

Steel Water-Storage Tanks

Revised Edition



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Steel Water-Storage Tanks

AWWA MANUAL M42

Revised Edition



**American Water Works
Association**

Manual of Water Supply Practices — M42, Revised Edition

Steel Water-Storage Tanks

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**American Water Works
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6666 West Quincy Avenue
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303.794.7711
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Preface

The purpose of this manual is to provide the water distribution system manager, operator, contractor, and consultant with information concerning steel tanks used for the storage of water during water production, treatment, and distribution. The manual covers the planning, specification, construction, operation, and maintenance of steel tanks of riveted, welded, and bolted construction.

This manual is not intended to be a technical commentary on American Water Works Association (AWWA) standards dealing with steel water-storage tanks; reference is made to those standards to make the reader aware of their existence and application. ANSI/AWWA D101, Standard for Inspecting and Repairing Steel Water Tanks, Standpipes, Reservoirs, and Elevated Tanks for Water Storage, was last reaffirmed in 1986 and withdrawn as a standard in 1998, the year this manual was first published. That standard is included in this manual as appendix C.

While the scope of this edition of the manual remains largely unchanged, updates have been made to the content throughout. This revised edition includes several new and many revised figures and tables, information on composite elevated tanks, recommended steel tank guidelines, water quality assurance, references to AWWA standards, and current steel water tank industry sources and organizations.

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Acknowledgments

The Standards Committee on Steel Elevated Tanks, Standpipes, and Reservoirs, which reviewed and approved this manual, had the following personnel at the time of approval:

Stephen W. Meier, Chair

User Members

<i>J. Camarena</i> , East Bay Municipal Utility District, Oakland, Calif.	(AWWA)
<i>T.M. Dawson</i> , Emerald Coast Utilities Authority, Pensacola, Fla.	(AWWA)
<i>M. Gaffey</i> , Naval Facilities Engineering Service Center, Washington, D.C.	(AWWA)
<i>M.W. Griffin</i> ,* Missouri-American Water Co., St. Louis, Mo.	(AWWA)
<i>C.P. Harder</i> , City of Fort Worth, Fort Worth, Texas	(AWWA)
<i>G.S. Jacobson</i> , California Water Service Company, San Jose, Calif.	(AWWA)
<i>E.J. King</i> , Connecticut Water Co., Clinton, Conn.	(AWWA)
<i>M.J. Mazurek</i> , Baltimore County Department of Public Works, Towson, Md.	(AWWA)
<i>J.L. Ortiz</i> , San Francisco Public Utilities Commission, San Francisco, Calif.	(AWWA)
<i>J.P. Scott</i> , New Jersey–American Water Company, Voorhees, N.J.	(AWWA)
<i>J. Travers</i> , City of Richardson, Richardson, Texas	(AWWA)

General Interest Members

<i>D.M. Algranti</i> , Albert A. Webb Associates, Riverside, Calif.	(AWWA)
<i>J.D. Brock</i> , Poggemeyer Design Group, Bowling Green, Ohio	(AWWA)
<i>E. Darrimon</i> , Bay Area Coating Consultant Service Inc., Denair, Calif.	(AWWA)
<i>W.J. Dixon</i> , Dixon Engineering, Inc., Lake Odessa, Mich.	(AWWA)
<i>M.L. Hickey</i> , Murray, Smith & Associates Inc., Portland, Ore.	(AWWA)
<i>F.S. Kurtz</i> ,† Standards Engineer Liaison, AWWA, Denver, Colo.	(AWWA)
<i>S.W. Meier</i> , Tank Industry Consultants, Indianapolis, Ind.	(AWWA)
<i>B.M. Shepherd</i> ,† Standards Council Liaison, Ocean Park, Wash.	(AWWA)
<i>J.I. Strand</i> , Short Elliott Hendrickson Inc., Chippewa Falls, Wis.	(AWWA)
<i>C.C. Sundberg</i> , CH2M HILL, Issaquah, Wash.	(AWWA)
<i>R.S. Wozniak</i> , Bow Tech Ltd., Batavia, Ill.	(AWWA)

Producer Members

<i>J.W. Davis</i> , Tnemec Company, Kansas City, Mo.	(AWWA)
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<i>G.A. Larson</i> , CB&I Inc., Clive, Iowa	(AWWA)
<i>K. McGuire</i> , CST Storage, Parsons, Kan.	(AWWA)
<i>R.L. Moore</i> , Utility Service Company, Kirkwood, Mo.	(AWWA)
<i>L.D. Scott</i> , Associated Construction & Engineering, Paso Robles, Calif.	(AWWA)
<i>J. Snodgrass</i> ,* Utility Service Company, Omaha, Neb.	(AWWA)
<i>D.L. Stilger</i> , Caldwell Tanks Inc., Louisville, Ky.	(AWWA)

* Alternate

† Liaison

The AWWA Standards Committee on Steel Elevated Tanks, Standpipes, and Reservoirs would like to dedicate this manual to Robert E. Vansant, past chairperson of the Standards Committee on Steel Elevated Tanks, Standpipes, and Reservoirs, who initiated work on this manual.

The following organizations and companies generously provided photos and illustrative materials for use in this manual: A.O. Smith Harvestore Products Inc., Cathodic Protection Services Company, Chicago Bridge and Iron Company, GPE Controls, Harco Waterworks CP, Mid Atlantic Storage Systems Inc., North Consumer Products, PDM Hydrostorage, Peabody TecTank Inc., Resource Development Company, Steel Plate Fabricators Association, and Tank Industry Consultants Inc.

Introduction

More than 100,000 steel water-storage tanks have been constructed within the last 100 years, a value that far exceeds the number of large water-storage vessels of any other type of construction material. Many steel water tanks have service histories in excess of a century and are still in service today (Figure F-1). Whereas early tanks were riveted, modern practice uses welded or bolted design and construction, which provide the advantage of a zero leakage tolerance.

To further increase their potential service life, steel tanks can be dismantled and re-erected in new locations. A tank that was originally in an optimal location can become useless if a factory relocates or there is a shift in housing patterns. However, a steel tank can be dismantled and then erected and coated at a new location.

This manual provides information on the selection, design, construction, maintenance, inspection, and repair of steel tanks for potable water storage. The manual will assist in tank sizing, configuration, site selection, design, operation, and maintenance.



Source: Tank Industry Consultants Inc.

Figure F-1 A tank constructed in 1902 is still serving Wabash, Ind., with practically no metal loss

DEFINITIONS

The following definitions apply in this manual:

Bottom capacity level (BCL) The water level in the tank when the tank is emptied through the specified discharge fittings (unless otherwise specified by the purchaser). In an elevated tank, the elevation of the bottom capacity level(s) is as given by the purchaser and is determined by the design features of the tank configuration.

Capacity The net volume in gallons (liters) that may be removed from a tank emptied to its bottom capacity level after being filled to its top capacity level.

Constructor The party that furnishes the work and materials for placement and installation.

Elevated tank A container or storage tank supported on one or more columns.

Engineer An employee of the purchaser or, more commonly, a professional engineering firm engaged by the purchaser to perform specification and inspection services.

Head range The difference between the lower and upper capacity levels of a tank.

Manufacturer The person or company that furnishes the tank components.

Owner The person or firm that will own and operate the completed tank. The owner may designate agents, such as an engineer, purchaser, or inspector, for specific project responsibilities.

Purchaser The person, company, or organization that purchases the tank.

Reservoir A ground-supported, flat-bottom cylindrical tank with a shell height less than or equal to its diameter.

Standpipe A ground-supported, flat-bottom cylindrical tank with a shell height greater than its diameter.

Tank An elevated tank, standpipe, or reservoir used for water storage.

Top capacity level (TCL) The maximum operating level of water in a tank, as dictated by the elevation at which water discharges from the tank through the overflow pipe entrance. In a standpipe or reservoir, the top capacity level is as given by the purchaser. In an elevated tank, the elevation of the top and/or bottom capacity level(s) is as given by the purchaser.

AWWA STANDARDS

The majority of all steel potable water-storage tanks constructed in the United States adhere to specifications that reference the following American Water Works Association (AWWA) steel tank standards:

- ANSI/AWWA D100, Standard for Welded Carbon Steel Tanks for Water Storage.
- ANSI/AWWA D102, Standard for Coating Steel Water-Storage Tanks.
- ANSI/AWWA D103, Standard for Factory-Coated Bolted Carbon Steel Tanks for Water Storage.
- ANSI/AWWA D104, Standard for Automatically Controlled, Impressed-Current Cathodic Protection for the Interior Submerged Surfaces of Steel Water Storage Tanks.
- ANSI/AWWA D106, Standard for Sacrificial Anode Cathodic Protection Systems for the Interior Submerged Surfaces of Steel Water Storage Tanks.

- ANSI/AWWA D107, Standard for Composite Elevated Tanks for Water Storage.
- ANSI/AWWA D108, Standard for Aluminum Dome Roofs for Water Storage Facilities.
- ANSI/AWWA C652, Standard for Disinfection of Water-Storage Facilities.

These standards (except ANSI/AWWA C652) are developed and maintained under the direction of the AWWA Standards Committee on Steel Elevated Tanks, Standpipes, and Reservoirs, which is composed of members representing consumer (utility), general interest (academic and consulting engineering), and producer (constructor and manufacturer) groups. ANSI/AWWA C652 was developed and is maintained by the AWWA Standards Committee on Disinfection of Facilities.

Once a draft standard or revision is approved by a standards committee, it is forwarded to the AWWA Standards Council for review and approval. If approved by the council, it is offered for public review and then presented to the AWWA Board of Directors for final approval. The standards listed above have also been approved as standards by the American National Standards Institute (ANSI). AWWA D101-53 (R86), Standard for Inspecting and Repairing Steel Water Tanks, Standpipes, Reservoirs, and Elevated Tanks for Water Storage (included here as appendix C), was withdrawn upon publication of the first edition of this manual in 1998.

