

ANSI AWWA

C150/A21.50-21(R23)

*(Revision of ANSI/AWWA C150/A21.50-21)
(Reaffirmed without revision 2023)*

AWWA Standard

Thickness Design of Ductile-Iron Pipe

Effective date: May 1, 2024.

First edition approved by Board of Directors June 23, 1965.

This Reaffirmation approved Oct. 23, 2023.

Approved by American National Standards Institute Jan. 19, 2024.



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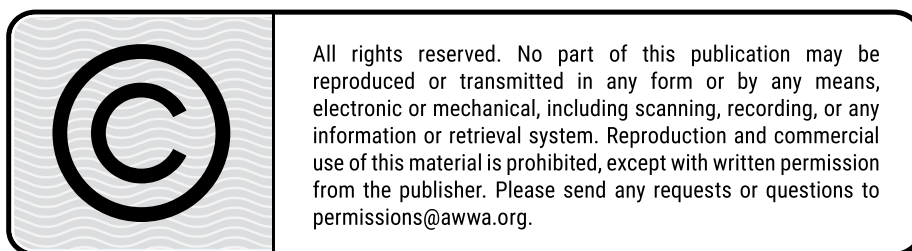
AWWA Standard

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ISBN-13, print: 978-1-64717-183-4

ISBN-13, electronic: 978-1-61300-710-5

DOI: <http://dx.doi.org/10.12999/AWWA.C150.23>

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA C150/A21.50.*

I. Introduction.

I.A. *Background.* The purpose of this standard is to provide pipeline designers with a recommended design procedure and associated tabular data necessary to establish the wall thickness(es) required for buried ductile-iron pipe based on the type of pipe embedment, depths of trench cover, live load conditions, internal working pressures, and surge conditions appropriate for the specific pipeline project. Once the required wall thickness(es) are established, the ductile-iron pipe should be specified to be manufactured in accordance with ANSI/AWWA C151/A21.51. ANSI/AWWA C151/A21.51 contains options that must be addressed by the purchaser in response to site-specific project requirements.

Although ANSI/AWWA C150/A21.50 is commonly used for designing ductile-iron pipe for services other than water, users are also directed to ASTM[†] A746, Standard Specification for Ductile Iron Gravity Sewer Pipe, and ASTM A716, Standard Specification for Ductile Iron Culvert Pipe.

I.B. *History.* American National Standards Committee A21, Cast-Iron Pipe and Fittings, was organized in 1926 under the sponsorship of the American Gas Association (AGA), ASTM International (ASTM), AWWA, and New England Water Works Association (NEWWA). Between 1972 and 1984, the co-secretariats were AGA, AWWA, and NEWWA, with AWWA serving as administrative secretariat. In 1984, the committee became an AWWA committee with the name of American Water Works Association Standards Committee A21 on Ductile-Iron Pipe and Fittings. In 1988, NEWWA withdrew as a separate secretariat; however, it continues to maintain its representation on the AWWA Committee A21.

The present scope of AWWA Committee A21 activity is the development of standards and manuals addressing ductile-iron pressure pipe for water and other liquids and ductile-iron and gray-iron fittings for use with this pipe. These standards and manuals include design, dimensions, materials, coatings, linings, joints, accessories, and methods of inspection and testing.

The work of AWWA Committee A21 is conducted by subcommittees. The scope of Subcommittee 1, Pipe, includes the periodic review of current A21 standards for

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

† ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19418.

pipe, the preparation of revisions and new standards when needed, as well as other matters pertaining to pipe standards.

The first edition of C150/A21.50, American National Standard for the Thickness Design of Ductile-Iron Pipe, was issued in 1965, and revisions were issued in 1971, 1976, 1981, 1991, 1996, 2002, 2008, and 2014. This edition was approved by the AWWA Board of Directors on October 25, 2021, and reaffirmed without revision on October 23, 2023.

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). 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. Specific policies of the state or local agency.
2. Two standards developed under the direction of NSF,[§] NSF/ANSI/CAN[¶] 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI/CAN 61, Drinking Water System Components—Health Effects.
3. 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/CAN 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.

[‡] Persons outside the United States should contact the appropriate authority having jurisdiction.

