

NFPA® 22

Standard for Water Tanks for Private Fire Protection

2023 Edition



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NFPA® 22

Standard for

Water Tanks for Private Fire Protection

2023 Edition

This edition of NFPA 22, *Standard for Water Tanks for Private Fire Protection*, was prepared by the Technical Committee on Water Tanks. It was issued by the Standards Council on April 14, 2022, with an effective date of May 4, 2022, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See “Codes & Standards” at www.nfpa.org for more information.

This edition of NFPA 22 was approved as an American National Standard on May 4, 2022.

Origin and Development of NFPA 22

In 1909, the NFPA Committee on Gravity Tanks developed the *Standard on Gravity Tanks*. Amendments were considered in 1912 and 1913, and the standard was adopted in 1914. Revised or amended editions were adopted in 1915, 1917, 1918, 1919, 1922, 1926, 1928, 1930, 1931, 1933, 1936, 1941, 1949, and 1950.

The name of the committee was changed to the Committee on Water Tanks, and its recommendations resulted in changes adopted in 1957, 1958, 1962, 1965, 1967, 1970, 1971, 1974, 1976, 1978, 1981, and 1987.

Tanks other than gravity tanks (which, at that time, included concrete reservoirs) and valve pits were first covered in 1913, pressure tanks (formerly covered by *Standards for Sprinkler Systems*) were covered in 1915, and tank heating was covered in 1922. The standard title has been periodically amended to reflect the expanded scope of the standard.

The 1993 edition provided new, environmentally friendly requirements for tank-coating systems. Two new chapters were included to cover the design and erection of bolted steel tanks and concrete tanks. Information on fiberglass tanks also was included. These changes, along with other editorial changes, reflected the current information for water storage tank design.

The 1996 edition of NFPA 22 consolidated tank care and maintenance information within a single chapter. Further revisions addressed the corrosion resistance of certain tank components, access into tanks, the monitoring of internal conditions, and the structural stresses to which tanks are subjected. The figures in Appendix B were revised to reflect current practices. Editorial changes were also made.

The 1998 edition further addressed environmental issues. All inspection, testing, and maintenance requirements were removed and added to the appropriate chapter of the 1998 edition of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.

The 2003 edition was changed to conform to the *Manual of Style for NFPA Technical Committee Documents*, 2000 edition. Referenced publications were updated.

The 2008 edition recognized the use of fiberglass-reinforced plastic (FRP) tanks with a new Chapter 11. Acceptance test requirements were consolidated into a new Chapter 17, “Acceptance Test Requirements,” to improve user-friendliness.

The 2013 edition added sizing requirements for break tanks in Chapter 4 and sizing procedures for pressure tanks in the Chapter 7 annex material. The term *suction tank* was defined, and the requirements for anti-vortex plates were revised. Table 5.4 was updated to align with current industry standards.

The 2018 edition substantially modified Chapters 5 and 6. In Chapter 5 all duplicate requirements to AWWA D100 have been removed and reference to AWWA D100 has been made;

requirements specific to fire protection remain in Chapter 5. In Chapter 6 all duplicate requirements to AWWA D103 have been removed and reference to AWWA D103 made; requirements specific to fire protection remain in Chapter 6. Requirements for check valves in the discharge pipe of a suction tank have been clarified in Chapter 14, and tank repair requirements have been modified requiring the impairment procedures of NFPA 25 to be followed. Chapter 16 has added new criteria for electric immersion heaters, and the lowest one-day mean temperature map has been removed in lieu of using calculations to determine tank heating needs.

The 2023 edition was revised to remove redundant sections to provide clarity. Sections related to external loads, such as wind, snow, and live load requirements, have been updated to recognize other standards, and to replace outdated design approaches. Tank sizing requirements have been updated to ensure that pump suction pressure is considered when designing water tanks. Water tank construction features have been updated in line with newly referenced standards, and other applicable standards have been recognized by the standard. Additional valve requirements have been incorporated to improve maintainability. Fill line and suction pipe separation distances have been provided to prevent cavitation in the fire pump. Editorial corrections, such as unit conversions, were made where applicable. References have been updated to the latest applicable codes and standards.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on the design, construction, installation, and maintenance of tanks and accessory equipment supplying water for fire extinguishment, including gravity and pressure tanks, towers and foundations, pipe connections and fittings, valve enclosures and frost protection, and tank heating equipment.

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NFPA 22

Standard for

Water Tanks for Private Fire Protection

2023 Edition

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

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Information on referenced publications can be found in Chapter 2 and Annex C.

Chapter 1 Administration

1.1 Scope. This standard provides the minimum requirements for the design, construction, installation, and maintenance of tanks and accessory equipment that supply water for private fire protection, including the following:

- (1) Gravity tanks, suction tanks, pressure tanks, and embankment-supported coated fabric suction tanks
- (2) Towers
- (3) Foundations
- (4) Pipe connections and fittings
- (5) Valve enclosures
- (6) Tank filling
- (7) Protection against freezing

1.2 Purpose. The purpose of this standard is to provide a basis for the design, construction, operation, and maintenance of water tanks for private fire protection.

1.3 Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.3.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.3.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.3.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

1.4 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.4.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.4.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.5 Types of Tanks. This standard addresses elevated tanks on towers or building structures, water storage tanks that are at grade or below grade, and pressure tanks.

1.5.1 Bladder Tanks Not Within the Scope of NFPA 22. The following types of bladder tanks shall not be required to meet NFPA 22:

- (1) Listed bladder tanks used as surge suppressors on the discharge side of fire pumps installed in accordance with NFPA 20
- (2) Listed bladder tanks used as expansion tanks for anti-freeze sprinkler systems installed in accordance with NFPA 13
- (3) Bladder tanks used as foam concentrate tanks installed in accordance with NFPA 11

1.5.2 Bladder Tanks Within the Scope of NFPA 22. Bladder tanks shall be permitted to be a part of the water supply for a fire protection system when they meet the requirements for pressure tanks of this standard.

1.6 Units.

1.6.1 Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The bar unit, which is outside of but recognized by SI, is commonly used in international fire protection. Metric units and their conversion factors are shown in Table 1.6.1.

Table 1.6.1 Metric Unit Conversion Factors

Name of Unit	Unit Symbol	Conversion Factor
bar	bar	1 psi = 0.0689 bar
bar	bar	1 bar = 10 ⁵ Pa

Note: For additional conversions and information, see IEEE/ASTM SI 10.

1.6.2 If a value for measurement in this standard is followed by an equivalent value that is expressed in other units, the first stated value shall be regarded as the requirement. A given equivalent value could be approximate.

1.6.3 SI units in this standard have been converted by multiplying the number of units by the conversion factor and then rounding the result to the appropriate number of significant digits.

1.6.4 Where sizes for pipe, sheet and plate steel, and wire gages are indicated, they are noted in trade sizes and not by hard conversions.

N 1.7 New Technology.

N 1.7.1 Nothing in this standard shall be intended to restrict new technologies or alternate arrangements, provided the level of safety prescribed by this standard is not lowered.

N 1.7.2 Materials or devices not specifically designated by this standard shall be utilized in complete accord with all conditions, requirements, and limitations of their listings.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2021 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2022 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2022 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2022 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2022 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2023 edition.

NFPA 70®, *National Electrical Code®*, 2023 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2022 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, 2022 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2023 edition.

2.3 Other Publications.

2.3.1 ACI Publications. American Concrete Institute, 38800 Country Club Drive, Farmington Hills, MI 48331-3439.

ACI 318, *Building Code Requirements for Structural Concrete and Commentary*, 2019.

ACI 350, *Code Requirements for Environmental Engineering Concrete Structures*, 2006.

2.3.2 AISC Publications. American Institute of Steel Construction, 130 East Randolph Street, Suite 2000, Chicago, IL 60601.

ANSI/AISC 360, *Specification for Structural Steel Buildings*, 2019.

2.3.3 API Publications. American Petroleum Institute, 200 Massachusetts Avenue NW, Suite 1100, Washington, DC 20005-4070.

API SPEC 5L, *Specification for CRA Line Pipe*, 4th edition, 2018.

2.3.4 ASHRAE Publications. ASHRAE Inc., 180 Technology Parkway NW, Peachtree Corners, GA 30092.

ASHRAE *Handbook — Fundamentals*, 2017.

2.3.5 ASME Publications. American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

Boiler and Pressure Vessel Code, “Rules for the Construction of Unfired Pressure Vessels,” 2021.

2.3.6 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM A36/A36M, *Standard Specification for Carbon Structural Steel*, 2019.

ASTM A53/A53M, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*, 2020.

ASTM A106/A106M, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*, 2019a.

ASTM A108, *Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished, Standard Quality*, 2018.

ASTM A131/A131M, *Standard Specification for Structural Steel for Ships*, 2019.

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ASTM A502, *Standard Specification for Rivets, Steel, Structural*, 2015.

ASTM A516/A516M, *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*, 2017.

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ASTM D2261, *Standard Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant-Rate-of-Extension Tensile Testing Machine)*, 2017.

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AWWA D102, *Coating Steel Water-Storage Tanks*, 2017.

AWWA D103, *Factory-Coated Bolted Carbon Steel Tanks for Water Storage*, 2019.

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AWWA D106, *Sacrificial Anode Cathodic Protection Systems for the Interior Submerged Surfaces of Steel Water Storage Tanks*, 2020.

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AWWA D108, *Aluminum Dome Roofs for Water Storage Facilities*, 2019.

AWWA D110, *Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks*, 2018.

AWWA D115, *Tendon-Prestressed Concrete Water Tanks*, 2019.

AWWA D120, *Thermosetting Fiberglass-Reinforced Plastic Tanks*, 2019.

AWWA D121, *Bolted Aboveground Thermosetting Fiberglass-Reinforced Plastic Panel-Type Tanks for Water Storage*, 2014.

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NWTI Bulletin S82, *Specifications for Tanks and Pipes*, 1982.

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SSPC SP 6/NACE No. 3, *Commercial Blast Cleaning*, 2007.

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2.4 References for Extracts in Mandatory Sections. (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.2.7 Standard. An NFPA **standard**, the main text of which contains only mandatory provisions using the word "shall" to

indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA manuals of style. When used in a generic sense, such as in the phrases “standards development process” or “standards development activities,” the term “standards” includes all NFPA standards, including codes, standards, recommended practices, and guides.

3.3 General Definitions.

3.3.1 Holiday. A discontinuity in the coating system that includes, but is not limited to, voids, cracks, pinholes, or scratches.

3.3.2 Tank.

3.3.2.1* Bladder Tank. A type of pressure tank containing air and water separated by a flexible membrane (bladder).

3.3.2.2 Break Tank. A tank providing suction to a fire pump whose capacity is less than the fire protection demand (flow rate times flow duration).

3.3.2.3* Gravity Tank. A storage tank that uses elevation (head) as a source of pressure.

3.3.2.4* Pressure Tank. A tank that uses air or some other gas under pressure as a means of expelling its contents.

3.3.2.5 Suction Tank. A tank that provides water to a fire pump for which a minimal amount of head pressure is provided.

3.3.3* Tank Riser. A large diameter shaft that surrounds and encloses the piping below an elevated gravity tank to provide a measure of insulation and protection.

Chapter 4 General Information

4.1 Capacity and Elevation.

4.1.1* The size and elevation of tanks shall be determined by the required fire flow and duration for the attached fire protection system(s) and the pressures required.