WELDED TANKS

Welded tanks have been used for water storage since the 1930s. Welded construction had totally replaced riveted construction by the 1950s. This 20-year transition period from riveted to welded design and construction was necessary because time was needed to train enough skilled welders and because contractors wanted to keep their skilled riveting crews working as long as possible. Today, design and construction of welded tanks are usually performed under the guidelines of ANSI/AWWA D100. This standard was first published in the November 1935 edition of *Journal - American Water Works Association* as “Standard Specifications for Riveted Steel Tanks and Standpipes” and has undergone several revisions since then.

Advantages

The advent of welded tanks provided opportunities for new tank configurations, but the greatest advantage of welded over riveted tanks was the development of smooth structures with much lower maintenance costs than was possible with lapped, riveted seams. Manual, semiautomatic, and automatic welding processes have improved continually over the years, offering increased economy and strength.

Thicknesses and Capacities

Thicknesses of welded tank shells vary from $\frac{3}{16}$ in. (4.76 mm) to 2 in. (50 mm) or more. As of the writing of this manual, the largest welded steel water-storage tank constructed had a capacity of 34 mil gal (130 ML). Elevated tanks have been constructed with capacities up to 4 mil gal (15 ML), and designs are available for greater capacities.

BOLTED TANKS

Factory-coated bolted steel storage tanks were developed in the early 1900s to serve as crude-oil and brine containment vessels. In the late 1970s, this tank design gained acceptance for potable water containment through the release of ANSI/AWWA D103, which allows the use of lighter-gauge steel in the production of tank sheets.

Construction

Bolted steel tanks are made of uniformly sized panels (usually 5 ft wide by 8 ft high or 9 ft wide by 5 ft high [1.5 m × 2.4 m or 2.7 m × 1.5 m]), which can be readily transported and assembled at the tank site. Organic gaskets or sealants are used to achieve a watertight seal at the bolted joints. Thicknesses of bolted tank panels vary from a minimum of 0.073 in. (1.85 mm) to 0.500 in. (12.7 mm). Since the panels are bolted together, the tanks can be dismantled and relocated with relative ease.

Capacities

Bolted tanks are currently offered in incremental sizes depending on the tank manufacturer's panel size. Capacities offered range from 4,000 gal (15,000 L) to approximately 2.5 mil gal (6.8 ML). Bolted tanks are available in reservoir and standpipe configurations. Maximum tank heights and capacities are limited by the manufacturer's steel fabrication facility, as well as by ANSI/AWWA D103.

Coating and Life of Tank

Bolted tanks are factory coated for long-term corrosion protection. Four coating systems are presently available for bolted tanks: galvanized, glass, thermoset liquid suspension epoxy, and thermoset powder epoxy. According to the foreword of ANSI/AWWA D103, the anticipated life of a bolted tank is usually limited by the effective life of the protective coating and cathodic protection system. If the coatings are not abused or damaged, the anticipated life expectancy of bolted tanks is more than 30 years.

COMPOSITE ELEVATED TANKS

Composite elevated tanks have been used for water storage since the 1970s, with hundreds of tanks of this style having been constructed and placed into service before the issuance of an AWWA standard. Today the design and construction of composite elevated welded tanks are performed under the guidelines of ANSI/AWWA D107, which was issued in 2010.

NOTE: The scope of ANSI/AWWA D107 is specific to "composite elevated tanks that use a *welded* steel tank for watertight containment" (emphasis added). As of the publication of this edition of Manual M42, no national standard exists that provides guidance on the design, construction, inspection, and testing of composite elevated tanks that use a *bolted* steel tank for watertight containment.

Construction

The composite elevated water tank consists of a concrete support structure (pedestal) and a welded or bolted steel tank. A variety of different styles of pedestal construction are employed by tank fabricators. The top of the pedestal may be constructed with either a concave, convex, or flat top. A welded steel liner is placed over the concrete pedestal top and serves as the floor of the welded steel tank. Bolted tanks may be furnished with a concrete or bolted steel floor.

Elements of Steel Water Tanks

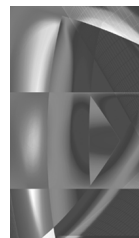
Typical Capacities and Configurations

Appurtenances

Cathodic Protection

Coating Systems

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Chapter 1

Typical Capacities and Configurations

Steel tanks may be configured as reservoirs, standpipes, or elevated tanks. The configuration selected depends primarily on the required capacity and elevation, as well as on cost. Appearance is also an important consideration.

RESERVOIRS

A reservoir is a ground-supported, flat-bottom cylindrical tank with a shell height less than or equal to its diameter. Reservoirs represent the most common type of water-storage structure. They are used both as a part of the distribution system and to hold treated water for pumping into the distribution system. Of the three types of steel water tanks, a reservoir is generally the most economical to fabricate, erect, and maintain, because of its low height. A photo and a cross-sectional view of a welded steel reservoir are shown in Figure 1-1 and 1-2. A photo and a cross-sectional view of a bolted steel reservoir are shown in Figure 1-3 and 1-4. Table 1-1 gives typical sizes of welded steel reservoirs, and T1-2 gives typical sizes of bolted steel reservoirs and standpipes with different coating systems.

Storage reservoirs for potable water are covered by roof structures, which may be either column supported or self-supporting. Standard tank accessories may include shell and roof manholes, screened roof vents, inside or outside ladders, and connections for pipes as required.

STANDPIPES

Standpipes are ground-supported flat-bottom cylindrical storage tanks that are taller than their diameter. They are usually built where there is little elevated terrain and extra height is needed to create pressure for water distribution. A photo and a cross-sectional view of a welded steel standpipe are shown in Figure 1-5 and 1-6. A photo and a cross-sectional view of a bolted steel standpipe are shown in