[§] NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

[¶] Standards Council of Canada, 55 Metcalfe Street, Suite 600, Ottawa, ON K1P 6L5 Canada.

^{**} Both publications available from The National Academies Press, 500 Fifth Street, NW, Washington, DC 20001.

Annex A, “Toxicology Review and Evaluation Procedures,” to NSF/ANSI/CAN 61 does not stipulate a maximum allowable level (MAL) of a contaminant for substances not 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 C150 does not address additives requirements. Thus, 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.

In order to meet a project’s schedule, at the manufacturer’s option and with the purchaser’s agreement, pipe may be shipped whose class is heavier than required or ordered.

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. *Purchaser Options and Alternatives.* The following items should be provided by the purchaser:

1. Standard used—that is, ANSI/AWWA C150/A21.50, Thickness Design of Ductile-Iron Pipe, of latest revision.
2. As noted in Sec. I.A of the Foreword, ANSI/AWWA C151/A21.51 contains options that must be addressed by the purchaser in response to site-specific requirements for ductile-iron pipe.

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

IV. Major Revisions. Major revisions made to the standard in this edition include the following:

1. Option for shipping heavier pipe with agreement of the purchaser was moved from Section 4 to Section II, Special Issues, in the Foreword.

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

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ANSI/AWWA C150/A21.50-21(R23)
(Revision of ANSI/AWWA C150/A21.50-21)
(Reaffirmed without revision 2023)

AWWA Standard

Thickness Design of Ductile-Iron Pipe

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes the thickness design of ductile-iron pipe complying with the requirements of ANSI*/AWWA C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast. Sec. 4.1 outlines the design procedure, and Sec. 4.2 gives a design example. Sec. 4.3 explains the basis of design. As opposed to using procedures in Sec. 4.1 or Sec. 4.3, the designer may reference Table 12, Table 13, and Table 14 directly.

Table 12 lists thicknesses for standard laying conditions and certain depths of cover. Table 13 lists thicknesses for 150-psi through 350-psi (1,034-kPa through 2,413-kPa)[†] water working pressure.

The greater thickness from Table 12 or Table 13 for given trench load or internal pressure should be used.

Table 14 lists working pressures and maximum depths of cover for standard laying conditions and standard pressure classes. Table 15 lists special thickness classes of ductile-iron pipe.

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

[†] Metric identifiers in this standard are nominal sizes and are not those specified in International Organization for Standardization (ISO) standards.

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for the thickness design of ductile-iron pipe, including basis of design and design procedure.

Sec. 1.3 Application

This standard can be referenced in purchase documents for the thickness design of ductile-iron pipe. The stipulations of this standard apply when this document has been referenced and then only to the thickness design of ductile-iron pipe.

SECTION 2: REFERENCES

This standard references the following documents. In their latest editions, these documents form a part of this standard to the extent specified within the standard. In any case of conflict, the requirements of this standard shall prevail.

AASHTO* T-99—Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop.

ANSI/AWWA C115/A21.15—Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.

ANSI/AWWA C151/A21.51—Ductile-Iron Pipe, Centrifugally Cast.

ANSI/AWWA C600—Installation of Ductile-Iron Mains and Their Appurtenances.

ANSI/AWWA C606—Grooved and Shouldered Joints.

ASTM[†] D2487—Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

ASTM D3282—Standard Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes.

NSF[‡]/ANSI/CAN[§] 61—Drinking Water System Components—Health Effects.

* American Association of State Highway and Transportation Officials, 555 12th St NW, Ste 1000, Washington, DC 20004.

[†] ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428.

[‡] NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

[§] Standards Council of Canada, 55 Metcalfe Street, Suite 600, Ottawa, ON K1P 6L5 Canada.

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. *Casting allowance:* Tolerance added to provide the latitude required by the manufacturing process and that is dependent on pipe size (Table 3).
2. *Manufacturer:* The party that manufactures, fabricates, or produces materials or products.
3. *Service allowance:* Added thickness of 0.08 in. (2 mm) for all pipes that provide an additional safety factor for unknowns.
4. *Surge pressure:* Internal pressure in excess of the working pressure caused by rapid changes in pipeline flow velocity.
5. *Working pressure:* Maximum internal pressure exerted under normal operating conditions.

