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(Revision of ANSI/AWWA D110-04)
Reaffirmed without revisions

American Water Works Association

AWWA Standard

Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks

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AWWA Standard

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Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

Foreword

This foreword is for information only and is not a part of ANSI/AWWA D110.*

I. Introduction.

I.A. *Background.* The New England Water Works Association (NEWWA) established a committee in 1958 to prepare a standard specification for the design and construction of prestressed concrete water-storage tanks. The committee submitted a suggested specification to NEWWA in October 1962 as a guide to those in the water industry who wished to consider the use of these tanks.

American Concrete Institute (ACI) Committee 344 concluded eight years of committee work with a report titled "Design and Construction of Circular Prestressed Concrete Structures," published in the *ACI Journal* September 1970. This report referred primarily to wire-wound tanks.

I.B. *History.* In the December 1972 issue of *Journal AWWA*, the applicability of the ACI report to water containment structures was discussed in four articles. As a result of these articles and continued discussion on the subject, a standards committee was authorized by the American Water Works Association (AWWA) to develop an AWWA standard for circular, prestressed concrete water tanks.

An AWWA standards committee on circular, prestressed concrete water tanks was appointed and held its first meeting June 19, 1974. During its first two years, the committee studied the various types of prestressed tanks then in service or under construction and determined that most were of the wire-wound type. Therefore, the committee in 1976 was directed to limit its scope to the wire- and strand-wound prestressed tank wall design. The first edition of this standard incorporated the work of ACI Committee 344 and contained additional requirements and recommendations, specifically for potable and process water, and for wastewater containment structures. The new standard, ANSI/AWWA D110-86, Standard for Wire-Wound Circular Prestressed-Concrete Water Tanks, was approved by the AWWA Board of Directors on June 22, 1986, and had an effective date of June 1, 1987. The standard has been in use since approval by the American National Standards Institute (ANSI) on Mar. 3, 1987.

The first revision of this standard was initiated by the AWWA Standards Committee during 1990 according to AWWA Standards Council policy. The revised standard ANSI/AWWA D110-95 was approved on June 22, 1995, by the AWWA Board of

* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

Directors. The next edition of the standard, ANSI/AWWA D110-04, was approved by the AWWA Board of Directors on Jan. 18, 2004. This edition, ANSI/AWWA D110-13, was approved by the AWWA Board of Directors on Jan. 20, 2013.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for direct and indirect drinking water additives. Other members of the original consortium included the Water Research Foundation (formerly AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (AWWA) and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States, authority to regulate products for use in, or in contact with, drinking water rests with individual states.* Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. An advisory program formerly administered by USEPA, Office of Drinking Water, discontinued on Apr. 7, 1990.
2. Specific policies of the state or local agency.
3. Two standards developed under the direction of NSF, NSF†/ANSI‡ 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.
4. Other references, including AWWA standards, *Food Chemicals Codex*, *Water Chemicals Codex*,§ and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI 61. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdiction. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

Annex A, "Toxicology Review and Evaluation Procedures," to NSF/ANSI 61 does not stipulate a maximum allowable level (MAL) of a contaminant for substances not

* Persons outside the United States should contact the appropriate authority having jurisdiction.
† NSF International, 789 N. Dixboro Road, Ann Arbor, MI 48105.
‡ American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
§ Both publications available from National Academy of Sciences, 500 Fifth Street, NW, Washington, DC 20418.

regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of "unregulated contaminants" are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA D110 does not address additives requirements. Users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements, including applicable standards.
2. Determine the status of certifications by parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

II. Special Issues.

II.A. *Intent.* This standard reflects a committee consensus of industry practice concerning the design, detailing, and construction of circular, prestressed concrete water tanks of several types, with or without vertical prestressing of the tank core wall. The horizontal prestressed reinforcement of the tank wall is accomplished by the application of helically wound high-tensile-stress wire or strand under controlled tension on the surface of the core wall, protected by shotcrete cover coats.

Recommended criteria and guidelines are presented to assist engineers in the design, construction, and inspection of tanks with shotcrete, cast-in-place concrete, or precast circular concrete core walls, with or without internal steel diaphragms, based on the successful application of these concepts in practice and the detailed experience of committee members. Engineering principles are tied to existing codes where applicable.

The intent is also to assist the designer and constructor by sharing information on the unique aspects in analysis and construction that are encountered in these types of structures.