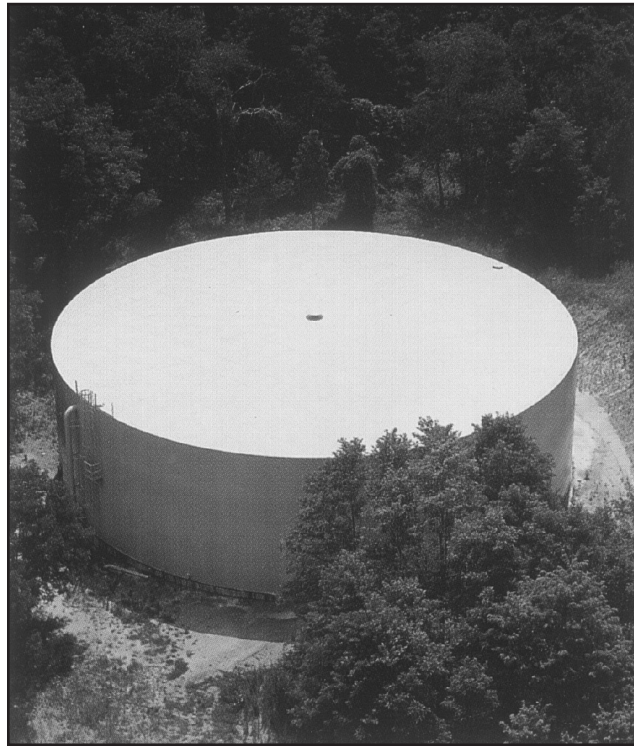


Figure 1-1 Welded steel reservoir

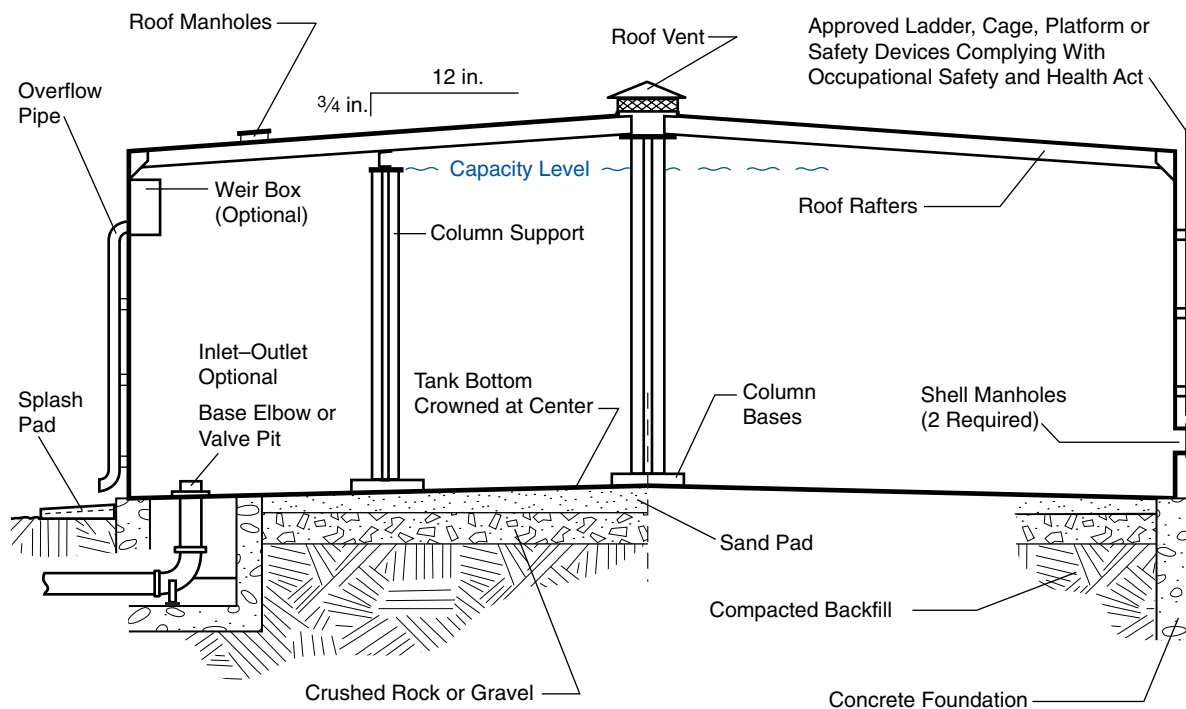


Figure 1-2 Cross-sectional view of a welded steel reservoir



Figure 1-3 Bolted steel reservoir, glass fused to steel

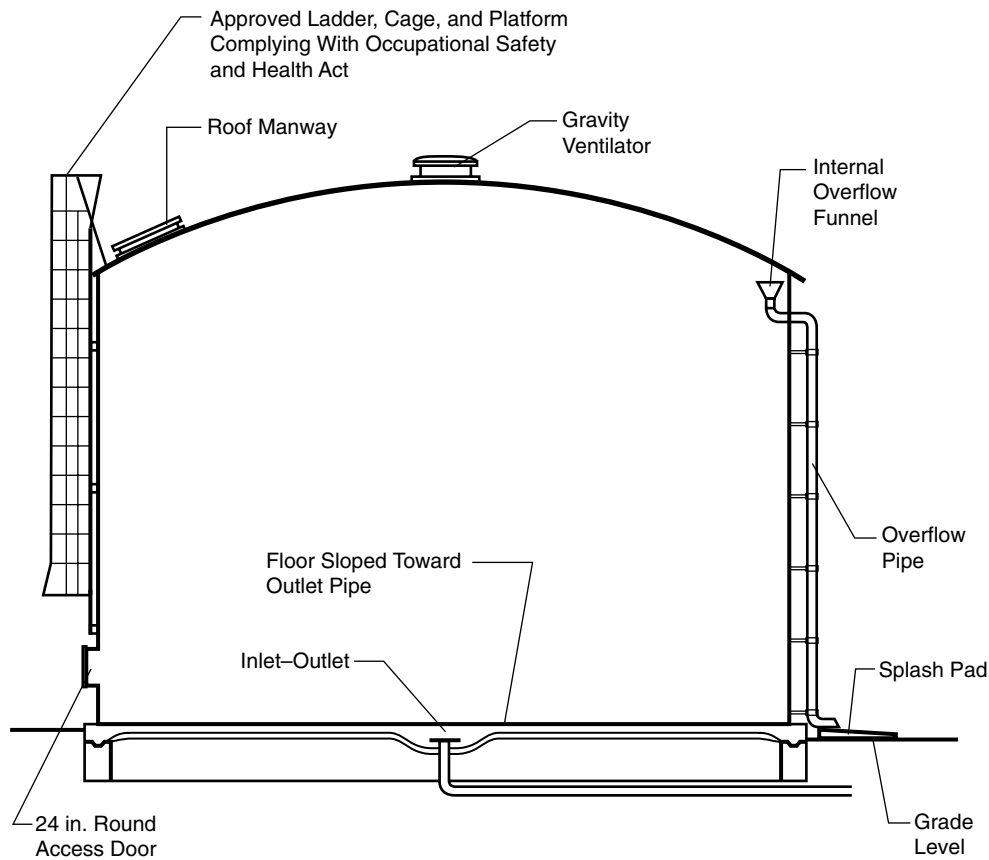


Figure 1-4 Cross-sectional view of a bolted steel reservoir

Table 1-1 Typical welded steel water-storage reservoir sizes

Capacity		Range of Sizes Available			
<i>gal</i>	<i>m³</i>	Diameter <i>ft-in.</i>	Height to TCL <i>ft-in.</i>	Diameter <i>m</i>	Height to TCL <i>m</i>
50,000	189	19-3	24-0	5.9	7.3
60,000	227	21-0	24-0	6.4	7.3
75,000	284	23-6	24-0	7.2	7.3
100,000	379	23-6	32-0	7.2	9.8
		27-0	24-0	8.2	7.3
125,000	473	26-0	32-0	7.9	9.8
		30-3	24-0	9.2	7.3
150,000	568	28-6	32-0	8.7	9.8
		33-0	24-0	10.0	7.3
200,000	757	33-0	32-0	10.0	9.8
		38-3	24-0	11.7	7.3
250,000	946	37-0	32-0	11.3	9.8
		42-9	24-0	13.0	7.3
300,000	1,135	40-6	32-0	12.3	9.8
		46-9	24-0	14.3	7.3
400,000	1,515	46-6	32-0	14.2	9.8
		54-0	24-0	16.5	7.3
500,000	1,890	46-6	40-0	14.2	12.2
		52-0	32-0	15.9	9.8
		60-6	24-0	18.4	7.3
600,000	2,270	51-0	40-0	15.6	12.2
		57-0	32-0	17.4	9.8
750,000	2,840	57-0	40-0	17.4	12.2
		64-0	32-09	19.5	9.8
1,000,000	3,785	66-0	40-0	20.1	12.2
		74-0	32-0	22.6	9.8
1,500,000	5,680	80-6	40-0	24.5	12.2
		90-6	32-0	27.6	9.8
2,000,000	7,570	93-0	40-0	28.4	12.2
		104-6	32-0	31.9	9.8
3,000,000	11,360	114-0	40-0	34.7	12.2
		127-6	32-0	38.9	9.8
4,000,000	15,140	131-6	40-0	40.1	12.2
		147-6	32-0	44.9	9.8
5,000,000	18,930	147-0	40-0	44.8	12.2
		165-0	32-0	50.3	9.8
7,500,000	28,390	180-0	40-0	54.9	12.2
		201-6	32-0	61.4	9.8
10,000,000	37,850	233-0	32-0	71.0	9.8
		208-0	40-0	63.5	12.2

Figures 1-7 and 1-8. Table 1-2 gives typical sizes of bolted steel reservoirs and standpipes. Table 1-3 gives typical sizes of welded steel standpipes.

Operationally, standpipe systems are often designed so that the water in the tank, until it reaches a certain low level, maintains the system pressure. When that low level is reached, pumps come on, valving is changed, and distribution of water is pumped from the lower portion of the standpipe into the system.

Table 1-2 Glass-coated bolted steel reservoirs and standpipes (capacity in thousand gallons*)

[illegible]

*To convert feet to meters, multiply by 0.3048; to convert gallons to m³, multiply by 0.0037854.

As with reservoirs, steel standpipes are covered with a roof structure and may be provided with ornamental trim. Standard accessories may include shell and roof manholes, roof vent(s), a fixed outside ladder, and connections or pipes as required. Inside ladders are not recommended in locations where freezing weather can be expected.

