an air-vent and preferably a water-gage shall be provided near the heater whenever the return is not by gravity or to a vacuum system. Excessive lifts from the trap shall be avoided. A ¾-in. or larger bypass with a globe valve normally kept shut shall be provided around the trap. A globe valve shall also be placed on each side of the trap between the bypass connections.

b. A gravity return may be used only when the heater is located well above the boiler water-level and when the steam pressure at the heater plus the static head of water in the return pipe between the heater and the boiler water-level is greater than the steam pressure at the boiler.

c. Whenever it becomes necessary to return the condensate to a vacuum heating system, the layout shall have the approval of the makers of the heating specialties as well as a final approval by the authority having jurisdiction.

3519. Heating with Hot Water. Hot water as a heating element in coils or shell of a heater designed for steam shall not be used unless special permission to do so is obtained from the authority having jurisdiction, and in all such cases the complete detailed design of the heater, together with information regarding the temperature of the hot water, shall be submitted to the authority having jurisdiction and approval received before the equipment is installed.

3520. Steam Coils Inside Tanks.

a. Steam coils inside the tank do not permit convenient observation of water temperatures and have other faults which make them unsuited for heating elevated tanks except occasionally in the south where only intermittent heating is necessary. This method may, however, be used for heating suction tanks and standpipes with flat bottoms supported near the ground level if kept filled so that the coils are submerged continuously.

b. The coil shall consist of at least 1¼-in. genuine wrought iron, brass or copper pipe, pitched to drain and shall be supplied with steam preferably at not less than 10 pounds pressure, through a pipe of sufficient size to furnish the required quantity of steam from a reliable source. A globe valve and a steam gage with siphon shall be placed in the steam-supply line. The coil shall be substantially supported and, together with the supply and return pipes, shall have adequate provision for expansion. The return shall be connected to a steam trap. If the tank is elevated, the steam pipes shall be placed inside the frostproof casing around the discharge pipe. (See note of caution Article 3521d.) The coil shall contain a sufficient area of heating surface (explained in Article 3529) to maintain the temperature of the coldest water at not less than 42°F. The coil shall be placed within a distance of approximately three (3) feet from the shell, and shall be sized for a maximum steam velocity of 8000 feet per minute so that the pressure drop does not exceed ½ the initial inlet pressure.

c. The surface water temperatures for elevated tanks and for standpipes and suction tanks shall be ascertained by means of an approved temperature detecting device. This device shall have the temperature response element secured in a position about 3 ft. below the permanent fire service water level. If long distance thermometers are used, the external tubing shall be supported substantially at about 12 ft. intervals and the indicating dial located conveniently near grade in a substantial weatherproof cabinet. For a high structure without a permanent fire service water level, a circulating type of heating system or radiator heater with sleeve shall be used with socket thermometer located in the coldest water. For any exception to these provisions, approval from the authority having jurisdiction shall first be obtained.

3521. Methods in Southern Localities.

a. The intermittent heating required for tanks having small risers located where the lowest mean temperature for one day as shown by the Isothermal Map, Figure 20, is from 5°F. to 10°F., inclusive, may be accomplished by a circulating system, by steam coils or, the least satisfactorily, by blowing steam from an adequate supply directly into the tank through a pipe not less than 1 in. in diameter, in which case the steam pipe shall extend inside the frostproof casing, through the tank bottom to a point above the maximum water level then horizontally a short distance, with an air vent and a check valve to keep the water from siphoning back and thence downward to a point three or four feet below the normal fire-service water level. The section of the pipe inside the tank shall be of brass or copper securely