II.B. *Limitations.* Because of the wide range of site-specific environments, foundation conditions, loadings, and construction conditions throughout North America, this standard should not be expected to apply universally nor to produce a cost-effective and completely maintenance-free structure in every situation. In adapting this standard to obtain the structure's expected service life for the actual conditions that are anticipated, the purchaser and the designer of the tank are advised to carefully study all factors affecting the structure during its anticipated service life.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

III.A. *Industry Practice and Assumptions.* It is not the purpose of this standard to either define or recommend contractual relationships or to stipulate contractual obligations, both of which are the responsibility of the purchaser. Generally, purchasers may solicit competitive bids for wire- and strand-wound circular prestressed concrete tanks by one of two methods.

According to the first method, a design professional is retained by the purchaser to prepare construction drawings, specifications, and other contract documents. Competitive bids are then solicited from constructors and suppliers for construction of the tank. In this standard, these are referred to as purchaser-furnished designs.

According to the second method, the purchaser prepares performance specifications that require bidding constructors to prepare project designs and specifications and to construct the tank according to the design. In this standard, these are referred to as design–construct projects.

While the division of information that must be covered in the purchaser's specifications for execution of each method of contracting differs substantially, depending on who is responsible for the tank design, the information that must be supplied by the purchaser to successfully apply this standard is essentially the same.

ANSI/AWWA D110 does not address matters related to site selection and property acquisition. It is assumed that the purchaser will have conducted sufficient background work in the form of water system studies, predesign surveys, subsurface investigations, preliminary design work, etc., to establish the desired tank site, volume, operating water depth, and elevations. Further, it is assumed that the purchaser will have acquired the property, easements, and rights-of-way necessary for construction of the facility, including site access, the tank structure, and associated water pipelines connecting the tank to the water system and drainage, if required. Specifically, it has been assumed that the purchaser will arrange for or provide the following as necessary or appropriate:

1. The site on which the tank is to be built, with adequate space to permit the constructor to erect the structure using customary methods.

2. A predesign site survey and preparation of a site plan showing existing topography, property lines, approximate tank centerline location, setback, encumbrances, details of special construction features, and extent of final site grading.

3. A site geotechnical survey and foundation report, including logs of borings and test pits, soil densities, and other pertinent soil and geological information; construction criteria for any backfill that may be necessary at a particular site; and foundation design criteria prepared by a registered design professional specializing in

soil mechanics, including allowable bearing loads, anticipated total and differential settlements, and the seismic soil profile type.

4. Structural loading conditions, including, but not limited to, snow, wind, seismic, hydrostatic uplift, and other live loads depending on the tank's intended use; the amount of earth cover over the tank, if any; the height of backfill against the tank wall, if any; and any other special loading conditions that are anticipated or special criteria on which the tank design is to be based. If, for example, the tank is located in a high-intensity earthquake area and must continue to serve without damage following an earthquake, the purchaser may specify an importance factor for earthquake design as described in Table 2 or provide design values for the peak horizontal ground acceleration and for the spectrum velocity. In cases for which the design must consider static and dynamic earth pressures resulting from seismic shaking, the purchaser shall provide the required geotechnical data to evaluate these additional loading conditions in the tank design along with the soil site class as shown in Table 4.

5. Requirements for subdrainage and overflow collection systems.

6. The use of electric power and water service, if available, at the site.

III.B. *Purchaser Options and Alternatives.* The following information should be provided by the purchaser:

1. Whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects, is required.

The items that follow are either required information or alternative options in the standard that should be considered and covered by the purchaser, unless the purchaser intends that the choice for a particular option be left to the tank designer's discretion.

1. The standard to be used—that is, ANSI/AWWA D110, Standard for Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks, of latest revision.

2. The required capacity of the tank, including side water depth or diameter.

3. Requirements for subdrainage and overflow collection systems.

4. Seismic information required.

   a. The Occupancy Category as indicated in ASCE 7-05.

   b. Importance factor (Table 2).

   c. Structural response coefficient for type of tank (Table 3).

   d. Soil site class definitions (Table 4).

5. Information on access to the site for the constructor's equipment and for supply of construction materials.

6. Availability and characteristics of electric power and source of water for construction.

7. The type of roof and type or types of tank wall. Basic wall types (Sec. 1.1.1). Roof structures may be shotcrete or concrete domes (Sec. 3.6), nonprestressed concrete flat slabs supported by columns (Sec. 3.7), or other types of roofs selected by the purchaser. Preference for wet mix or dry mix for the tank wall or shotcrete cover coats (Sec. 2.2.2.2).

8. Details of other federal, state or provincial, and local requirements (Sec. 2.1).

9. Subsurface investigation and report (Sec. 3.8.4).

10. Tank appurtenances required (Sec. 3.11).

a. Specifications for any additional accessories to be provided.

b. Requirements for a water-level gauge or pressure sensor, or other level monitoring device (Sec. 3.11.2.4).

c. Size, material, and location of vents, access hatches, ladders, stairs, and manways; and locking and safety devices required (Sec. 3.11.3).

d. Whether or not a removable silt stop is required and whether baffles are provided for circulation (Sec. 3.11.7).