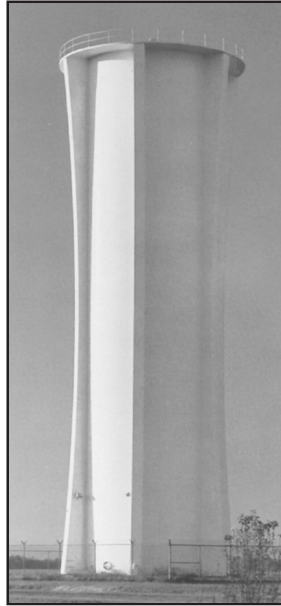


Figure 1-5 Welded steel standpipe with decorative pilasters

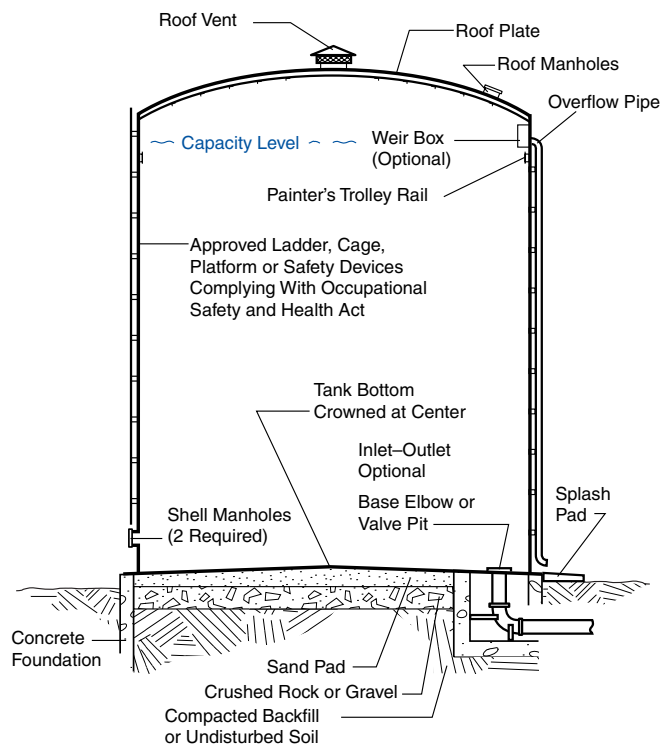


Figure 1-6 Cross-sectional view of a typical welded steel standpipe

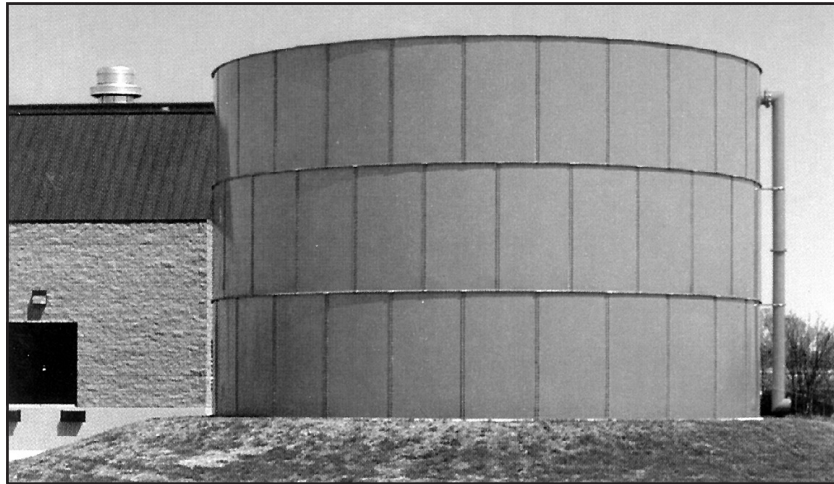


Figure 1-7 Bolted steel reservoir

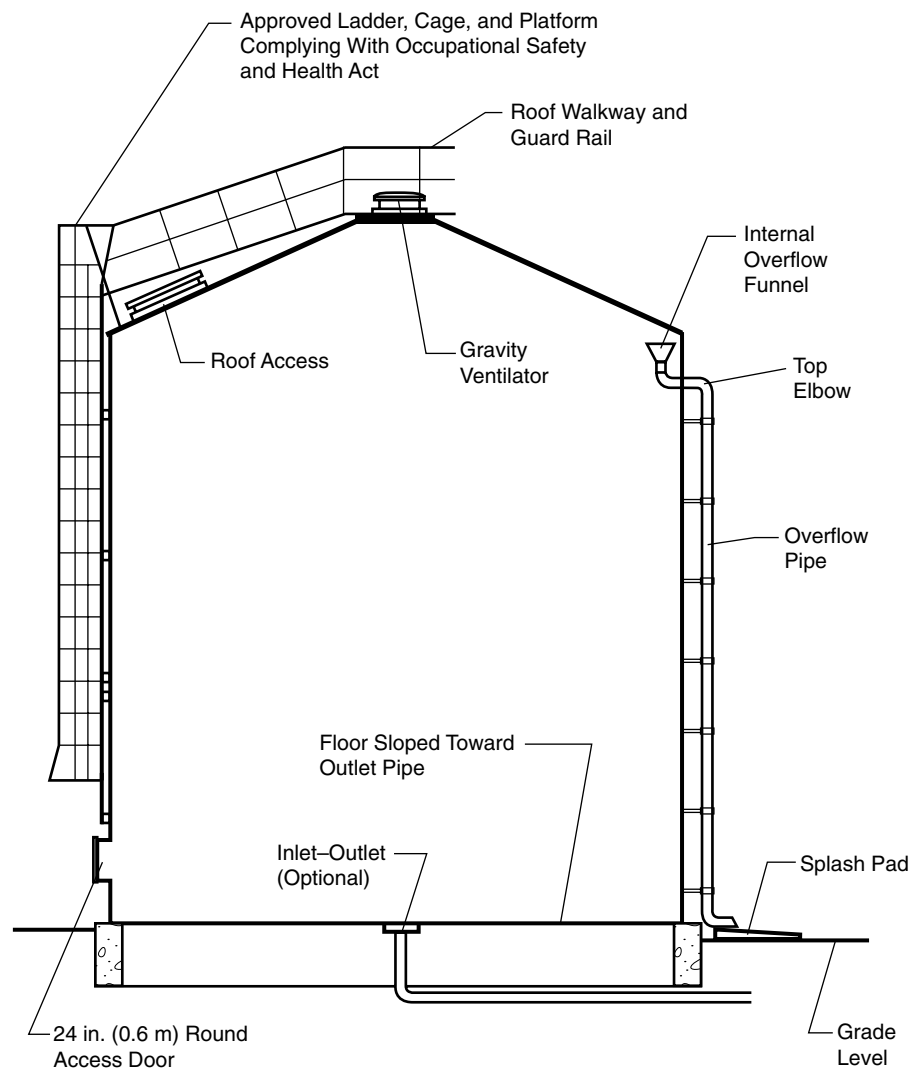


Figure 1-8 Cross-sectional view of a bolted steel standpipe

Table 1-3 Typical welded steel water-storage standpipe sizes

Capacity		Range of Sizes Available			
<i>gal</i> (US)	<i>m</i> ³	Diameter <i>ft-in.</i>	Height to TCL <i>ft-in.</i>	Diameter <i>m</i>	Height to TCL <i>m</i>
50,000	189	14-9	40-0	4.5	12.2
60,000	227	16-2	40-0	4.9	12.2
75,000	284	18-0	40-0	5.5	12.2
100,000	379	19-0	48-0	5.8	14.6
125,000	473	21-3	48-0	6.5	14.6
150,000	568	23-3	48-0	7.1	14.6
200,000	757	24-10	56-0	7.6	17.1
250,000	946	27-9	56-0	8.5	17.1
300,000	1,135	28-5	64-0	8.7	19.5
400,000	1,515	32-10	64-0	10.0	19.5
500,000	1,890	34-7	72-0	10.5	21.9
600,000	2,270	37-10	72-0	11.5	21.9
750,000	2,840	42-6	72-0	12.9	21.9
1,000,000	3,785	46-4	80-0	14.1	24.4
1,500,000	5,680	56-9	80-0	17.3	24.4
2,000,000	7,570	65-6	80-0	20.0	24.4
2,500,000	9,465	69-10	88-0	21.3	26.8
3,000,000	11,360	76-6	88-0	23.3	26.8
4,000,000	15,140	84-6	96-0	25.8	29.3
5,000,000	18,930	94-6	96-0	28.8	29.3

ROOF DESIGNS FOR RESERVOIRS AND STANDPIPES

The emphasis on making steel water reservoirs and standpipes attractive as well as functional has led to the development of a wide variety of roof designs. Alternative roof styles for welded tanks include conical, toriconical, umbrella, dome, and ellipsoidal designs, some of which are column supported; others are self-supporting. Bolted steel tanks are usually provided with conical roofs or may be furnished with an aluminum geodesic dome. Column-supported roof structures are not usually employed on steel standpipes greater than 50 ft (15 m) in height. Whichever design is selected, it is particularly important to design any rafters, trusses, columns, stiffeners, and connections so as to minimize potential corrosion sites. All interfaces and connections of such members should be analyzed for their corrosion potential, and protective coatings should be applied to all surfaces deemed necessary from a cost-benefit standpoint.

Column- and Rafter-Supported Cone Roofs

The column- and rafter-supported roof is generally the most economical for a reservoir (Figure 1-9). The roof has a minimum slope for adequate drainage and provides easy access to the manhole for interior inspection. Column loads are spread to a safe limit by column bases, and concrete footings under the columns are not usually required. A modification of this design incorporates a transition from the shell plate to the roof plate that is a smooth curve rather than a sharp break. This transition, or knuckle plate, is a dished or rolled section that usually requires a stiffener at the rafter attachment point (Figure 1-10).

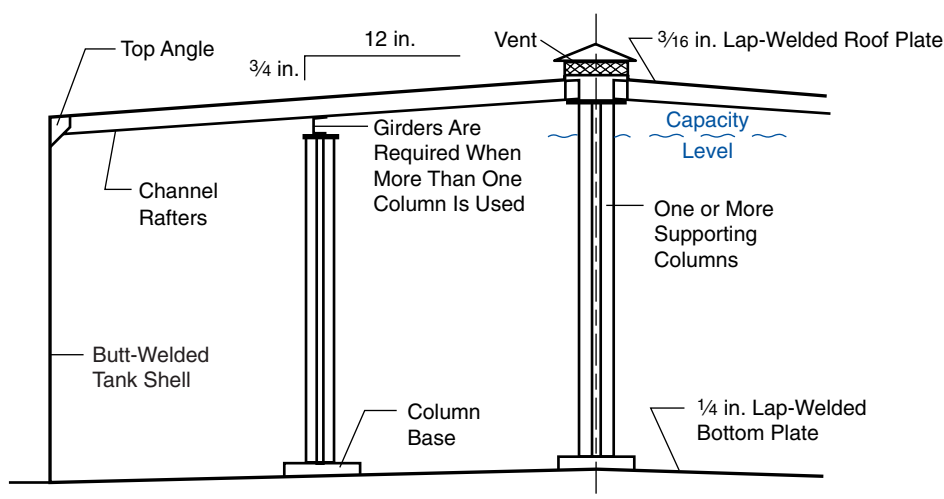


Figure 1-9 Column- and rafter-supported cone roof tank

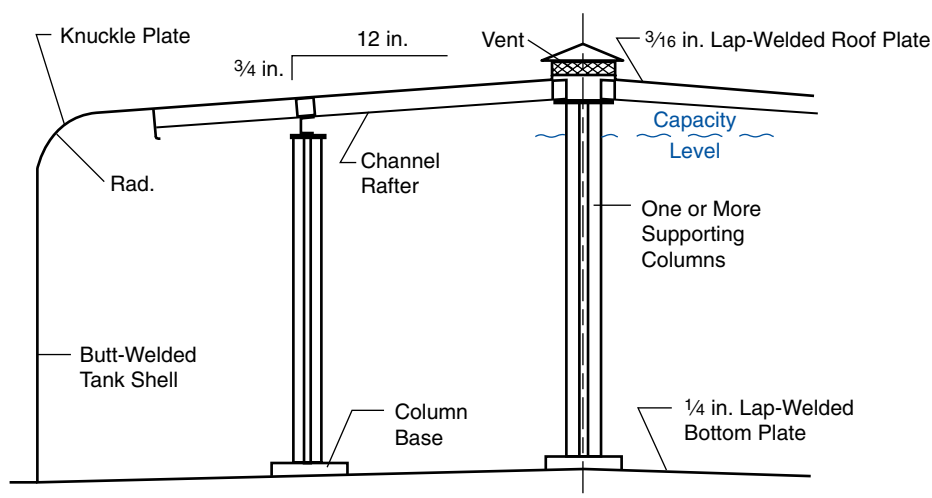


Figure 1-10 Column- and rafter-supported roof with knuckle

Self-Supporting Dome Roof and Umbrella Roof

Steel self-supporting roofs are constructed of plates that are butt welded, lap welded, or lap bolted. They are supported directly on the top angle and shell plate. This type of roof is used where an uncluttered interior and smooth exterior appearance are desired. Dome roof sections are pressed to form a spherical shape. Umbrella roofs are formed to a radius in one direction only, forming chords like the cloth between the spines of an umbrella (Figure 1-11).