4.1.2 Standard sizes of tanks shall be as specified in 5.1.3, 6.1.2, 8.1.3, and Sections 9.2 and 10.3.

4.1.3 Tanks other than standard size shall be permitted.

4.1.4* For suction tanks, the net capacity shall be the number of U.S. gallons (cubic meters) between the inlet of the overflow and the level of the vortex plate.

4.1.5 For all tanks other than suction tanks, the net capacity shall be the number of U.S. gallons (cubic meters) between the inlet of the overflow and the discharge outlet.

4.1.6* A tank shall be sized so that the net capacity plus automatic refill shall meet the system demand for the design duration, except as modified by Section 14.5 for break tanks.

4.2 Water Sources.

4.2.1* The adequacy and dependability of the water source for filling the tank are of primary importance and shall be fully determined, with due allowance for its reliability in the future.

4.2.1.1 Any source of water that is adequate in quality, quantity, pressure, and reliability to fill the tank in accordance with this standard shall be permitted.

4.2.1.2 Where the water supply from a public service main is not adequate in quality, quantity, or pressure, an alternative water source shall be provided.

4.2.1.3 The adequacy of the water supply shall be determined and evaluated prior to the specification and installation of the tank.

4.2.1.4 The water supply shall be capable of filling the minimum required fire protection volume within the tank in a maximum of 8 hours.

4.3 Location of Tanks.

4.3.1 The location of tanks shall be such that the tank and structure are protected from fire exposure in accordance with 4.3.1.1 through 4.3.1.5.

4.3.1.1 If lack of yard room makes this impracticable, the exposed steel work shall be suitably fireproofed or shall be protected by open sprinklers (see A.13.1.1).

4.3.1.2 Fireproofing, where necessary, shall be provided for steelwork supporting tanks within 20 ft (6.1 m) of exposures, combustible buildings or windows, and doors from which fire might issue.

4.3.1.3 Where used for supports near combustible construction or occupancy inside the building, steel or iron shall be fireproofed 6 ft (1.8 m) above combustible roof coverings, and within 20 ft (6.1 m) of windows and doors from which fire might issue.

4.3.1.4 Steel beams or braces that join two building columns that support a tank structure shall also be suitably fireproofed where near combustible construction or occupancy.

4.3.1.5 Interior timber shall not be used to support or brace tank structures.

4.3.2 Fireproofing, where required, shall have a fire resistance rating of not less than 2 hours.

4.3.3 Foundations or footings shall furnish adequate support and anchorage for the tower.

4.3.4 If the tank or supporting trestle is to be placed on a building, the building shall be designed and built to carry the maximum loads.

4.4 Tank Materials.

4.4.1 Materials shall be limited to steel, wood, concrete, coated fabrics, and fiberglass-reinforced plastic tanks.

4.4.2 The elevated wood and steel tanks shall be supported on steel towers or reinforced concrete towers.

4.5 Workmanship.

4.5.1 In addition to complying with the requirements of this standard, it is expected that the manufacturers of approved structures will also follow the spirit of the standard by using their experience and ability to create structures that shall prove reliable under all specified conditions.

4.5.1.1 Manufacturers shall replace all parts that are defective due to faulty materials or workmanship and shall replace all parts that fail to comply with this standard.

4.5.2 The contractor's representatives shall provide careful inspection during shop fabrication and field erection.

4.5.2.1 The inspection shall include, but shall not be limited to, a check of the following:

- (1) The thickness of butt-welded plates in tanks and tubular columns
- (2) The appearance of welding in tank plates and in tubular columns and at struts, except near the ladder and base of the structure
- (3) The extent of dents and out-of-roundness of tubular columns and struts

4.6 Plans.

4.6.1 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 the erection of the structure.

4.6.2 Approval of Layouts.

4.6.2.1 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.

4.6.2.2 The information submitted shall include the following:

- (1) Size and arrangement of all pipes
- (2) Size, location, and type of all valves, tank heater, and other accessories
- (3) Steam pressures available at the heater
- (4) Arrangement of, and full information regarding, the steam supply and return system together with pipe sizes
- (5) Details of construction of the frostproof casing
- (6) Where heating is required, heat loss calculations
- (7) Structural drawings and calculations
- (8) Seismic bracing details and calculations
- (9) Operational settings and sequence of operation
- (10) Monitoring equipment and connections
- (11) Underground details including foundations, compaction, and backfill details and calculations
- (12) Buoyancy calculations for buried tanks

4.7 Tank Contractor Responsibility.

4.7.1 Any necessary work shall be handled by experienced contractors.

4.7.1.1 Careful workmanship and expert supervision shall be employed.

4.7.1.2 The manufacturer shall warranty the tank for at least 1 year from the date of completion and final customer acceptance.

4.7.2 Upon completion of the tank construction contract, and after the contractor has tested the tank and made it watertight, the tank contractor shall notify the authority having jurisdiction so that the tank can be inspected and approved.

4.7.3 Cleaning Up.

4.7.3.1 During and upon completion of the work, the contractor shall remove or dispose of all rubbish and other unsightly material in accordance with NFPA 241.

4.7.3.2 The condition of the premises shall be as it was before tank construction.

4.8 Attachments to Tank Structures.

4.8.1 If tank structures are used to support signs, flagpoles, steel stacks, or similar objects, they shall be specifically designed for the purpose.

4.8.2* Confined entry requirements signs shall be posted at each shell manway.

4.9 Lightning Protection. To prevent lightning damage to tanks, protection shall be installed in accordance with NFPA 780.

4.10 Strength.

4.10.1 The material, as specified, shall be without defects that affect its strength or service.

4.10.2 The workmanship shall be of such quality that defects or injuries are not produced during manufacture or erection that cause the specified allowable stresses to be exceeded under any specified design loads.

4.10.3 The structure and its details shall possess the requisite strength and rigidity.

4.11 National Standards. Materials produced and tested in accordance with the requirements of a recognized national standard and within the mechanical (strength), metallurgical, and chemical limitations of one of the material grades specified in this document shall be permitted.

4.12 Loads.

4.12.1 Dead Load.

4.12.1.1 The dead load shall be the estimated weight of all permanent construction and fittings.

4.12.1.2 The unit weight of steel shall be considered to be 490 lb/ft³ (7849 kg/m³); the unit weight of concrete shall be considered to be 144 lb/ft³ (2307 kg/m³).

4.12.2 Live Load.

4.12.2.1 Under normal conditions, the live load shall be the weight of all the liquid when it overflows the top of the tank.

4.12.2.2 The unit weight of water shall be considered to be 62.4 lb/ft³ (1000 kg/m³).

4.12.2.3 Proper provisions shall be made for temporary stresses during erection.

4.12.2.4 Where roofs have slopes of less than 30 degrees, they shall be designed to support a uniform weight of 25 lb/ft² (122 kg/m²) on the horizontal projection.

4.12.3 Wind Load.

4.12.3.1 Under normal conditions, the wind load or pressure shall be assumed to be 30 lb/ft² (147 kg/m²) on vertical plane surfaces, 18 lb/ft² (88 kg/m²) on projected areas of cylindrical

surfaces, and 15 lb/ft² (73 kg/m²) on projected areas of conical and double-curved plate surfaces.

4.12.3.2 Structures shall comply with the locally adopted building code and applicable standards for wind load requirements.

N 4.12.3.3 The larger of the wind load or load in 4.12.3.1 shall be used.

4.12.4 Earthquake Load.

4.12.4.1 Tank structures shall comply with the local building code for seismic requirements.

4.12.4.2 Specific design criteria shall be contained in the appropriate chapter for the particular tank, or in local codes, whichever is more stringent.

4.12.4.3 Flat-bottom tanks shall be designed by a method that accounts for the sloshing of the contents (effective mass method).

N 4.12.5 Snow Load.

N 4.12.5.1 Structures shall comply with the locally adopted building code and applicable standards for snow load requirements.

N 4.12.5.2 The larger of the snow load or load in 4.12.2.4 shall be used.

4.12.6 Balcony, Platform, and Ladder Loads.

4.12.6.1 A vertical load of 1000 lb (454 kg) shall be assumed to be applied to any 10 ft² (0.93 m²) of area on the balcony floor and on each platform, 500 lb (227 kg) applied to any 10 ft² (0.93 m²) area on the tank roof, and 350 lb (159 kg) on each vertical section of ladder.

4.12.6.2 All of the structural parts and connections shall be designed to withstand such loads.

4.12.6.3 These specified loads shall not be required to be combined with snow loading.

4.12.7 Columns and Struts.

4.12.7.1 All steel columns and struts shall be designed in accordance with the applicable AWWA tank design standard for the type of tank being constructed.

4.12.7.2 Where no AWWA design standard exists for the type of tank being constructed, steel columns and struts shall be designed in accordance with ANSI/AISC 360.

4.12.7.3 The minimum thickness for any columns in contact with water shall be 0.25 in. (6.4 mm).

4.12.7.4 Tubular sections shall not be flattened to form end connections.

4.12.8 Stress Increases.

4.12.8.1 Where wind or earthquake loads are considered in calculating stresses, the maximum permissible increase in working unit stresses shall be one-third, provided the resulting section is not less than required for dead and live loads alone.

4.12.8.2 Wind and earthquake loads shall not be required to be considered simultaneously.

4.12.9 Roof Construction.

4.12.9.1 The roof shall be designed to withstand the forces anticipated during the erection, inspection, testing, and maintenance of the tank.

4.12.9.2 The maximum allowable uniform live load (in pounds per square foot) and the maximum allowable concentrated load (in pounds) shall be identified on the design drawings and tank nameplate.

4.13 Welding. All welding shall be completed in accordance with AWWA D100, NFPA 241, and ASME *Boiler and Pressure Vessel Code*, Section IX.

4.14 Roofs.

4.14.1* All tanks shall have roofs.

4.14.1.1 OSHA-compliant (29 CFR 1910) standard railing shall be placed around the roof hatch(es) and other accessories that require access.

4.14.2 A perimeter roof guardrail shall not be required on lap-jointed bolted steel tanks when fitted with a manway platform, roof walkway, and guardrails.

4.14.3 Guardrails shall be constructed in accordance with OSHA 29 CFR 1910.

4.15 Roof Vent.

4.15.1 Where the steel roof is essentially airtight, there shall be a substantial vent above the maximum water level.

4.15.2 A vent pipe shall have a cross-sectional area equal to a minimum of one-half the area of the discharge pipe(s) or fill pipe, whichever is the larger.

4.15.3 A corrosion-resistant screen or perforated plate with $\frac{3}{8}$ in. (9.5 mm) holes, to exclude birds or other animals, shall be provided and have a net area at least equal to the vent line.

4.15.4 In the case of a screen, a gross area at least one and one-half times the cross-sectional area of the discharge pipe(s) or fill pipe, whichever is larger, shall be required.

4.15.5 The screen or perforated plate shall be protected against the accumulation of sleet.

4.15.6 The weather hood above the perforated plate or screen, or its equivalent, shall be readily removable.

4.15.7 The overflow pipe shall not be included as vent area.

4.15.8 The vent shall be permitted to be combined with the roof finial.

4.15.9 Equivalent venting shall be permitted to be used, provided the area cannot be obstructed by sleet, and the ingress of birds or other animals shall be prevented.