11. Size, material, location, details, cover depths, and limits of responsibility for all other pipe connections (Sec. 3.11.1).

12. Maximum filling (overflow) and emptying rates required (Sec. 3.11.2).

13. Size, material, arrangement, and location for the overflow pipe (Sec. 3.11.2).

14. Special exterior wall coatings or architectural treatment, if any (Sec. 3.11.6).

15. Seismic joint types (Sec. 4.2).

16. Maximum allowable stresses and reinforcement requirements (Sec. 4.6).

17. Maximum allowable coefficient of friction requirements (Sec. 4.7).

18. Foundation design requirements (Sec. 4.9).

19. The required elevation of the overflow weir and freeboard requirements (Sec. 4.10).

20. Design for seismic effects on backfill requirements (Sec. 4.11).

21. Finish grade relative to the tank foundation. (Whether or not the wall is to be completely exposed, partially buried, or completely buried.) (Sec. 4.11, Sec. 5.14)

22. Restraint cable requirements (Sec. 5.8).

III.C. *Modification to Standard.* Any modification of the provisions, definitions, or terminology in this standard must be provided by the purchaser.

IV. Major Revisions. This edition of the standard has been edited throughout and includes revisions to stated definitions and terms to achieve a higher degree of consistency among the various AWWA standards. The technical revisions to this

standard reflect current thinking and construction practices. These include the following:

1. A global change of references from ACI 318, Building Code Requirements for Structural Concrete, to ACI 350, Code Requirements for Environmental Engineering Concrete Structures. ACI 350 is the ACI code that deals directly with liquid-containing structures and is applicable to ANSI/AWWA D110 structures.
2. The addition of specific strength requirements for concrete slab.
3. References to "portland cement" have been changed to "cementitious material"; this change is intended to include supplemental cementitious materials such as fly ash, ground granulated blast furnace slag, and microsilica.
4. A global change of reference from "seismic cables" to "restraint cables" to reflect their use for other lateral loading conditions, such as differential backfill.
5. The elimination of Table 1 of ANSI/AWWA D110-04, Sec. 2.6, providing PVC waterstop test methods and limits, as this is directly covered by reference to Corps of Engineers CRD-C572.
6. The addition of urethane elastomer as a type of sealant and joint filler.
7. An update to the minimum design wind and seismic loads from the most recent versions of the IBC and ASCE 7.
8. The addition of construction loads as a roof design load.
9. The addition of metric equivalents to equations.
10. A clarification that the design calculations are performed by a registered design professional who is responsible for the design.
11. A reduction of the minimum roof rise-to-span ratio from 1:12 to 1:16 as a result of successful industry experience with lower-rise domes.
12. An update of the dome buckling equation to address changes in load factors.
13. The addition of requirements for compaction of cohesionless base material, such as gravel, under the floor.
14. A clarification of methods for concrete pipe encasement of under-floor pipe.
15. The addition of ultrasonic level sensors.
16. Guidance on conditions in which an interior ladder and/or wall accessway would be appropriate.
17. Incorporation of the new seismic design approach based on the IBC, ASCE 7-05 code standards, and current seismic technological advances resulting from the NEHRP research study.
18. The inclusion of urethane as a suitable material for crack injection.

19. Additional information on tank inspection, including inspector qualifications and suggested areas of inspection.

V. Comments. If you have any comments or questions about this standard, please call AWWA Engineering and Technical Services at 303.794.7711, FAX at 303.795.7603, write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098, or email at standards@awwa.org.

ANSI/AWWA D110-13
(Revision of ANSI/AWWA D110-04)

American Water Works Association

AWWA Standard

Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks

SECTION 1: GENERAL

Sec. 1.1 Scope

1.1.1 *Intent of standard.* The intent of this standard is to describe current recommended practice for the design, construction, inspection, and maintenance of wire- and strand-wound, circular, prestressed concrete water-containing structures with the following four types of core walls:

Type I—cast-in-place concrete with vertical prestressed reinforcement

Type II—shotcrete with a steel diaphragm

Type III—precast concrete with a steel diaphragm

Type IV—cast-in-place concrete with a steel diaphragm

1.1.2 *Items not described in standard.* This standard does not describe bonded or unbonded horizontal tendons for prestressed reinforcement of the tank wall, floor, or roof.

1.1.3 *Tank contents.* This standard applies to containment structures for use with potable water or raw water of normal temperature and pH commonly found in drinking water supplies. It is not intended for use in the design of containment structures for highly aggressive waters or high-temperature waters without special consideration being given to their effects on the structure; nor is it