Structural stiffeners may be used internally on large-diameter roofs to avoid excessive plate thickness on welded or bolted tanks. Sometimes steel trusses may be used to support the roof, but these should be avoided if possible because they may create corrosion problems and increased coating costs. In addition, the trusses should be kept above the water line to avoid damage by ice and accelerated rates of corrosion.

A modification of the self-supporting dome is the toriconical roof, which consists of a rolled or pressed knuckle and a higher-pitched self-supporting center.

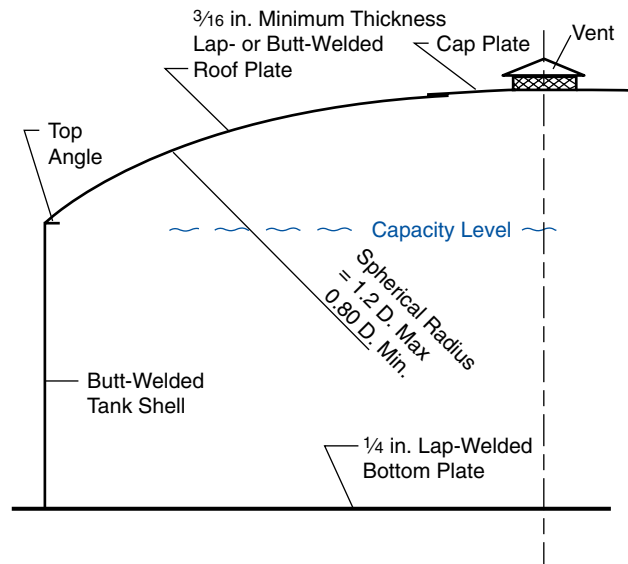


Figure 1-11 Self-supporting dome roof or umbrella roof

Aluminum dome roofs are sometimes erected on bolted or welded steel tanks in accordance with ANSI/AWWA D108, Standard for Aluminum Dome Roofs for Water Storage Facilities. These aluminum domes are usually constructed of triangulated space truss (geodesic) panels. The dead weight of these domes is usually 3 lb/ft² (143 N/m²) or less, as compared with 3.8 lb/ft² (181 N/m²) for a bolted steel roof and 7.6 lb/ft² (364 N/m²) for a welded steel roof.

Self-Supporting Ellipsoidal Roof

The self-supporting ellipsoidal roof is not a true ellipse, but it is formed with two radii yielding major and minor axis proportions of approximately 2:1. The transition from shell to roof is a smooth unbroken curve (Figure 1-12). This roof design is suitable for large- and small-diameter reservoirs and standpipes. On tanks of 50-ft (15-m) diameter or less, the roof is usually free of internal structural members. Larger-diameter tanks usually have radial and circumferential stiffening members or rafters, which may be subject to corrosion problems if they are not properly designed or maintained.

Self-Supporting Cone Roof

An inexpensive and very functional type of roof for small-diameter reservoirs and standpipes is the self-supporting cone roof without internal structural members. This roof will normally be too steep to walk on. Access to manholes and vents by a roof ladder or steps and handrail should be provided. All means of access should be designed individually and installed to comply with current standards.

ELEVATED TANKS

An elevated steel water tank has two primary components: the tank itself and its supporting structure. Such tanks are ordinarily used where ground elevation is insufficient to ensure distribution of water at suitable pressure by gravity. Typically these tanks are of welded construction, but they can also be of bolted construction.

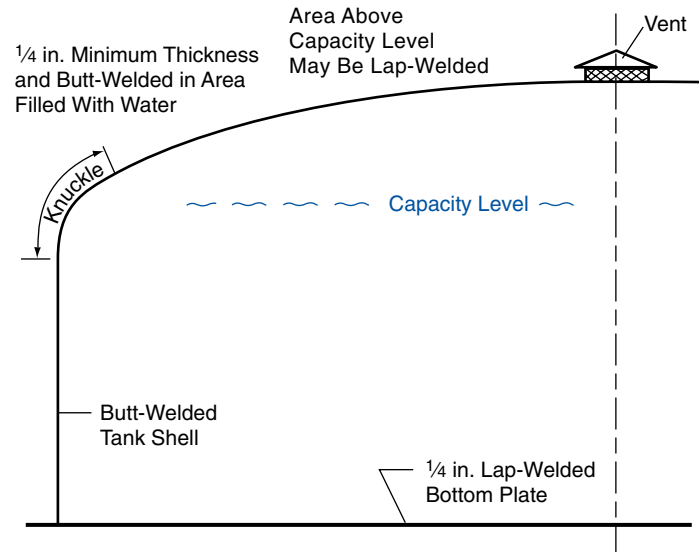


Figure 1-12 Self-supporting ellipsoidal roof

Elevated tanks can be categorized into several different types. The various diameters and head ranges for the tanks shown in the remaining figures and tables in this chapter are only representative and may vary with individual fabricators. Specific diameter/head range combinations should be determined by the tank fabricator within the limits indicated in the tables. Height should be specified by the purchaser as the dimension between the top of the foundation and the top capacity level of the tank. Further dimensions, which are a function of the fabricator's standard, should not be specified. In order to minimize cost, desired operating ranges should be specified to fall within standard available tank dimensions. However, individual operating needs may dictate nonstandard operating ranges.

MULTIPLE-COLUMN ELEVATED TANKS

Small-Capacity Elevated Tanks

The small-capacity multiple-column elevated (or double-ellipsoidal) tank has a cylindrical sidewall, an ellipsoidal bottom and roof, and a top capacity level in the roof several feet above the top of the cylindrical shell. Although in the past they were constructed in capacities up to 1 mil gal (3.8 ML), today double-ellipsoidal tanks are typically constructed only in capacities of 200,000 gal (760,000 L) or less. A photo and a cross-sectional view of a small-capacity elevated tank are shown in Figures 1-13 and 1-14. Table 1-4 gives typical sizes of double-ellipsoidal elevated tanks.

Medium-Capacity Elevated Tanks

For medium-capacity multiple-column elevated tanks, the toroellipsoidal design provides a lower initial cost by most efficiently using the strength of steel. The features used (torus bottom and ellipsoidal roof) cause the central riser to support, as well as contain, a considerable portion of the stored water, while the major portion of the steel bottom acts as a membrane in tension. These tanks usually have a capacity between 200,000 gal (760,000 L) and 500,000 gal (1.9 ML). A photo and a cross-sectional view of a medium-capacity elevated tank are shown in Figures 1-15 and 1-16. Table 1-5 gives typical sizes of medium-capacity elevated tanks.