4.15.10 Where dual service is specified and where local health departments require screening vents against insects, a special fail-safe vent shall be provided to minimize the risk in the event that the insect screens occlude.

4.15.11 A vent fan attached to a flanged neck shall be installed on steel tanks prior to entering the tank.

4.15.11.1 The flanged neck shall be designed to accommodate an adequately sized exhaust fan.

4.16 Test Reports. Copies of mill test reports for steel plates and certificates of compliance for bolts and other structural members shall be maintained at the premises of the vendor and shall be made available for review by the purchaser.

Chapter 5 Welded-Carbon Steel and Composite Concrete and Carbon Steel Gravity Tanks and Suction Tanks

5.1 General.

5.1.1 This chapter shall apply to the design, fabrication, and erection of welded-carbon steel or composite concrete and carbon steel gravity water tanks, including pump suction tanks.

5.1.2 Capacity.

5.1.2.1 The capacity of the tank shall be the number of U.S. gallons (cubic meters) available above the outlet opening.

5.1.2.2 The net capacity between the outlet and the inlet of the overflow shall be equal to at least the rated capacity.

5.1.2.3 The net capacity for gravity tanks with large plate tank risers shall be the number of U.S. gallons (cubic meters) between the inlet of the overflow and the designated low-water level line.

5.1.3 Standard Sizes.

5.1.3.1 The standard net capacity sizes of steel tanks shall be as follows:

- (1) 5000 gal (18.93 m³)
- (2) 10,000 gal (37.85 m³)
- (3) 15,000 gal (56.78 m³)
- (4) 20,000 gal (75.70 m³)
- (5) 25,000 gal (94.63 m³)
- (6) 30,000 gal (113.55 m³)
- (7) 40,000 gal (151.40 m³)
- (8) 50,000 gal (189.25 m³)
- (9) 60,000 gal (227.10 m³)
- (10) 75,000 gal (283.88 m³)
- (11) 100,000 gal (378.50 m³)
- (12) 150,000 gal (567.75 m³)
- (13) 200,000 gal (757.00 m³)
- (14) 300,000 gal (1135.50 m³)
- (15) 500,000 gal (1892.50 m³)

5.1.3.2 Tanks of other sizes shall be permitted.

5.1.4 Form. Steel tanks shall be permitted to be of any form desired, provided they conform to all requirements of this standard.

5.2 Materials.

5.2.1 All tank foundations, materials, accessories, fabrication, construction, and welding shall be in accordance with AWWA D100 or AWWA D107.

5.2.2 All tank and tower foundations, steel tank towers, pipe connections and fittings, valve enclosures and frost protection, tank heating and acceptance test requirements shall be in accordance with this standard.

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

5.4 Corrosion Protection for Bottom Plates on Soil or Concrete.

5.4.1* The underside of all bottom plates shall be protected against corrosion by one of the methods required by 5.4.1.1 or 5.4.1.2.

5.4.1.1 The sand pad, including pH range of the lime sand mix, sulfate content, and chloride content, shall meet the requirements of AWWA D100 or AWWA D107.

5.4.1.2 Where permitted by environmental authorities, an oiled sand cushion shall be permitted to be used in accordance with AWWA D100.

5.5 Painting Inaccessible Areas.

5.5.1 Except for the underside of the floor on ground-supported flat-bottom tanks, faying surfaces of bolted connections that prohibit coatings, and overlapping surfaces of single-welded lap joints above the high waterline, parts that are inaccessible after fabrication, but that are subject to corrosion, shall be protected by paint before assembly.

5.5.1.1 This requirement shall not apply to the overlapping surfaces of single-welded lap joints above the high waterline.

5.6 Painting and Corrosion Protection.

5.6.1 Except where exempted by 5.5.1, all interior surfaces of steel tanks that are exposed to water immersion or the vapor phase zone above the high water level shall be cleaned by near-white blasting in accordance with SSPC SP 10 and shall be painted in accordance with the requirements of AWWA D102 and the project specifications. If cathodic protection is used to supplement corrosion protection on the immersed surfaces then it shall be done in accordance with AWWA D104 or AWWA D106.

5.6.2 All exterior surfaces and inside dry surfaces (pedestal tanks) shall be cleaned by commercial blasting in accordance with SSPC SP 6 and shall be coated in accordance with the requirements of AWWA D102.

5.6.3 Other interior or exterior paint systems shall be permitted to be used, provided permission is first obtained from the authority having jurisdiction.

5.6.4 After construction, all weld seams, unprimed surfaces, or any areas where the primer (if preprimed) has been damaged shall be blast-cleaned and primed with the specified coating system primer.

5.7 Painting Application. All painting shall be applied in accordance with the appropriate requirements of *SSPC Systems and Specifications Steel Structures Painting Manual*, Chapter 5.

5.8 Heavy Metals. The coating systems described in this section shall not exceed state and local limits of regulated heavy metals.

Chapter 6 Factory-Coated, Bolted Carbon Steel Tanks

6.1 General.

6.1.1* This chapter shall apply to the design, fabrication, and erection of bolted carbon steel water tanks, including pump suction tanks with factory-applied coatings.

6.1.2 Standard Capacity. The standard capacity of bolted tanks varies with the number of panels added to the diameter and ranges from 4000 gal to approximately 500,000 gal (15.1 m³ to approximately 1900 m³) net capacity.

6.1.2.1 Tanks of other capacities shall be permitted.

6.1.3 Form.

6.1.3.1 Bolted tanks shall be cylindrical.

6.1.3.2 All joints, including vertical, horizontal, shell-to-roof, and shell-to-bottom plates or sheets, shall be field bolted.

6.1.3.3 Coatings shall be factory applied in accordance with AWWA D103.

6.1.3.4 Bolt holes shall be shop-punched or drilled for field assembly.

6.1.3.5 Joints that are in contact with water and weathertight joints shall be sealed.

6.2 Materials, Fabrication, and Installation.

6.2.1 All design materials, fabrication, and installation shall be in accordance with AWWA D103.

6.2.2 All tank and tower foundations, accessories, steel tank towers, pipe connections and fittings, valve enclosures and frost protection, tank heating and acceptance test requirements shall be in accordance with this standard.

6.3 Corrosion Protection. Where cathodic protection is used to supplement corrosion protection on the immersed surfaces or underside of floor plates, it shall be done in accordance with AWWA D104 or AWWA D106.

6.4 Structural Shapes. Aluminum shapes shall be permitted to be used for portions of the tank that are not in contact with water and shall follow the design criteria in AWWA D108.

Chapter 7 Pressure Tanks

7.1 General.

7.1.1 Service. Pressure tanks shall be permitted to be used for limited private fire protection services, such as those covered by the following NFPA standards:

- (1) NFPA 13
- (2) NFPA 14
- (3) NFPA 15

7.1.2 Pressure tanks shall not be used for any other purpose.

7.1.2.1 Pressure tanks approved by the authority having jurisdiction shall be permitted to be used for other purposes.

7.1.3 Capacity. The capacity shall be approved by the authority having jurisdiction.

7.1.4 Water and Air Pressure.

7.1.4.1 Pressure tanks shall be kept with a supply of water to meet the flow and duration demands of the fire protection system.

7.1.4.2* The quantity of air in the tank and pressure shall be sufficient to push all of the water out of the tank while maintaining the necessary residual pressure at the top of the system.

7.1.5* Air Lock. Methods used for the prevention of air lock shall be approved by the authority having jurisdiction in each case.

7.1.6 Location. Subject to the approval of the authority having jurisdiction, tanks shall be permitted to be buried in accordance with the requirements of 7.1.10.

7.1.7 Construction.

7.1.7.1* General. Pressure tanks shall be constructed in accordance with the ASME *Boiler and Pressure Vessel Code*, "Rules for the Construction of Unfired Pressure Vessels," Section VIII, Division 1, Unfired Pressure Vessels.

7.1.7.1.1 This requirement shall not apply where otherwise specified herein.

7.1.7.2 Supports.

7.1.7.2.1 The supports shall be steel or reinforced concrete and shall be located in a manner that prevents sagging or vibration and that properly distributes the loads caused by the weight of the vessel when full of water.

7.1.7.2.2 Stresses in steel supports shall not exceed those permitted by Section 13.4 for steel towers.

7.1.7.2.3 Horizontal tanks shall have at least one support near each end of the tank that is located so that combined stresses in any part of the tank do not exceed those specified in 13.4.6.

7.1.7.3 Painting. Tanks shall be cleaned and painted inside and outside in accordance with the requirements of Section 5.5 through Section 5.7. An ASME Specifications for Material stamp and an ASME Standard Pressure Vessel stamp shall not be rendered illegible.

7.1.8 Marking.

7.1.8.1 General. All stamps required by the ASME specification shall be applied.

7.1.8.1.1 The nameplate or water-level marking shall be securely fastened without obliterating any lettering.

7.1.8.1.2 If screws are used, they shall not penetrate more than one-half of the tank plate thickness.

7.1.8.2 Nameplate. A metal nameplate, with raised or stamped letters and numbers that are large enough to be easily read, that bears the following information shall be provided:

- (1) Name and location of manufacturer
- (2) Year of assembly
- (3) Length and diameter
- (4) Total capacity [gal (m³)]
- (5) Working pressure [lb/in.² (bar)]

7.1.8.3 Water-Level Indicator.

7.1.8.3.1 The nameplate shall also serve as the water-level indicator by bearing an easily observed raised arrow.

7.1.8.3.2 The tank plate shall be marked “ $\frac{2}{3}$ capacity line” in raised or stamped lettering behind the gauge glass and shall be located in such a position that the arrow is at the water level when the tank is two-thirds full. For horizontal tanks, the two-thirds capacity line is $\frac{63}{100}$ of the diameter above the bottom of the tank.

7.1.8.3.3 Where the design water level is at a point other than the $\frac{2}{3}$ level, the nameplate shall be so lettered and positioned behind the gauge glass accordingly.

7.1.9 Housing.

7.1.9.1 Where subject to freezing, the tank shall be located in a substantial noncombustible housing.

7.1.9.2 The tank room shall be large enough to provide free access to all connections, fittings, and manholes, with at least 18 in. (457 mm) around the rest of the tank.

7.1.9.3 The distance between the floor and any part of the tank shall be at least 3 ft (0.91 m).

7.1.9.4 The floor of the tank room shall be watertight and shall be arranged to drain outside the enclosure.

7.1.9.5 The tank room shall be adequately heated to maintain a minimum temperature of 40°F (4.4°C) and shall be equipped with ample lighting facilities.

7.1.10 Buried Tanks. Where necessary due to lack of space or other conditions, pressure tanks shall be permitted to be buried, provided the requirements of 7.1.10.1 through 7.1.10.7 are satisfied.

7.1.10.1 The tank shall be located below the frost line to protect against freezing.

Δ 7.1.10.2 The end of the tank, and at least 18 in. (457 mm) of its shell, shall project into the building basement or into a pit in the ground provided with protection against freezing.

7.1.10.3* There shall be adequate space for inspection, maintenance, and use of the tank manhole for interior inspection.

7.1.10.4 The exterior surface of the tank shall be cleaned and painted in accordance with 7.1.7.3, and additional protection shall be provided as required by 7.1.10.4.1 and 7.1.10.4.2.

7.1.10.4.1 An approved cathodic system of corrosion protection shall be provided.

7.1.10.4.2 At least 12 in. (305 mm) of sand shall be backfilled around the tank.

7.1.10.5 The tank shall be located above the maximum ground water level so that the buoyancy of the tank, when empty, does not force it upward. The tank shall be permitted to be anchored to a concrete base as an alternative.

7.1.10.6 The tank shall be designed with strength to resist the pressure of earth to which it is subjected.

7.1.10.7 A manhole shall be located on the vertical centerline of the tank end as close as possible to the knuckle but remaining clear of it.

7.2 Pipe Connections and Fittings.

7.2.1 Openings.

7.2.1.1 A manhole and all openings needed for the connection of the piping and fittings specified in 7.2.1.2 and 7.2.1.3 shall be provided.

7.2.1.2 The manhole and threaded openings shall conform in design to the ASME *Boiler and Pressure Vessel Code*, “Rules for the Construction of Unfired Pressure Vessels.”

7.2.1.3 The manhole shall be placed below the water level.

7.2.2 Tank Discharge.

7.2.2.1 The discharge pipe shall be sized to supply the required amount of water for the fire protection system, but shall not be less than 4 in. (102 mm) in size in any case.

7.2.2.2 The discharge pipe shall be connected to the bottom of the tank by means of a fitting that projects 2 in. (51 mm) above the bottom to form a settling basin and to prevent sediment from passing into the system.

7.2.2.3 A listed horizontal swing-check valve and a listed indicating valve shall be located in the discharge pipe, directly under or near the tank.

7.2.2.4 The pipe shall be adequately supported.

7.2.3 Filling Pipe.

7.2.3.1 The water-filling pipe shall be at least 1½ in. (38 mm) in size, shall be run separately from the filling pump or other acceptable source of supply, and shall be adequately supported and protected from mechanical injury.

7.2.3.2* The filling pipe shall be connected to the top or bottom of the tank as required by the authority having jurisdiction.

7.2.3.3 A listed check valve and an indicating control valve shall be provided in the horizontal position in the pipe near the tank.

7.2.3.4 The indicating control valve shall be placed between the check valve and the tank.

7.2.4 Air Pipe.

7.2.4.1 The air supply pipe shall be at least 1 in. (25.4 mm) in size, well supported, and protected from breakage.

7.2.4.2 The air supply pipe shall be connected to the tank above the water level.

7.2.4.3 A reliable horizontal bronze-seat swing-check valve and listed renewable-disc globe valve shall be provided in the pipe near the tank.

7.2.4.4 The globe valve shall be placed between the tank and the check valve.

7.2.5 Water-Level Gauge.

7.2.5.1 A ¾ in. (19.1 mm) water-level gauge with a listed valve at each end shall be provided with the center of the glass tube at the normal water level.

7.2.5.2 The gauge glass shall be not over 12 in. (305 mm) long for horizontal tanks or 18 in. (457 mm) long for vertical tanks.

7.2.5.3 Listed angle globe valves with renewable discs shall be installed in the connections from the gauge to the tank and shall be independent of the shutoff valves that are a part of the gauge fittings.

7.2.5.4 The water-level gauge shall be connected through valves into the tank.

7.2.5.5 A petcock shall be provided for draining the glass.

7.2.5.6 All fittings and nipples shall be of brass, not less than $\frac{3}{4}$ in. (19.1 mm) in size.

7.2.5.6.1 The nipple that extends into the tank shall be permitted to be $\frac{1}{2}$ in. (12.7 mm) in size.

7.2.5.7 The glass gauge tube shall be protected from mechanical injury by a guard that consists of at least three $\frac{3}{16}$ in. (4.8 mm) brass rods.

7.2.5.8 The valves on the water-level gauge connections shall be opened only when ascertaining the amount of water in the tank.

7.2.6 Air-Pressure Gauge.

7.2.6.1 A listed $4\frac{1}{2}$ in. (114 mm) dial, double-spring gauge shall be connected into the air chamber between the tank and any valve, generally to the line between the upper end of the water-level gauge and the tank.

7.2.6.2 The pressure gauge shall have a maximum range equivalent to twice the normal working pressure when installed and shall be controlled by a valve that is arranged to drain.

7.2.6.3 A plugged outlet at least $\frac{1}{4}$ in. (6.4 mm) in size shall be provided between the valve and the gauge for the inspector's gauge.

7.2.7 Safety Appliances.

7.2.7.1 A brass relief valve not less than $\frac{3}{4}$ in. (19.1 mm) in size that is set to operate at a pressure that is 10 percent in excess of the normal tank pressure shall be placed in the air supply pipe between the check valve and the air compressor.

7.2.7.2 There also shall be a brass relief valve not less than $1\frac{1}{2}$ in. (38.1 mm) in size at the filling pump that is set to relieve pressures that are 10 percent in excess of the pressure at the pump when the tank is under normal working pressure.

7.2.7.3 No safety appliances shall be installed between the tank and other valves.

7.2.8 Emergency Drain.

7.2.8.1 Provisions shall be made to drain each tank independently of all other tanks and the sprinkler system by means of a pipe that is not less than $1\frac{1}{2}$ in. (nominal 40 mm) in diameter.

7.2.8.1.1 The drain valve shall be a globe valve with a renewable disc and shall be located near the tank.

7.2.8.2 Use of drains other than those shown in Figure B.1(a) and Figure B.1(b) below the pressure tank, after shutting off other water supplies, shall not be permitted under any condition, as collapse of the pressure tank can result.

7.2.9 Water Filling Supply.

7.2.9.1 The filling supply or pump shall be reliable and shall be capable of replenishing the water that is required to be

maintained in the tank with the required air pressure restored in not more than 4 hours.

7.2.9.2 A relief valve shall be provided at the pump, as specified in 7.2.7.

7.2.10 Air Compressor.

7.2.10.1 An air compressor capable of delivering not less than 16 ft³/min (0.45 m³/min) of free air for tanks of 7500 gal (28.39 m³) total capacity, and not less than 20 ft³/min (0.57 m³/min) for larger sizes, shall be provided.

7.2.10.2 The compressor shall be located in the tank house.

7.2.10.2.1 The compressor shall be permitted to be located elsewhere if permitted by the authority having jurisdiction.

7.2.10.3 A safety valve shall be provided, as specified in 7.2.7.

7.2.11 Arrangement. All pipe connections and valves, including the manhole, the emergency drain valve, and all valves on the discharge pipe, shall be arranged for convenient manipulation.

7.2.12* Watertight Intersections at Roofs and Floors. The intersections of all piping with the building roof and concrete or waterproof floors shall be watertight.

7.2.13 Fire Protection. The tank shall be protected by automatic sprinklers if combustible contents or construction could heat the tank in the event of a fire.

Chapter 8 Wood Gravity Tanks and Suction Tanks

8.1 General.

8.1.1 This chapter shall apply to the design, fabrication, and erection of wood gravity water tanks, including pump suction tanks.

8.1.2 Capacity.

8.1.2.1 The capacity of the tank shall be the number of U.S. gallons (cubic meters) available above the outlet opening.

8.1.2.2 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.

8.1.3* Standard Sizes. The standard net capacity sizes of wood tanks shall be as follows:

- (1) 5000 gal (18.93 m³)
- (2) 10,000 gal (37.85 m³)
- (3) 15,000 gal (56.78 m³)
- (4) 20,000 gal (75.70 m³)
- (5) 25,000 gal (94.63 m³)
- (6) 30,000 gal (113.55 m³)
- (7) 40,000 gal (151.40 m³)
- (8) 50,000 gal (189.25 m³)
- (9) 60,000 gal (227.10 m³)
- (10) 75,000 gal (283.88 m³)
- (11) 100,000 gal (378.50 m³)

8.1.4 Strength.

8.1.4.1 The materials as specified shall have no defects other than those that are permitted by the grading rules for the lumber specified in 8.2.2.

8.1.4.2 The use of second-hand materials, including such materials as hoops and lumber, shall not be permitted.

8.1.4.3 The workmanship shall be of such quality that defects or injuries are not produced during manufacture or erection.

8.1.4.4* Unit stresses, as specified in Section 8.3, shall not be exceeded except where additionally reinforced.

8.1.4.5 The structure and its details shall possess the requisite strength and rigidity.

8.2 Material.

8.2.1 Lumber — General. All lumber shall be well-seasoned and free from rot, sap, loose or unsound knots, worm holes, and shakes in accordance with National Wood Tank Institute Bulletin S82.

8.2.2 Lumber — Staves and Bottom.

8.2.2.1 Untreated lumber in the staves and bottom shall be thoroughly air-dried (below 17 percent moisture content) “all heart” or “tank stock” without any sapwood after shaping.

8.2.2.2* Acceptable untreated species, in order of preference, shall be redwood, western yellow cedar, southern white cedar (dismal swamp), western red cedar, and Douglas fir (coast type).

8.2.2.3 Treatment.

8.2.2.3.1 Acceptable treated species shall include all those specified in 8.2.2.1 and yellow pine, all without sapwood restriction.

8.2.2.3.2 Treatment shall consist of a 6 lb/ft³ to 8 lb/ft³ (96 kg/m³ to 128 kg/m³) retention of creosote or pentachlorophenol that is applied by means of the empty-cell process after shop fabrication, in accordance with the American Wood Preservers Association.

8.2.3 Timber Supports. Wooden dunnage beams, where used, shall be a dense grade of southern pine or Douglas fir or shall be a construction heart-untreated redwood or red cypress (coast type).

8.2.3.1 Structural grades of other species shall be permitted to be used, provided they are treated with 6 lb/ft³ to 8 lb/ft³ (96 kg/m³ to 128 kg/m³) retention of creosote or pentachlorophenol that is applied by means of the empty-cell process in accordance with the standard specifications of the American Wood Preservers Association. (See 8.3.1 and 8.4.8.)

8.2.3.2 Wood dunnage beams shall be at least 4 in. × 6 in. (102 mm × 152 mm) nominal size.

8.2.4 Hoops.

8.2.4.1 Hoops shall be round bars of steel.

8.2.4.2 The steel bars shall conform to ASTM A36/A36M, ASTM A502, or ASTM A675/A675M.

8.2.4.3 Steel shall be made only by the open-hearth or electric-furnace processes.

8.2.5 Hoop Lugs. The lugs shall be malleable iron, cast steel, or fabricated steel and shall have equal or greater ultimate strength than the steel hoop with which they are used that is in accordance with ASTM A36/A36M, ASTM A502, or ASTM A675/A675M.

8.2.6 Steel Shapes. The steel for structural shapes shall conform to ASTM A36/A36M.

8.3 Unit Stresses.

8.3.1* General. The following stresses in pounds per square inch (megapascals) shall apply particularly to wood tanks and shall not be exceeded.

8.3.1.1 Tension Hoops.

8.3.1.1.1 The unit stress for tension hoops made of steel in accordance with ASTM A675/A675M shall be 15,000 lb/in.² (103.43 MPa) (use with hydrostatic load and neglect initial tension).

8.3.1.1.2 Steel in accordance with ASTM A36/A36M or ASTM A502 shall have a unit stress of 20,000 lb/in.² (137.90 MPa).

8.3.1.2 Timber. The allowable working stresses for timbers referenced in 8.2.3 and 8.4.8 shall be as specified in Table 8.3.1.2.