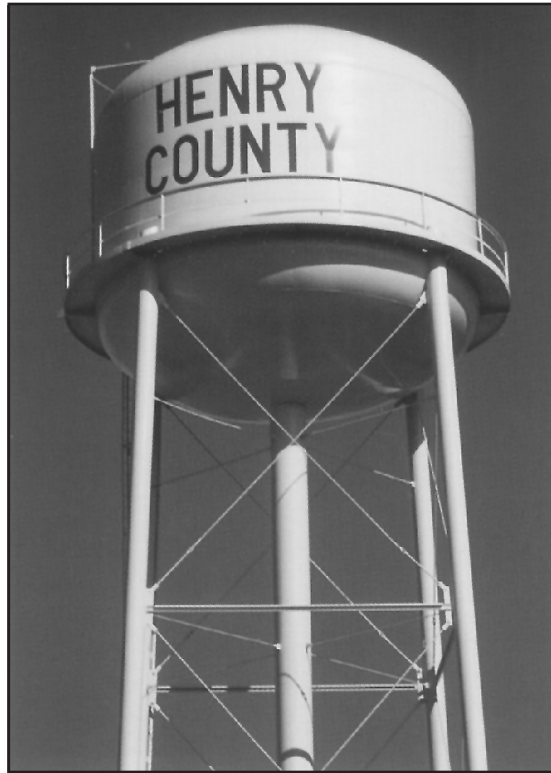


Figure 1-13 Double-ellipsoidal tank

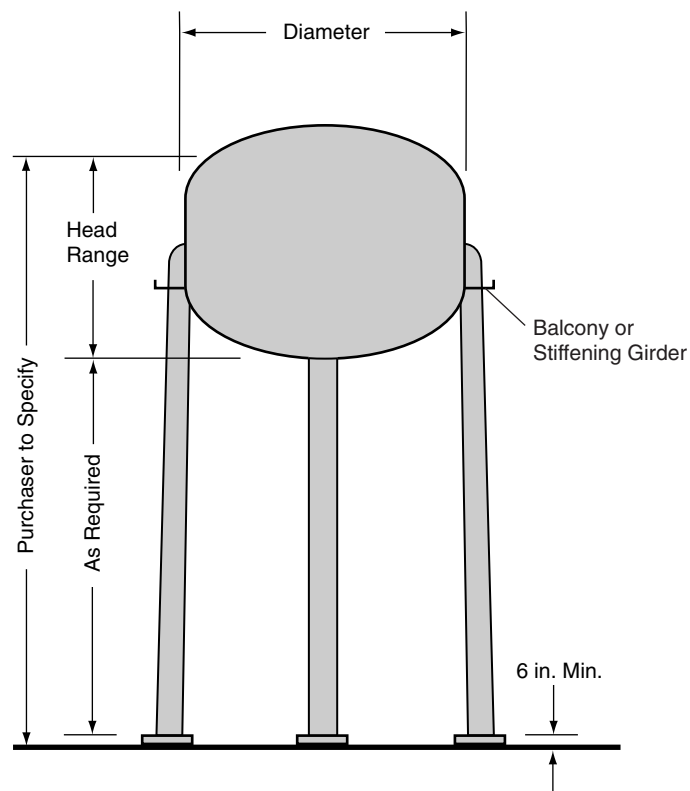


Figure 1-14 Cross-sectional view of double-ellipsoidal tank

Table 1-4 Typical double-ellipsoidal steel elevated tank sizes

Capacity		Range of Sizes Available			
<i>gal</i>	<i>m</i> ³	Diameter	Head Range	Diameter	Head Range
		<i>ft</i>	<i>ft</i>	<i>m</i>	<i>m</i>
25,000	95	18–20	12.5–15.5	5.5–6.1	3.3–4.7
30,000	114	18–20	15.0–16.5	5.5–6.1	4.6–5.0
40,000	150	22–23	15.0–17.0	5.7–7.0	4.6–5.2
50,000	189	22–24	18.0–20.0	6.7–7.3	5.5–6.1
60,000	227	22–25	19.0–23.0	6.7–7.6	5.3–7.0
75,000	234	26–30	16.0–24.0	7.9–9.1	4.9–7.3
100,000	379	28–30	20.0–25.0	8.5–9.1	6.1–7.6
125,000	473	30–32	23.0–28.0	9.1–9.7	7.0–8.5
150,000	568	32–34	24.5–29.5	9.7–10.4	7.5–9.0
200,000	757	36–38	28.0–29.5	11.0–11.6	8.5–9.0

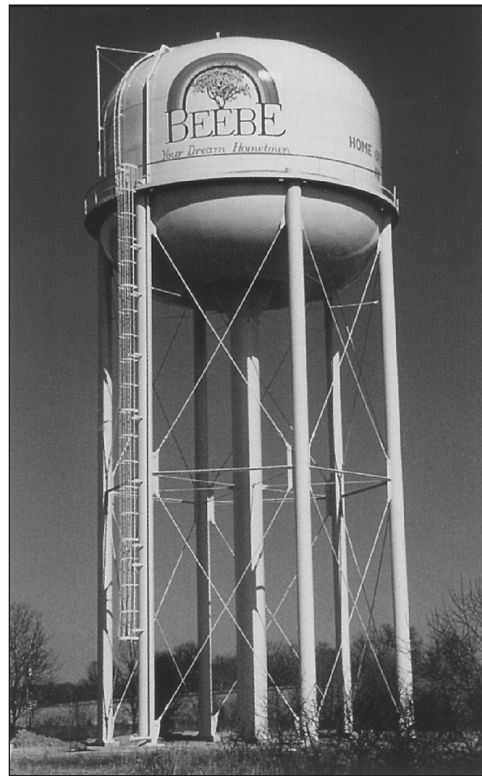


Figure 1-15 Medium-capacity welded elevated tank

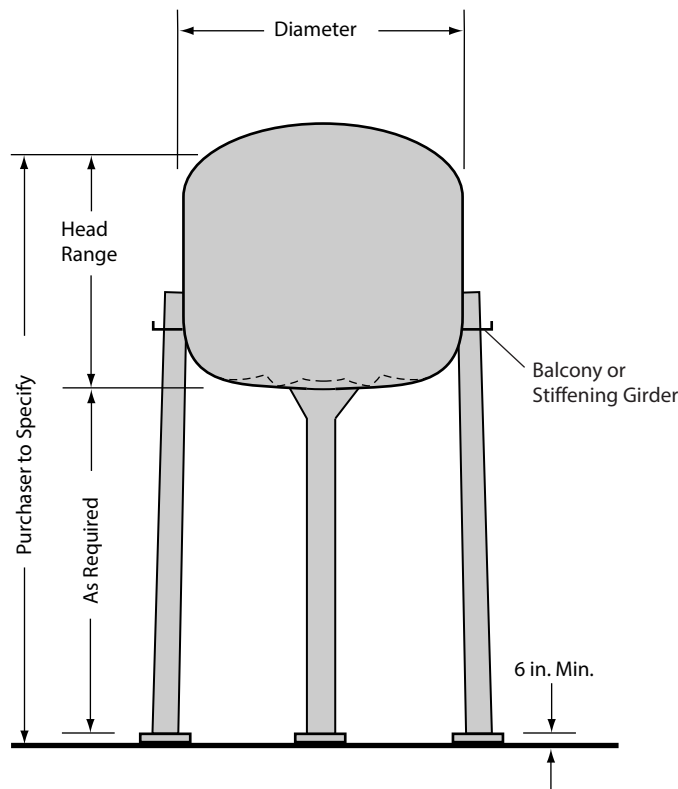


Figure 1-16 Cross-sectional view of medium-capacity torus-bottom welded elevated tank

Table 1-5 Typical medium-capacity welded steel elevated tank sizes

Capacity		Range of Sizes Available			
<i>gal</i>	<i>m</i> ³	Diameter <i>ft</i>	Head Range <i>ft</i>	Diameter <i>m</i>	Head Range <i>m</i>
200,000	757	36–38	28–30	11.0–11.6	8.5–9.1
250,000	946	38–40	28–33	11.6–12.2	8.5–10.1
300,000	1,135	43–45	28–31	13.1–13.7	8.5–9.4
400,000	1,515	46–50	30–36	14.0–15.2	9.1–11.0
500,000	1,890	50–56	29–38	15.2–17.1	8.8–11.5
750,000	2,840	56–65	34–45	17.1–19.8	10.4–13.7
1,000,000	3,785	64–65	45–46	19.5–19.8	13.7–4.0

Large-Capacity Multiple-Column Elevated Tanks

Large-capacity elevated tanks (>500,000 gal [1,890 m³]) provide economical service for communities that need to store a substantial volume of water. Lower operating and pumping costs are ensured because of the low head range, which achieves minimum variation of water pressure throughout the system. A photo and a cross-sectional view of a large-capacity elevated tank are shown in Figures 1-17 and 1-18. Table 1-6 gives typical sizes of large-capacity elevated tanks.

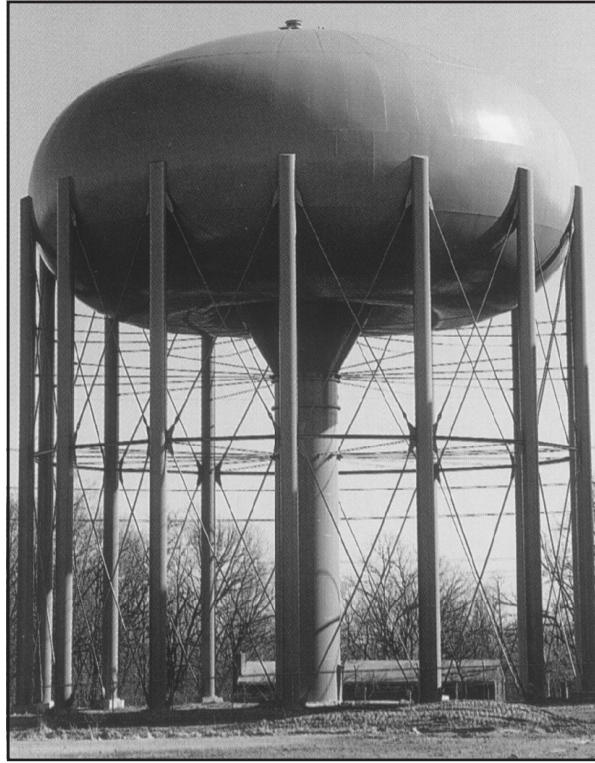


Figure 1-17 Large-capacity elevated tank

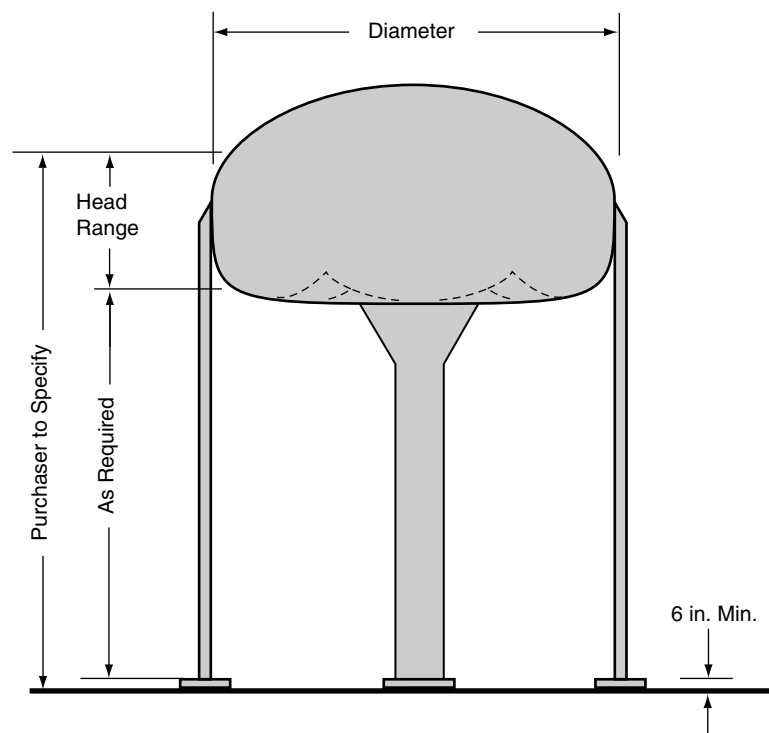


Figure 1-18 Cross-sectional view of large-capacity multi-column elevated tank

Table 1-6 Typical large-capacity welded steel elevated tank sizes

Capacity		Range of Sizes Available			
<i>gal</i>	<i>m</i> ³	Diameter	Head Range	Diameter	Head Range
		<i>ft</i>	<i>ft</i>	<i>m</i>	<i>m</i>
500,000	1,890	60–65	24–25	18.3–19.8	7.3–7.9
600,000	2,270	65–70	24–25	19.8–21.3	7.3–7.9
750,000	2,840	70–76	25–30	21.3–23.2	7.6–9.1
1,000,000	3,735	75–87	25–35	22.9–25.5	7.6–10.7
1,500,000	5,680	91–98	30–35	27.7–29.9	9.1–10.7
2,000,000	7,570	105–106	34–36	32.0–32.3	10.4–11.0
2,500,000	9,465	108–117	39–41	32.9–35.7	11.9–12.5
3,000,000	11,360	119–127	35–40	36.3–38.7	10.7–12.2

PEDESTAL ELEVATED TANKS

Small-Capacity Single-Pedestal Tanks

The single-pedestal spherical tank, widely favored for smaller tank capacities, is often used when appearance is a concern. The gracefully flared base contains sufficient space for pumping units and other operating equipment, a feature common to all pedestal-type vessels.