8.4 Details of Design.

8.4.1 Lumber Thickness. The lumber in the staves and in the bottom shall be at least 2½ in. (64 mm) (nominal), dressed to not less than 2½ in. (54 mm) thickness for tanks less than 20 ft (6.1 m) in depth or diameter; for larger tanks, the lumber shall be at least 3 in. (76 mm) (nominal), dressed to not less than 2⅝ in. (60 mm) thickness.

8.4.2 Hoop Sizes. Hoops shall not be smaller than the pitch diameter of ¾ in. (19.1 mm) thread. No more than two sizes of hoops shall be used on a tank.

8.4.3* Hoop Schedules.

8.4.3.1 A hoop shall be assumed to support one-half the length of the stave to the two adjacent hoops.

8.4.3.2* Other schedules shall be acceptable, provided the unit stresses specified in Section 8.3 are not exceeded.

8.4.4 Hoops at Bottom.

8.4.4.1 One hoop shall be placed at approximately the center of the bottom planks of tanks with diameters of 19 ft (5.8 m) or less.

8.4.4.1.1 The stress in this hoop shall not exceed one-half the allowable unit tension, with the excess strength provided to accommodate the swelling of the bottom planks.

8.4.4.2 On tanks with diameters of over 19 ft (5.8 m), two hoops of equal size shall be placed opposite the tank bottom.

8.4.4.2.1 The stress in the upper hoop shall be limited as specified in 8.4.4.1.1.

8.4.5 Hoops at Top. The top hoops shall be placed 3 in. (76 mm) below the bottom of the flat cover joists or 3 in. (76 mm) below the top of the staves if the flat cover is omitted.

8.4.5.1 The maximum spacing of hoops shall not exceed 21 in. (533 mm).

8.4.6 Hoop Lugs.

8.4.6.1 The ends of the hoop sections shall be connected by malleable iron, cast steel, or fabricated steel lugs and shall have equal or greater ultimate strength than the steel hoop with

Table 8.3.1.2 Working Stresses for Timber (Select Grade)

Species	Allowable Stress							
	Bending				Compression		Compression Parallel to Grain; Short Columns	
	In Extreme Fiber		Horizontal Shear		Perpendicular to Grain			
	psi	MPa	psi	MPa	psi	MPa	psi	MPa
Cedar, western red	900	6.21	80	0.55	200	1.38	700	4.83
Cedar, northern and southern white	750	5.17	70	0.48	175	1.21	550	3.79
Douglas fir (western Washington and Oregon)	1600	11.03	90	0.62	345	2.38	1175	8.10
Douglas fir (western Washington and Oregon), dense grade	1750	12.07	105	0.72	380	2.62	1290	8.89
Douglas fir (Rocky Mountain type)	1100	7.58	85	0.57	275	1.90	800	5.52
Pine, southern yellow	1600	11.03	110	0.76	345	2.38	1175	8.10
Pine, southern yellow, dense	1750	12.07	120	0.83	380	2.62	1290	8.89
Pine, white, sugar, western white, western yellow	900	6.21	85	0.57	250	1.72	750	5.17
Pine, Norway	1100	7.58	85	0.57	300	2.07	800	5.52
Redwood	1200	8.27	70	0.48	250	1.72	1000	6.90
Spruce, red, white, Sitka	1100	7.58	85	0.57	250	1.72	800	5.52

which they are used that is in accordance with ASTM A36/A36M or ASTM A502.

8.4.6.2 The lugs shall be so designed that water cannot be pocketed.

8.4.6.3 The hoops shall be so located on the tank that the lugs form fairly uniform spiral lines.

8.4.7 Main Supports. Steel I-beams or reinforced concrete beams shall be used for the main supports where the dunnage beams rest.

8.4.8 Spacing of Supports.

8.4.8.1 The maximum distance in the clear between the beams where the tank bottom rests shall not exceed 21 in. (533 mm).

8.4.8.2 The maximum distance between the outer edge of the outer dunnage beam and the inside surface of the tank staves, measured on a line perpendicular to the beam at its midpoint, shall not exceed 14 in. (356 mm).

8.4.9 Air Circulation Under Tank Bottom. Tank supports shall be designed to allow the free circulation of air under the tank bottom and around the ends of the staves.

8.5 Workmanship.

8.5.1* Lumber Edges and Surfaces. Planks for the staves and bottom shall be planed on both sides.

8.5.1.1 The edges of the staves and bottom planks shall be machine-planed or sawed.

8.5.1.2 The edges of staves shall be cut to obtain full bearing at the joints.

8.5.1.3 The last stave to be placed in the tank shall be carefully planed to the required size.

8.5.2 Croze.

8.5.2.1 The croze shall be cut at right angles to the centerline of the staves.

8.5.2.2 The edges of the bottom planks shall be beveled on the underside and smoothed off on the upper side by planing to obtain a tight joint at the croze.

8.5.2.3 The depth and width of the croze shall be at least $\frac{3}{4}$ in. (19.1 mm) and $\frac{2}{8}$ in. (54 mm), respectively, for 3 in. (76 mm) nominal staves, and $\frac{5}{8}$ in. (15.9 mm) and 2 in. (51 mm), respectively, for $2\frac{1}{2}$ in. (64 mm) nominal staves.

8.5.3 Chime.

8.5.3.1 The chime shall be of uniform depth and shall be not less than 3 in. (76 mm).

8.5.3.2 Before erection, the chimes of staves shall be fastened with at least two nails or staples at least $1\frac{1}{4}$ in. (32 mm) long.

8.5.3.3 Nails or staples shall be coated with zinc or copper, or they shall be of other material that is highly resistant to corrosion.

8.5.4 Dowels. The edges of each bottom plank shall be bored with holes not over 5 ft (1.5 m) apart for wooden dowels not less than $\frac{1}{2}$ in. (12.7 mm) in diameter for planks up to $2\frac{1}{2}$ in. (64 mm) nominal, and $\frac{5}{8}$ in. (15.9 mm) in diameter above that thickness.

8.5.5 Splices.

8.5.5.1 Finger joint splices shall be used in a stave or in a bottom plank where permitted by the authority having jurisdiction.

8.5.5.2 Such joints in adjacent staves or bottom planks shall be staggered a minimum of 2 ft (0.61 m).

Shaded text = Revisions.  = Text deletions and figure/table revisions.

• = Section deletions.

 = New material



8.5.6 Joints at Bottom. The joints between staves shall not be closer than $\frac{1}{2}$ in. (12.7 mm) to a joint between the bottom planks.

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

8.5.8 Marking of Staves. The proper hoop spacing shall be plainly marked on at least six staves before shipment.

8.5.9 Clearance at Supports.

8.5.9.1 The distance between the ends of dunnage beams and the inside surface of the staves shall be not less than 1 in. (25.4 mm) or more than 3 in. (76 mm).

8.5.9.2 The supports shall be of such depth that the clearance beneath the ends of staves is not less than 1 in. (25.4 mm) at any point.

8.5.10 Hoop Forming. Hoops shall be cut to the proper length and shall be bent in the shop to the radius of the tank.

8.5.11 Hoop Threads. The nut threads shall fit tightly and shall be U.S. Standard.

8.5.12 Hoop Tightening. Care shall be taken when 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.

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

8.6 Accessories.

8.6.1 Roof — General.

8.6.1.1 Where the tank is located outdoors, it shall have a flat wooden cover over the top and a conical roof above the wooden cover.

8.6.1.1.1 The flat cover shall not be required, and the conical cover shall be made self-supporting, provided the approval of the detailed design is first obtained from the authority having jurisdiction.

8.6.1.2 Roofs shall be constructed as shown in Figure B.1(c) and Figure B.1(d), or shall be in accordance with other designs approved by the authority having jurisdiction.

8.6.1.3 Roof boards shall be of not less than 1 in. (25.4 mm) nominal thickness or $\frac{3}{8}$ in. (9.5 mm) exterior grade plywood that is laid without spacing between.

8.6.1.4 If plywood is used, the end joints shall be made over roof joists, or ply clips shall be used to support the edges.

8.6.1.5 Shiplap or matched joints shall be used on boards in the flat cover, unless plywood is used.

8.6.1.6 The joint between the tank staves and roof shall be tight.

8.6.1.7 Nails or staples shall be heavily galvanized or shall be of nonferrous metals.

8.6.2 Flat Cover.

8.6.2.1 The flat cover, if provided, shall rest on parallel joists and shall be spaced not over 36 in. (914 mm) on centers.

8.6.2.2 The nominal size of the joists shall be at least 2 in. $\times$ 6 in. (51 mm $\times$ 152 mm) for lengths up to 18 ft (5.5 m); 3 in. $\times$ 6 in. (76 mm $\times$ 152 mm) for lengths up to 22 ft (6.7 m); and 3 in. $\times$ 8 in. (76 mm $\times$ 203 mm) for lengths up to 30 ft (9.2 m).

8.6.2.3 The full section of all joists at their ends shall be solidly supported by resting in slots that are cut entirely through the staves or by other means that are approved by the authority having jurisdiction.

8.6.3* Conical Roof.

8.6.3.1 The conical roof shall be supported by 2 in. $\times$ 4 in. (51 mm $\times$ 102 mm) rafters spaced not over 36 in. (914 mm) apart around the top of the tank.

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

8.6.3.3 The roof shall be covered with galvanized iron, at least 60 lb (27 kg) asphalt, asbestos, or equivalent fire-resistive roofing and shall be securely fastened in place.

8.6.3.3.1 Prepared asphalt roofing shall be laid with at least $2\frac{1}{2}$ in. (64 mm) laps, be properly cemented, and use $\frac{3}{4}$ in. (19.1 mm) galvanized roofing nails with at least $\frac{1}{2}$ in. (12.7 mm) heads and large washers spaced not over 3 in. (76 mm) on centers, or 0.050 in. (1.27 mm) nonferrous staples $\frac{1}{2}$ in. (12.7 mm) in length for 65 lb (30 kg) covering and $\frac{3}{4}$ in. (19.1 mm) for 90 lb (41 kg) covering.

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

8.6.5 Roof Hatches.

8.6.5.1 A hatch not less than 20 in. $\times$ 22 in. (508 mm $\times$ 559 mm) shall be built in the conical roof and shall be accessible from the tank ladder.

8.6.5.1.1 The hatch shall be placed high enough on the conical roof that entrance to the flat roof is reasonably easy when the cover for the flat roof hatch is in place.

8.6.5.2 The four sides of the hatch shall be of not less than $1\frac{1}{2}$ in. (38.1 mm) dressed stock and shall be raised not less than 3 in. (76 mm) above the roof boards.

8.6.5.2.1 The top of the hatch cover shall be made of not less than 1 in. (25.4 mm) dressed and matched boards or $\frac{3}{8}$ in. (9.5 mm) exterior grade plywood, and shall be covered with the same material as specified for the roof.

8.6.5.2.2 The edges of the hatch cover shall be of not less than $1\frac{1}{2}$ in. (38.1 mm) dressed stock and shall lap down over the raised sides of the hatch.

8.6.5.2.3 The hatch cover shall be arranged to open freely by sliding upward on two $\frac{1}{2}$ in. (12.7 mm) guide rods that are securely bolted to the roof, one on each side of the cover.

8.6.5.2.4 A substantial handle shall be bolted to the lower side of the cover.

8.6.5.3 Other forms of hatch covers shall be acceptable, provided approval is first obtained from the authority having jurisdiction.

8.6.5.4 A hatch of not less than 20 in. × 22 in. (508 mm × 559 mm) shall be built in the flat cover, if provided, and shall be located directly beneath the hatch in the conical roof.