Ladders to access the container and roof are inside to protect against unauthorized access. Such tanks are usually constructed in capacities of 200,000 gal (760,000 L) or less. A photo and a cross-sectional view of a small-capacity single-pedestal tank are shown in Figures 1-19 and 1-20. Table 1-7 gives typical sizes of small-capacity single-pedestal tanks.

Small-capacity elevated tanks are also constructed as various combinations of cones and cylinders. An alternative design is shown in Figure 1-21.

Large-Capacity Single-Pedestal Tanks

The tubular supporting pedestal gives the large-capacity single-pedestal tank a distinctively contemporary look. Large capacities (0.2–2 mil gal [0.76–7.6 ML]) are provided by this low-head-range spheroidal tank design. A photo and a cross-sectional view of a large-capacity single-pedestal tank are shown in Figures 1-22 and 1-23. Table 1-8 gives typical sizes of large-capacity single-pedestal tanks.

Modified Single-Pedestal Tanks

The attractive modified single-pedestal tank has a central support column, usually fluted to give structural rigidity, that encloses the riser pipe, overflow pipe, and access ladder to the tank roof. The support column may be constructed of steel or concrete. The space within the column can provide multistory usable floor space for pumping, storage, and office facilities. Although available in all capacities, these tanks are not usually constructed in capacities below 500,000 gal (1.9 ML). A photo and a cross-sectional view of a modified single-pedestal tank are shown in Figures 1-24 and 1-25. Table 1-9 gives typical sizes of modified single-pedestal tanks.



Figure 1-19 Spherical single-pedestal tanks give pleasant silhouette

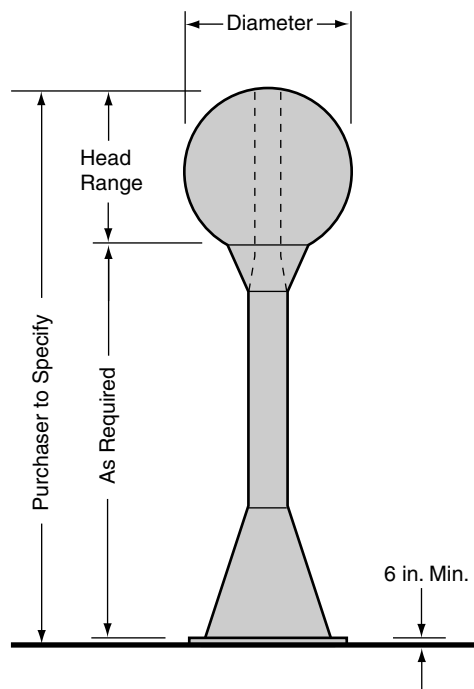


Figure 1-20 Cross-sectional view of small-capacity spherical single-pedestal tank

Table 1-7 Typical small-capacity single-pedestal steel elevated tank sizes

Capacity		Range of Sizes Available			
<i>gal</i>	<i>m³</i>	Diameter <i>ft</i>	Head Range <i>ft</i>	Diameter <i>m</i>	Head Range <i>m</i>
25,000	95	19–20	15–17	5.8–6.1	4.6–5.2
30,000	114	20–21	15–18	6.1–6.4	4.6–5.5
40,000	150	21–23	19–22	6.4–7.0	5.8–6.7
50,000	189	23–24	19–23	7.0–7.3	5.8–7.0
60,000	227	24–26	22–24	7.3–7.9	6.7–7.3
75,000	234	25–28	23–27	7.9–8.5	7.0–8.2
100,000	379	29–30	25–30	8.8–9.1	7.6–9.1
125,000	473	31–33	27–32	9.4–10.0	8.2–9.7
150,000	568	33–34	30–34	10.1–10.4	9.1–10.4
200,000	757	36–38	36–38	11.0–11.6	11.0–11.6



Figure 1-21 Alternative single-pedestal tank design



Figure 1-22 Large-capacity single-pedestal elevated tank

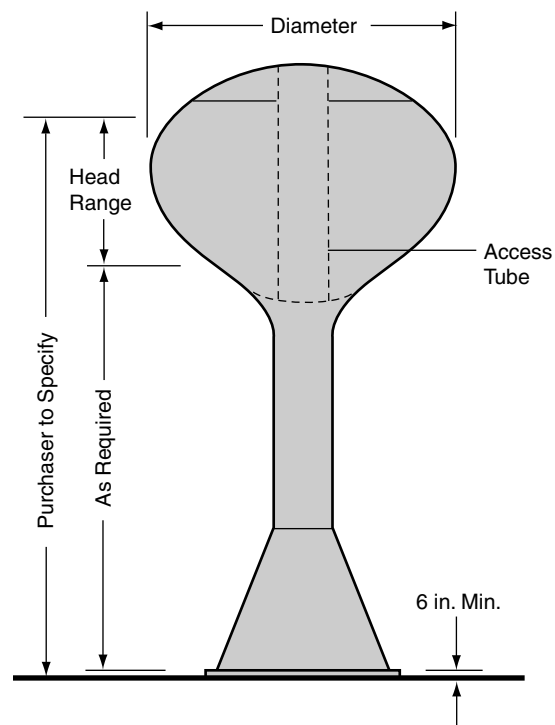


Figure 1-23 Cross-sectional view of large-capacity single-pedestal elevated tank

Table 1-8 Typical large-capacity single-pedestal steel elevated tank sizes

Capacity		Range of Sizes Available			
<i>gal</i>	<i>m³</i>	Diameter <i>ft</i>	Head Range <i>ft</i>	Diameter <i>m</i>	Head Range <i>m</i>
200,000	757	40–42	27–30	12.2–12.8	8.2–9.1
250,000	946	43–47	25–32	13.1–14.3	7.6–9.7
300,000	1,135	46–48	30–33	14.0–14.6	9.1–10.1
400,000	1,515	50–53	30–40	15.2–16.1	9.1–12.2
500,000	1,890	55–60	30–40	16.3–18.3	9.1–12.2
750,000	2,840	64–66	38–42	19.5–20.1	11.6–12.3
1,000,000	3,785	74–78	35–40	22.5–23.8	10.7–12.2
1,250,000	4,750	76–80	40–45	22.9–24.4	12.2–13.7
1,500,000	5,880	85–90	45–50	25.9–27.4	13.7–15.2
2,000,000	7,570	90–95	50–55	27.4–29.0	15.2–16.3

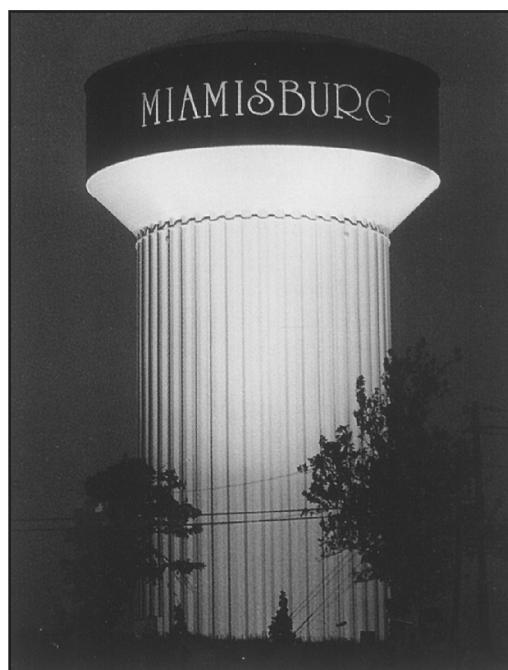


Figure 1-24 Folded-plate design of a modified single-pedestal tank support

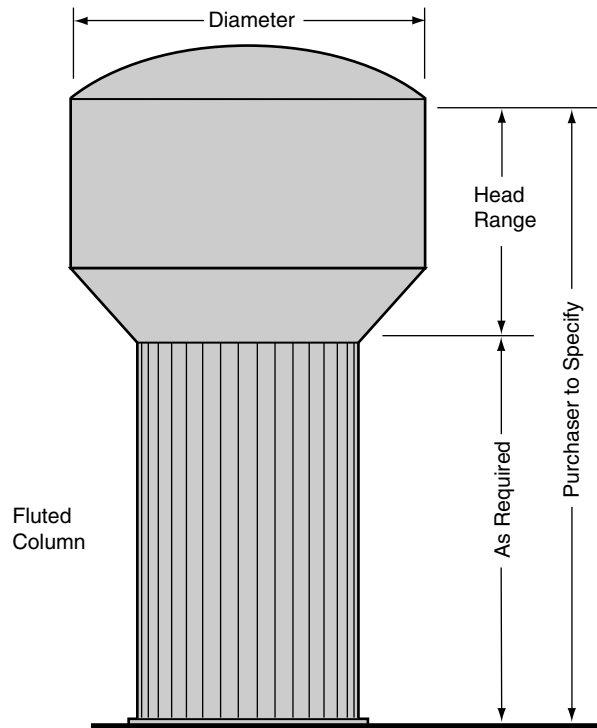


Figure 1-25 Cross-sectional view of modified single-pedestal tank

Table 1-9 Typical modified single-pedestal steel elevated tank sizes

Capacity		Range of Sizes Available			
<i>gal</i>	<i>m³</i>	Diameter <i>ft</i>	Head Range <i>ft</i>	Diameter <i>m</i>	Head Range <i>m</i>
250,000	946	41–43	29–31	12.5–13.1	8.8–9.4
300,000	1,135	43–45	29–31	13.1–13.7	8.8–9.4
500,000	1,890	49–64	30–39	14.9–19.5	9.1–11.9
750,000	2,840	63–65	37–40	19.2–19.8	11.3–12.2
1,000,000	3,785	73–78	35–42	22.2–23.8	10.7–12.8
1,500,000	5,680	85–87	39–46	25.9–26.5	11.9–14.0
2,000,000	7,570	97–102	38–46	29.6–31.1	11.6–14.0
2,500,000	9,465	107–110	43–45	32.6–33.5	13.1–13.7
3,000,000	11,360	109–120	40–45	33.3–36.6	12.2–13.7