8.6.5.4.1 The hatch cover shall be made of 1 in. (25.4 mm) dressed and matched boards or $\frac{3}{8}$ in. (9.5 mm) exterior grade plywood, and shall be of sufficient size to prevent it from falling through the hatch.

8.6.6 Ladders — General.

8.6.6.1 Inside and outside ladders that are arranged for convenient passages from one to the other and through the roof hatch shall be provided.

8.6.6.2 Ladders shall not interfere with the opening of the hatch cover.

8.6.6.3 All ladders exceeding 20 ft (6.1 m) in length shall be equipped with a cage, a rigid notched rail, or other listed ladder safety device.

8.6.7 Outside Ladders.

8.6.7.1 A steel ladder that extends from the balcony to the roof shall be provided on the outside of the tank.

8.6.7.1.1 The sides of the ladder shall extend 18 in. (457 mm) above the top of the tank and downward in an arch to the roof or cover where the ends shall be securely fastened.

8.6.7.1.2 The ladder shall be placed at least 3 ft (0.91 m) to one side of the tower ladder if a balcony is provided. (*See 8.6.9.*)

8.6.7.2 The outside ladder shall have flat side bars of not less than 2 in. × $\frac{1}{2}$ in. (51 mm × 12.7 mm) or $2\frac{1}{2}$ in. × $\frac{3}{8}$ in. (64 mm × 9.5 mm), spaced at least 16 in. (406 mm) apart, and shall have at least $\frac{3}{4}$ in. (19.1 mm) round or square rungs, spaced 12 in. (305 mm) on centers.

8.6.7.2.1 The rungs shall be firmly welded to the side bars. The ladder shall be securely fastened by brackets at a location that is at least 7 in. (178 mm) between the side of the tank and the centerline of the rungs.

8.6.7.2.2 The upper brackets shall be placed not more than 12 in. (305 mm) below the top of the tank staves, and the lower end of the ladder shall be securely fastened to the balcony (*see 8.6.9*); in the absence of a balcony, the lower end of the ladder shall be fastened to the tower ladder.

8.6.7.2.3 The brackets shall be designed to support a load of 350 lb (159 kg) on the ladder and shall be securely fastened to the tank with through bolts not less than $\frac{3}{8}$ in. (9.5 mm) in diameter.

8.6.8 Inside Ladder.

8.6.8.1 A wooden ladder that is made of the same type of wood as the tank shall be provided on the inside of the tank and shall extend from the hatch to the tank bottom with a slope of approximately 10 degrees from the vertical.

8.6.8.2 Inside ladders of up to 16 ft (4.9 m) in height shall have 2 in. × 4 in. (51 mm × 102 mm) side pieces.

8.6.8.2.1 Ladders over 16 ft (4.9 m) shall have 2 in. × 6 in. (51 mm × 152 mm) side pieces.

8.6.8.2.2 All side pieces shall be spaced at least 16 in. (406 mm) apart. Rungs shall be $1\frac{1}{4}$ in. × 3 in. (32 mm × 76 mm) and spaced 12 in. (305 mm) on centers.

8.6.8.2.3 Rungs shall be securely spiked with noncorrosive nails into slots of not less than $\frac{3}{4}$ in. (19.1 mm) and shall be not more than 1 in. (25.4 mm) in depth.

8.6.8.2.4 The ladder shall be securely fastened at the upper and lower ends with noncorrosive nails.

8.6.9 Balcony — General.

8.6.9.1 A wooden or steel balcony shall be placed around the base of the tank where the tank bottom is elevated more than 25 ft (7.6 m) above the main building roof.

8.6.9.2 For tanks with a diameter in excess of 15 ft 6 in. (4.7 m), the width of the balcony shall be 24 in. (607 mm) and, for smaller tanks, the width shall be not less than 18 in. (457 mm).

8.6.10 Balcony Floor.

8.6.10.1 Where the balcony is made of wood, the planks shall be at least 2 in. (51 mm) nominal dressed lumber of good quality and shall be spaced $\frac{1}{2}$ in. (12.7 mm) apart.

8.6.10.2 The planks shall be laid crosswise on stringers, or lengthwise on crossbeams, and spaced not over 4 ft (1.2 m) apart.

8.6.10.3 Where the balcony is made of steel, it shall be built of at least $\frac{1}{4}$ in. (6.4 mm) plate and shall be provided with drain holes.

8.6.11 Balcony Clearance.

8.6.11.1 A clearance of not less than 3 in. (76 mm) nor more than 5 in. (127 mm) at any point shall be provided between the balcony and the tank staves.

8.6.11.2 The clearance in the inside angles of polygonal balconies with plank laid lengthwise shall be limited to a maximum of 5 in. (127 mm) by means of properly supported filler pieces.

8.6.12 Balcony Supports. The balcony supports shall be built of structural steel shapes.

8.6.12.1 Reinforced concrete supports shall be permitted to be used where the tank is located on a concrete tower.

8.6.13 Balcony Railing.

8.6.13.1 A railing of 42 in. (1067 mm) in height shall be placed around the balcony and shall be rigid.

8.6.13.2 The top rail and posts shall be made of not less than $1\frac{1}{2}$ in. pipe or of angle iron not lighter than 2 in. × 2 in. × $\frac{3}{8}$ in. (51 mm × 51 mm × 9.5 mm).

8.6.13.3 An intermediate rail shall be provided.

8.6.13.4 The maximum spacing of rail posts shall be 8 ft (2.4 m).

8.6.13.5 The railing shall be designed to withstand a 200 lb (91 kg) load in any direction at any point on the top rail.

8.6.13.6 A toe board shall be provided where needed.

8.6.14 Balcony Opening. Where a hole is cut in the balcony for the tower ladder, it shall be at least 18 in. × 24 in. (457 mm × 607 mm).

8.6.15 Painting Inaccessible Parts. Portions of steelwork that are inaccessible after erection shall be painted before assembly.

8.6.16 Painting. All exterior surfaces shall be cleaned by commercial blasting in accordance with SSPC SP 6, or pickling in accordance with SSPC SP 8, and shall be primed with one coat of lead-free alkyd in accordance with the requirements for “Outside Paint System No. 1” of AWWA D102.

8.6.17 Field Painting — Steelwork.

8.6.17.1 After erection, a patch coat of the same kind of paint as the original coat shall be applied to all steel surfaces where the paint has worn off and shall also be applied to the thoroughly cleaned hoop threads.

8.6.17.2 Two overall field coats of aluminum or alkyd enamel in a color specified by the purchaser shall be used in accordance with the requirements of AWWA D102. (See Chapter 5.)

8.6.17.3 Other finish coats shall be permitted to be used, provided they are compatible with the primer and provided permission is obtained from the authority having jurisdiction.

8.6.18 Painting Application. Paint shall be applied in accordance with Section 5.7.

8.6.19 Preservatives — Woodwork. Exposed wood such as balconies, stringers, and supporting beams shall be provided with at least two coats of a good grade preservative sealer.

8.6.20 Lightning Protection. Lightning protection shall be in accordance with Section 4.9.

Chapter 9 Embankment-Supported Coated Fabric Suction Tanks

9.1 General. This section shall apply to the materials, embankment preparation, and installation of embankment-supported coated fabric suction tanks as shown in Table 9.1.

9.2 Standard Capacities. The standard capacities shall be in increments of 100,000 gal to 1,000,000 gal (378.5 m³ to 3785 m³).

9.3 Materials.

9.3.1 Construction. The material shall be of a nylon fabric and shall be coated with an elastomer that is compounded to provide abrasion and weather resistance.

9.3.2 Design. The tank shall be designed in accordance with 9.3.2.1 through 9.3.2.3.

9.3.2.1 The tank shall be designed to provide an assembly, with seams, that has a strength equal to or greater than the strength of the basic tank construction.

9.3.2.2 The top surface of the tank shall be coated with a weather-resistant elastomeric paint as recommended by the tank manufacturer.

9.3.2.3 The tank shall be designed to accommodate the field attachment of inlet/outlet fittings during installation.

Table 9.1 Physical Properties of Finished Embankment Tank Assembly

		Federal Standard 191 Method	ASTM Method	
Weight		5041	ASTM D751	40.5 oz/yd ± 2 oz/yd (0.06 kg/ 0.84 m ²)
Thickness		5030	ASTM D751	0.042 in. ± 0.003 in. (1.07 mm ± 0.08 mm)
Breaking strength	Warp	5100	ASTM D751	300 lb (136.2 kg) average
	Fill	5100	Grab	300 lb (136.2 kg) average
Tear strength	Warp	5134	ASTM D2261	20 lb (9.1 kg) average
	Fill	5134	Tongue	20 lb (9.1 kg) average
Adhesion of coating to fabric: jaw separation speed 12 in. (305 mm)/min		5970	ASTM D751	15 lb/in. (6.8 kg/mm) width, minimum
Puncture resistance			per MIL-T-6396F, 4.5.17	
Parallel to warp				90 lb (40.8 kg) minimum
Parallel to fill				90 lb (40.8 kg) minimum
45 degrees to cords				90 lb (40.8 kg) minimum
Abrasion resistance		5306	ASTM D1183	
Wheel — H-22			Taber	No fabric showing after 4000 cycles
Weight — 3.5 oz (100 g/wheel)				
Blocking resistance		5872		Rating of 1, maximum
Seam strength, 2 in. (51 mm) wide specimen		8311*		No seam slippage

* Federal Test Method Standard 601.

9.4 Embankment Preparation and Tank Installation Procedure.

9.4.1 Foundation. The embankment and earth base that support the tank shall be installed in accordance with Figure B.1(e).

9.4.1.1 The embankment shall be designed for stability and drainage.

9.4.1.1.1 Where two tanks are installed with a single embankment between tanks, such an embankment shall be designed to resist the load of a full single tank when one tank is drained.

9.4.1.2 A shallow excavation shall be permitted to be made below nominal grade level where allowed by local soil and groundwater conditions permit.

9.4.1.2.1 The removed soil, if suitable, shall be permitted to be used to extend the embankment above grade for the required height (cut and fill method).

9.4.1.3 The internal and external slopes of the embankment shall be 1½ to 1.

9.4.1.3.1 The slope shall be maintained in the original design condition to ensure the integrity of the embankment.

9.4.1.3.2 The soil shall provide a stable embankment.

9.4.1.3.3 Compliance with these requirements shall be subject to verification by a qualified professional soils engineer.

9.4.1.4 The inside corners of the embankment at the intersections of dike walls shall be rounded using a radius of ±1 ft (±0.31 m), approximately, at the bottom and a radius of ±½ ft (±0.76 m), approximately, at the top of the dike, with uniform gradation from the bottom to the top, as approved by an authorized design or soils engineer.

9.4.1.5 The floor of the embankment shall be graded to locate the inlet/outlet fitting at a minimum distance of 3 in. (76 mm) below the toe of the embankment inside juncture with the floor.

9.4.1.5.1 The grading between the fitting location and all points along the juncture of the sloping side walls and the floor shall be uniform to provide positive drainage.

9.4.1.6 Earth dike construction tolerances shall be as follows:

- (1) ±6 in. (152 mm) for surface variance on the interior slope of the dike walls
- (2) +2 percent on a specified vertical dimension for the dike height
- (3) ±1 percent on horizontal dimensions specified for the dike length and width where approved by the soils engineer

9.4.1.7 A 6 in. (152 mm) thick layer of fine sand or top soil shall be used for the surface layer of the floor and shall be underlaid by a 3 in. (76 mm) thickness of selected pea gravel to provide a firm, smooth bed and good drainage.

9.4.1.8 The finished surfaces of the inside dike walls and the floor shall be free from sharp rocks and debris.

9.4.1.9 A 4 in. (102 mm) diameter porous drain pipe shall be provided around the perimeter of the floor to ensure positive drainage of melted snow and rainwater from inside the dike.

9.4.1.9.1 The outlet of the pipe also shall serve as a telltale leak detector for the tank.

9.4.1.10 A cement-lined gutter, as shown in Figure B.1(e), shall be provided through the top and down the outside of the end wall nearest the inlet/outlet fitting to provide positive drainage of melted snow and rainwater from the tank top.

9.4.1.11 The exterior sides and top of the dike walls shall be protected against surface erosion.

9.4.2 Installation. Installation of the tank in the prepared embankment shall be accomplished with the assistance of the tank manufacturer's field technician.

9.4.2.1 The tank shall be shipped to the site packaged in a material that is designed for ease of handling by a crane and winch and that facilitates efficient placement in the enclosure.

9.4.2.2 The fittings shall be installed on-site.

9.4.2.3 At the time of installation, the tank shall be filled, and final adjustments on the tank shall be made to ensure that it rests uniformly against the embankment on all four sides.

9.4.2.3.1 Adjustments in anchoring stakes shall be made at this time.

9.4.2.3.2 The stakes shall be installed in accordance with Figure B.1(e).

9.4.2.3.3 The tank shall be secured entirely around the top periphery of the embankment walls using ropes that pass through straps that are built on the outer surface of the tank and that are tied around the stakes.

9.4.2.3.4 This entire operation shall be carried out under the direction of the tank manufacturer's field technician.

9.5 Tank Sump and Support for Bottom Fittings.

9.5.1* Inlet/Outlet. The concrete pad that contains the common inlet/discharge fitting and drain fitting for the tank shall be located near a corner of the embankment floor with the centerline of the inlet/discharge fitting located a minimum of 7 ft (2.1 m) from the bottom edges of the sloping embankment walls.

9.5.2 Finish. The surface of the concrete pad shall be smooth, and the edges shall be rounded.

9.5.2.1 The soil-to-concrete interface around the pad shall have a slight shoulder of sand to support the tank so that the coated-fabric construction of the tank is not abraded on the edge of the concrete.

9.6 Pipe Connections and Fittings.

9.6.1 General Information. The tank fittings, accessories, and piping connections shall be as shown in Figure B.1(f). The fittings attached to the tank shall be of flanged type.

9.6.1.1 All metal parts shall be corrosion resistant.

9.6.2 Fittings Attached to Tank.

9.6.2.1 The tank shall include either one or two access manhole fittings with cover plates in the top surface. A vent pipe with a pressure relief cap shall be attached to each manhole fitting.

9.6.2.2 The fittings that are located in the bottom of the tank shall include a combination inlet/outlet fitting and a drain fitting. Both of these fittings shall be located and secured to the concrete sump in the bottom of the tank.

9.6.2.3 A vortex-plate assembly, as shown in Figure B.1(f), shall be bolted to the combination inlet/outlet fitting.

9.6.2.3.1 The vortex-plate assembly, in addition to controlling vortex flow, shall serve as a guard so that it is possible to pump the calculated water capacity out of the tank at a high rate of flow.

9.6.2.4* An overflow shall be provided and shall be sized for the filling rate or shall be sized 2 in. (51 mm) larger than the fill line.

9.6.3 Water-Level Gauge. The tank shall be provided with a water-level gauge that consists of a sight glass that is constructed of clear acrylic tubing of $\frac{2}{8}$ in. (60 mm) outside diameter.

9.6.3.1 Where subject to freezing, the water gauge assembly shall be installed in the heated pump house.

Chapter 10 Concrete Gravity Tanks and Suction Tanks

10.1 General. The design, materials, and construction of concrete tanks shall conform to ACI 318 and ACI 350, with water considered as a live load.

10.2 Prestressed Tanks. Prestressed concrete water tanks shall conform to AWWA D110 or AWWA D115.

10.3 Standard Capacities. This chapter provides requirements for reinforced concrete tanks of 10,000 gal to 500,000 gal (37.85 m³ to 1892.50 m³) and prestressed concrete tanks of 10,000 gal to 1,000,000 gal (37.85 m³ to 3785.00 m³) net capacity.

10.3.1 Tanks of larger capacities shall be permitted.

10.4 Earthquake Load. Concrete tanks shall meet the requirements for resisting earthquake damage by complying with the earthquake provisions of ACI 350.

10.4.1 Earthquake requirements for prestressed concrete tanks shall comply with the earthquake provisions of AWWA D110 or AWWA D115, as applicable.

10.5 Wall Treatments. Concrete tank walls shall be made impermeable by means of an impervious membrane or coating that is applied to the interior surface of the tank to prevent visible leakage or seepage through the tank wall.

10.5.1 Tank designs that are not subject to such leakage shall not be required to be made impermeable.

Chapter 11 Fiberglass-Reinforced Plastic Tanks

11.1 General. Fiberglass-reinforced plastic tanks shall be permitted to be used for fire protection systems when installed in accordance with this standard.

11.2* Application. Fiberglass-reinforced plastic tanks shall be permitted only for storage of water at atmospheric pressure.

11.3* Tank Specification. Fiberglass-reinforced plastic tanks shall meet the requirements of AWWA D120 or AWWA D121.

11.4 Monolithic Tanks. Monolithic tanks shall be tested for leakage by the manufacturer prior to shipment.

11.4.1 Tanks that are assembled on site shall be tested for leakage by the manufacturer.

11.5 Protection of Buried Tanks.

11.5.1 Tanks shall be designed to resist the pressure of earth against them.

11.5.2 Tanks shall meet local building code requirements for resisting earthquake damage.

11.5.3 Tanks shall be installed in accordance with the manufacturer's instructions and 11.5.4 through 11.5.13.

11.5.4 Bedding and backfill shall be noncorrosive inert material, of a type recommended by the tank manufacturer, such as crushed stone or pea gravel that is properly compacted.

11.5.5 Tanks shall be set on the minimum depth of bedding, as recommended by the tank manufacturer, that extends 1 ft (0.3 m) beyond the end and sides of the tank.

11.5.6 Tanks shall be located completely below the frost line to protect against freezing.

11.5.7 Where tanks are buried below railroad tracks, the minimum depth of cover shall be 4 ft (1.2 m).

11.5.8 Where the tanks are not subjected to traffic, tanks shall be covered with not less than 12 in. (305 mm) of compacted backfill and topped with up to 18 in. (457 mm) of compacted backfill or with not less than 12 in. (305 mm) of compacted backfill, on top of which shall be placed a slab of reinforced concrete not less than 4 in. (100 mm) thick.

11.5.9 Where tanks are, or are likely to be, subjected to traffic, they shall be protected from vehicles passing over them by at least 36 in. (914 mm) of backfill, or 18 in. (457 mm) of compacted backfill, of a type recommended by the tank manufacturer, plus either 6 in. (152 mm) of reinforced concrete or 9 in. (229 mm) of asphaltic concrete or greater where specified by the tank manufacturer.

11.5.10 Where asphaltic or reinforced concrete paving is used as part of the protection, it shall extend at least 12 in. (305 mm) horizontally beyond the outline of the tank in all directions.

11.5.11 Tanks shall be safeguarded against movement when exposed to high groundwater or floodwater by anchoring with non-metallic straps to a bottom hold-down pad or deadman anchors with fittings built up or protected to prevent corrosion failure over the life of the tank or by securing by other equivalent means using recognized engineering standards.

11.5.12 The depth of cover shall be measured from the top of the tank to the finished grade, and due consideration shall be given to future or final grade and the nature of the soil.

11.5.13 Maximum burial depths, measured from the top of the tank, are established by underground tank manufacturers and independent testing laboratories. Maximum burial depth shall be specified by the tank manufacturer and shall be marked on the tank.

11.6 Protection of Aboveground Tanks.

11.6.1 Tanks shall meet local building code requirements for resisting earthquake damage.

11.6.2 Tanks shall be installed in accordance with the manufacturer's instructions and 11.6.3 through 11.6.5.

11.6.3 Fiberglass-reinforced plastic (FRP) tanks located inside a building shall be protected by automatic sprinklers in accordance with ordinary hazard Group 2 occupancies.

11.6.3.1 Where the hazard is greater than OH2, protection shall be in accordance with NFPA 13.

11.6.4 Horizontal fiberglass-reinforced plastic tanks that are greater than 4 ft (1.2 m) in diameter and are positioned 18 in. (457 mm) or greater above finished floor shall be protected in accordance with the obstruction rules of NFPA 13.

11.6.5 Fiberglass tanks installed outdoors shall be protected from freezing and mechanical and UV damage.

11.7 Tank Connections.

11.7.1 Tanks shall have a vent that extends above the ground to prevent against pressurization of the tank during filling and creation of a vacuum during use. Tank venting systems shall be provided with a minimum 2.0 in. (50 mm) nominal inside diameter.

11.7.2* For underground tanks, water level monitoring required by 14.1.8 shall be capable of being read above ground.

11.7.3* Tanks shall have an accessible method of filling the tank above ground.

11.7.4* Tanks that are used as cisterns for providing fire flow to fire department apparatus shall have a dry hydrant assembly with threads acceptable to the authority having jurisdiction.

11.7.5 Tanks used as cisterns for providing fire flow to fire department apparatus shall be located such that the lowest water in the tank used for fire protection is not more than 15 ft (4.6 m) below the grade where the fire department apparatus will site to extract water from the tank.

Chapter 12 Tank and Tower Foundations in the Ground

12.1 Concrete Specifications. Concrete foundations and footings shall be built of concrete with a specified compressive strength of not less than 3000 psi (20.69 MPa). Design, materials, and construction shall conform to ACI 318, with water considered as a live load.

12.2 Suction Tank Foundations.

12.2.1 Except as allowed by 12.2.2.4, suction tanks shall be set on a concrete slab foundation or a concrete ringwall foundation with a cushion of sand, compacted crushed stone, or granular base.

12.2.1.1 When a suction tank is set on a concrete ringwall foundation with a cushion of sand, at least 3 in. (76.2 mm) of clean, dry sand, laid on the compacted grade, shall be provided at the finished tank grade and shall slope up toward the center of the tank at the rate of 1 in. in 10 ft (25.4 mm in 3 m).

12.2.1.2 For suction tanks set on concrete foundations, the junction of the tank bottom and the top of the concrete foundation shall be tightly sealed to prevent water from entering the base.

12.2.1.3 For tanks supported on concrete slab foundations, a sand cushion at least 1 in. (25.4 mm) thick or a ½ in. (12.7 mm) cane fiber joint filler that complies with ASTM D1751 shall be provided between the flat bottom and the foundation.

Where a starter ring that is installed in accordance with AWWA D103 is embedded in a concrete slab floor, the sand cushion and cane fiber joint filler shall not be required.