Composite Elevated Tanks

Composite elevated tanks are an attractive design that uses the best design features of steel and concrete. Concrete, which is excellent for compression loads, is used as the support column for the steel water tank. Concrete has the advantage of requiring either no painting or a low cost exterior coating for aesthetic purposes. Two tank types are available: welded and bolted.

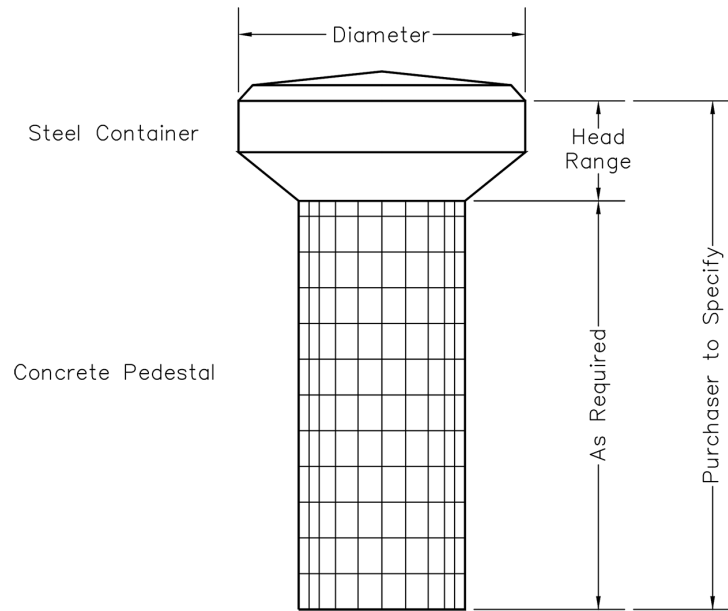
Welded tanks. The steel bowl construction is similar to that found on the fluted-column tanks; the bowl can be built with either a cone or a domed roof. The most common designs use a domed concrete floor with a steel liner. Commonly built to store between 500,000 gal and 2 mil gal (1.7 and 7.6 ML), these tanks provide many of the benefits of a fluted-column tank with significantly less area requiring painting, thereby reducing maintenance costs. A photo and a cross-sectional view of a composite elevated welded tank are shown in Figures 1-26 and 1-27. Table 1-10 gives typical sizes of composite elevated welded tanks.

Bolted tanks. The design and construction of an elevated bolted steel tank is similar to those used for a ground-supported, bolted steel tank. Common capacities range from 150,000 gal to 1.5 mil gal (0.6 and 5.7 ML). The tanks are factory-coated and supported by a reinforced concrete slab that is constructed at the top of the concrete support column. The slab becomes an elevated foundation for the tank and can be designed and constructed to serve as the tank bottom, or a bolted steel bottom may be erected on top of the slab. Roofs may be bolted steel or bolted aluminum domes. A photo and a cross-sectional view of a composite elevated bolted tank are shown in Figures 1-28 and 1-29. Table 1-11 gives typical sizes of composite elevated bolted tanks.



Courtesy of Walter Lagarenne

Figure 1-26 Composite elevated welded tank



Courtesy of Tank Industry Consultants

Figure 1-27 Cross-sectional view of a composite elevated welded tank

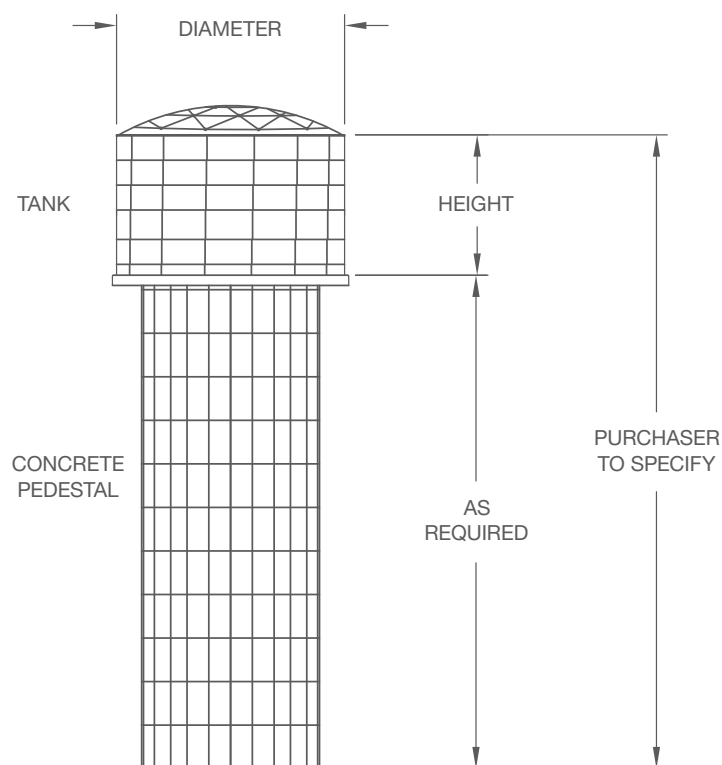
Table 1-10 Typical composite elevated welded tank sizes

Capacity		Range of Sizes Available			
<i>gal</i>	<i>m³</i>	Diameter <i>ft</i>	Head Range <i>ft</i>	Diameter <i>m</i>	Head Range <i>m</i>
500,000	1,890	50–55	35–40	16.3–18.3	10.7–12.2
750,000	2,840	58–60	38–42	19.5–20.1	11.6–12.8
1,000,000	3,785	68–72	38–42	22.5–23.8	11.6–12.8
1,250,000	4,750	78–80	38–42	23.8–24.4	11.6–12.8
1,500,000	5,680	85–90	38–42	25.9–27.4	11.6–12.8
2,000,000	7,570	90–95	42–47	27.4–29.0	12.8–14.3
2,500,000	9,460	103–107	42–47	31.4–32.6	12.8–14.3
3,000,000	11,360	115–120	42–47	35.1–36.6	12.8–14.3
3,500,000	13,250	115–120	48–52	35.1–36.6	14.6–15.8



Courtesy of CST Storage

Figure 1-28 Composite elevated bolted tank



Courtesy of CST Storage

Figure 1-29 Cross-sectional view of a composite elevated bolted tank

Table 1-11 Typical composite elevated bolted tank sizes

Capacity		Range of Sizes Available			
		Diameter	Height	Diameter	Height
<i>gal</i>	<i>m³</i>	<i>ft</i>	<i>ft</i>	<i>m</i>	<i>m</i>
150,000	568	28	33	8.5	10.1
200,000	757	31	33	9.4	10.1
300,000	1,140	39	33	11.9	10.1
500,000	1,890	50	33	15.2	10.1
750,000	2,840	59	38	18.0	11.6
1,000,000	3,785	62	47	18.9	14.3
1,500,000	5,680	67	56	20.4	17.1

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Chapter 2

Appurtenances

This chapter briefly describes the construction and function of common appurtenances for steel water-storage tanks. Appurtenances are covered in separate sections of ANSI/AWWA D100, Standard for Welded Carbon Steel Tanks for Water Storage, ANSI/AWWA D103, Standard for Factory-Coated Bolted Carbon Steel Tanks for Water Storage, and ANSI/AWWA D107, Standard for Composite Elevated Tanks for Water Storage. The majority of the appurtenances and attachments described for steel water-storage tanks are required by law, code, and industry standards to make the tank a safe and functional facility. Other accessories are optional and may be specified by the owner to improve the facility's function or appearance.

SHELL MANHOLES

A minimum of two opposing shell manholes are required on welded ground-supported tanks for ventilation during interior coating operations, for safety, and for ease of interior access during construction activities and maintenance inspections. On tanks more than 100 ft (30.5 m) in diameter, it may be desirable to have three or more shell manholes. ANSI/AWWA D103 requires only one shell manhole on bolted tanks because a tank panel can be removed to provide additional ventilation.

Sizes and Types

Normal manhole sizing is 24 or 30 in. (610 or 760 mm) in diameter to accommodate ventilating equipment and allow easy egress (Figures 2-1 and 2-2). Outward-opening, hinged covers or single-bolt, inward-opening manholes are standard. Outward-opening covers may require reinforcing plates on the shell, whereas inward-opening manholes usually accomplish their reinforcement through heavy plate necks. The heavy plate neck also provides the gasket surface to the cover. The inward-opening cover must be hinged to ensure proper operation. If a tank will be subject to severe icing conditions, an inward-opening manhole may not be desirable.