12.2.1.4 Embankment-supported coated fabric suction tank foundations shall comply with Section 9.4.

12.2.2 For ringwall foundations, a minimum 10 in. (254 mm) wide reinforced concrete ring wall that extends below the frost line and at least 1.0 ft (0.30 m) below finished grade shall be placed directly beneath the tank shell where tanks are supported on a cushion of sand, on crushed stone, or granular bases.

12.2.2.1 The ring shall project at least 6 in. (152 mm) to a maximum of 12 in. (300 mm) above the surrounding grade and shall be reinforced against temperature and shrinkage and shall be reinforced to resist the lateral pressure of the confined fill with its surcharge.

12.2.2.2 The minimum reinforcement shall conform to Chapter 14, Section 14.3 of ACI 318.

12.2.2.3 The tops of ringwall foundations shall be level within ±⅛ in. (±3.2 mm) in one plate length [approximately 34 ft (10.4 m)], and no two points on the wall shall differ by more than ±¼ in. (±6.4 mm).

Δ 12.2.2.4 In lieu of a concrete foundation, self-anchored steel suction tanks shall be permitted to be supported on granular berms, with or without steel retainer rings, in accordance with AWWA D100 or AWWA D103, as applicable.

12.2.3 Where soil does not provide direct support for the tank without excessive settlement, shallow foundation construction shall not be adequate, and a proper foundation shall be designed by a foundation engineer.

12.3 Foundation Piers for Elevated Tanks.

12.3.1 The tops of foundation piers shall be level, shall be at least 6 in. (152 mm) above grade, and shall be located at the correct elevations.

12.3.2 The bottom of foundations shall be located below the frost line or at least 4 ft (1.2 m) below grade, whichever is greater.

12.3.3 Pier foundations shall be of any suitable shape and shall be of either plain or reinforced concrete.

12.3.3.1 Where the pier foundation supports a tower, the center of gravity of the pier shall lie in the continued center of the gravity line of the tower column, or it shall be designed for the eccentricity.

12.3.3.2 The top surface shall extend at least 3 in. (76 mm) beyond the bearing plates on all sides and shall be chamfered at the edge.

12.4 Anchorage.

12.4.1 The weight of the piers shall be sufficient to resist the maximum net uplift that occurs when the tank is empty and wind loads are on the structure, as specified in previous sections.

12.4.1.1 The wind shall be considered to be blowing from any direction.

12.4.1.2 The weight of earth located vertically above the base of the pier shall be permitted to be included.

12.4.2 Anchor bolts shall be arranged to securely engage a weight at least equal to the net uplift when the tank is empty and the wind is blowing from any direction.

12.4.2.1 The lower ends of the anchor bolts shall terminate in a head, nut, washer plate, or u-bolt.

12.4.2.2 Design of the anchor embedment strength shall be in accordance with ACI 318.

12.4.3 Anchor bolts shall be accurately located with sufficient free length of thread to fully engage their nuts.

12.4.3.1 Expansion bolts shall not be acceptable.

12.4.3.2 Anchor bolts and nuts that are exposed to weather, water, or corrosive environments shall be protected by one of the following methods:

- (1) Galvanizing
- (2) Corrosion-resistant alloys
- (3) Field-applied coating after installation

12.4.3.3 Except as provided in 12.4.3.3.1, the minimum size of anchor bolts shall be 1¼ in. (32 mm).

△ **12.4.3.3.1** Anchor bolts and nuts less than 1¼ in. (32 mm) in diameter, but not less than ¾ in. (19.1 mm) in diameter, shall be permitted to be used, provided they are protected in accordance with 12.4.3.2(1) or 12.4.3.2(2).

12.5 Grouting. Bearing plates or base plates shall have complete bearing on the foundation or shall be laid on 1 in. (25.4 mm) minimum thickness cement grout to secure a complete bearing.

12.6 Soil-Bearing Pressures.

12.6.1 The design soil-bearing pressure and the corresponding depth of foundation shall be determined by subsurface investigation and by a review of foundation experience in the vicinity.

12.6.1.1* Such an investigation 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 support.

12.6.2 Where the presence of limestone or other soluble rock types are suspected, subsurface investigation shall include cavity investigation and competency of bedrock.

12.6.2.1 The potential for subsidence, collapse, soil liquefaction, and settlement shall be evaluated.

12.6.3 The design soil-bearing pressure shall not exceed a pressure that can cause settlements that impair the structural integrity of the tank.

12.6.4 Foundations shall not be constructed over buried pipes or immediately adjacent to existing or former deep excavations.

12.6.4.1 This requirement shall not apply where foundation bases extend below the excavation.

12.6.5 The design soil-bearing pressure shall provide for a factor of safety of 3 based on the calculated ultimate bearing capacity of the soil for all direct vertical loads, including wind moment load on the columns.

12.6.5.1 The factor of safety shall not be less than 2 when considering the toe pressure for the direct vertical loads, plus the overturning moment caused by wind shear at the tops of individual piers.

Chapter 13 Steel Tank Towers

13.1 General.

13.1.1* This section shall define the design, fabrication, and erection of steel towers to support water tanks.

13.1.2 Height. The height of the tower shall be the vertical distance from the top of the foundation to the bottom capacity line of the tank.

13.1.3 Strength.

13.1.3.1 The material specified shall be without defects that affect the strength or service of the structure.

13.1.3.2 The workmanship shall be of such quality that defects or injuries are not produced during manufacture or erection.

13.1.3.3 The unit stresses specified shall not be exceeded.

13.1.3.4 The structures and their details shall possess the requisite strength and rigidity.

13.1.4 Details. The details shall comply with the requirements of this chapter and, where not covered herein, to AWS D1.1/D1.1M.

13.2 Materials.

13.2.1 Plates, Shapes, and Tubular Columns.

13.2.1.1 Plates. Plate materials shall be of open-hearth, electric furnace, or basic oxygen process steel that conforms to the following:

- (1) ASTM A36/A36M
- (2) ASTM A283/A283M, Grades A, B, C, and D

13.2.1.1.1 Where plates of thicknesses greater than ¾ in. (19.1 mm) are used, ASTM A283/A283M, Grade D, shall not be used. ASTM A131/A131M, Grades A, B, and C; ASTM A285/A285M, Grades A, B, and C; or ASTM A516/A516M, Grades 55 and 60, shall be permitted to be used as alternatives.

13.2.1.2 Shapes. Structural materials shall be open-hearth, electric furnace, or basic oxygen process steel that conforms to ASTM A36/A36M; ASTM A131/A131M, Grade A, B, or C; or ASTM A992/A992M.

13.2.1.2.1 Copper-bearing steel that contains approximately 0.20 percent copper shall be used.

13.2.1.2.2 In all other respects, steel shall conform to the specifications of 13.2.1.1 and 13.2.1.2.

13.2.1.3 Tubular Columns. Steel pipe shall be permitted to be used for tubular columns or other structural members, provided it complies with ASTM A53/A53M, Type E or Type S, Grade B; ASTM A139/A139M, Grade B; and API SPEC 5L, Grade B, and provided the minimum wall thickness complies with the design requirements and the minimum thickness requirement of this standard.

13.2.1.3.1 The allowable underrun shall be subtracted from the nominal wall thickness when calculating the minimum pipe wall thickness.

13.2.1.3.2 Tubular sections shall not be flattened to form end connections.

13.2.2 Bolts, Anchor Bolts, and Rods.

13.2.2.1 Bolts and anchor bolts shall conform to ASTM A307, Grade A or Grade B. ASTM A36/A36M shall be considered an acceptable alternative material for anchor bolts.

13.2.2.2 Rods shall be open hearth, electric furnace, or basic oxygen process steel that conforms to ASTM A36/A36M.

13.2.3 Pins.

13.2.3.1 Pins shall comply with any of the following:

- (1) ASTM A36/A36M
- (2) ASTM A108, Grade 1018 or Grade 1025
- (3) ASTM A307, Grade A or Grade B

13.2.3.2 Size and diameter tolerances of turned pins shall be equal to that of cold-finished shafting. The surface finish shall depend on the application but shall not be rougher than 125 micro-in. (3.18 μm).

13.3 Loads.

13.3.1 Live Load — Large Tank Risers.

13.3.1.1 The water located directly above any tank riser shall not be considered to be carried by the tower columns.

13.3.1.1.1 Such water shall be considered to be carried by the tower columns where the tank riser is suspended from the tank bottom or from the tower columns.

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

13.3.1.2.1 The inside radius of the hollow cylinder shall be considered to be equal to the radius of the tank riser at the tank bottom.

13.3.1.2.2 The load shall be deducted from the weight of the tank water when designing the tower.

13.3.1.2.3 The load shall not be required to be deducted from the weight of the tank water where the tank riser is suspended from the tower.

13.3.1.3 If a hemispherical or ellipsoidal shape is continuous to the shell of a large tank riser without a flat horizontal diaphragm plate and the tank riser is supported by a separate solid foundation or is suspended from the tower, the tank riser plate shall be designed to carry the water load of a hollow cylinder that extends from the bottom of the tank to the top of the tank.

13.3.1.3.1 The outside radius of the hollow cylinder shall be assumed to be 2 ft (0.61 m) greater than, and the inside radius

shall be assumed to be equal to, the radius of the tank riser shell at the tank bottom.

13.3.1.3.2 The load shall not be deducted from the tank water load when designing the tank and tower.

13.3.1.3.3 The load shall be permitted to be deducted for the tower design of tanks with ellipsoidal bottoms of a flat shape at the connection to tank risers supported by a separate solid foundation.

13.3.1.4 If the tank bottom is a torus shape, the tank riser plate shall be designed to carry the weight of all water in the tank between a cylinder that intersects the bottom at its lowest elevation and a cylinder that is equal to the diameter of the tank riser.

13.3.1.4.1 The load shall be deducted from the weight of the tank water when designing the tower.

13.3.2 Wind Load. The load on the tower shall be assumed to be concentrated at the panel points.

13.3.3 Balcony and Ladder Loads.

13.3.3.1 A vertical load of 1000 lb (454 kg) shall be assumed to be applied to any 10 ft² (0.93 m²) of area on the balcony floor and on each platform; 500 lb (227 kg) shall be assumed to be applied to any 10 ft² (0.93 m²) of area on the tank roof; and 350 lb (159 kg) shall be assumed to be applied to each vertical section of ladder.

13.3.3.2 All structural parts and connections shall be designed to withstand such loads.

13.3.3.3 The loadings specified shall not be combined with snow loading.

13.3.4 Earthquake Load. Tank towers shall meet the requirements for resisting earthquake damage by complying with the earthquake design load provisions of AWWA D100 and 13.4.7.2.

13.4 Unit Stresses.

13.4.1 General. The maximum stresses in pounds per square inch (megapascals) produced by the loads specified in Section 13.3 shall not exceed the values specified in Table 13.4.1 and Table 13.4.3 through Table 13.4.5.

13.4.2 Slenderness Ratio. The maximum permissible slenderness ratio, L/r , for compression members that carry the weight or pressure of the tank contents shall be 120.

13.4.2.1 The maximum permissible slenderness ratio, L/r , for compression members that carry the loads from wind and earthquake only shall be 175.

13.4.2.2 The maximum permissible slenderness ratio, L/r , for columns that carry roof loads only shall be 175.

13.4.3 Bending. Table 13.4.3 shall be used for bending requirements.

13.4.4 Shearing. Table 13.4.4 shall be used to determine maximum shear stress requirements.

13.4.5 Bearing. Table 13.4.5 shall be used to determine maximum bearing stress.