SECTION 4: REQUIREMENTS

Sec. 4.1 Procedure for Calculating Thickness

The thickness of ductile-iron pipe is determined by considering trench load and internal pressure separately.

4.1.1 *Step 1: Design for internal pressure.* Calculate the net thickness required for internal pressure using the equation for hoop stress:

$$t = \frac{P_i D}{2S} \quad (\text{Eq 1})$$

where:

- t = net thickness, in. (mm)
- P_i = design internal pressure, psi (kPa) = $2 (P_w + P_s)$
- P_w = working pressure, psi (kPa)
- P_s = surge allowance, 100* psi (689 kPa)
- D = outside diameter of pipe, in. (mm)
- S = minimum yield strength in tension = 42,000 psi (289,590 kPa)

* If anticipated surge pressures are other than 100 psi (689 kPa), the actual anticipated pressure should be used.

4.1.2 Step 2: Design for trench load.

- a. Determine trench load P_v . Table 1 gives trench load, including earth load P_e , plus truck load P_p , for 2.5- to 32-ft (0.8- to 9.8-m) cover.
- b. Determine the standard laying condition from the descriptions in Table 2 and select the appropriate table for diameter-thickness ratios from Table 7, Table 8, Table 9, Table 10, and Table 11. Each table lists diameter-thickness ratios calculated over a range of trench loads.
- c. Refer to the column headed “Bending-Stress Design” in the appropriate table of Table 7, Table 8, Table 9, Table 10, and Table 11, and locate the tabulated trench load P_v from Sec. 4.1.2.a. If the calculated P_v is between two tabulated values, use the larger P_v value.
- d. Select the corresponding D/t value for this P_v .
- e. Divide the pipe’s outside diameter D (Table 5) by the D/t value to obtain the net thickness t required for bending-stress design.

4.1.3 Step 3: Selection of net thickness and addition of service allowances.

- a. Select the net thickness t from Step 1 or Step 2, whichever thickness is larger.
- b. Add the service allowance of 0.08 in. (2.0 mm) to the net thickness t . The resulting thickness is the minimum thickness t_1 .

4.1.4 Step 4: Check deflection. Refer to the column headed “Deflection Check” in the appropriate table of Table 7, Table 8, Table 9, Table 10, and Table 11, and locate the tabulated trench load P_v from Sec. 4.1.2.a. If the calculated P_v is between two tabulated values, use the larger P_v value. (If the calculated P_v is less than the minimum P_v listed in the table, deflection does not govern; proceed to Step 5.)

- a. Select the corresponding D/t_1 value for this P_v .
- b. Divide the pipe’s outside diameter D (Table 5) by the D/t_1 value to obtain the minimum thickness t_1 required for deflection.
- c. Compare this value to the required minimum thickness t_1 from Sec. 4.1.3.b. If the t_1 required for deflection is less than the t_1 from Sec. 4.1.3.b, deflection does not govern; proceed to Step 5. If the t_1 required for deflection is greater than the t_1 from Sec. 4.1.3.b, deflection governs and the minimum thickness t_1 required for deflection should be used in Step 5.

4.1.5 Step 5: Add the casting allowance. Add the casting allowance from Table 3 to the minimum manufacturing thickness t_1 . The resulting thickness is the total calculated thickness.

4.1.6 *Step 6: Selection of nominal thickness and standard pressure class.* Use the total calculated thickness from Sec. 4.1.5 to select a standard pressure-class thickness from Table 5. When the calculated thickness is between two nominal thicknesses, select the larger of the two. When specifying and ordering pipe, specify the pressure class listed in Table 5 corresponding to this nominal thickness.

NOTE: On specific projects, manufacturers may be willing to provide pipe with thicknesses that fall between standard classes.

4.1.7 *Alternative procedure.* The appropriate standard pressure class may also be determined by using the design equations in Sec. 4.3.

Sec. 4.2 Design Example for Calculating Thickness

Problem: Calculate the thickness for 30-in. (760-mm) ductile-iron pipe bedded in loose soil for a minimum depth of 4 in. (100 mm), backfill lightly consolidated to top of pipe, laying condition Type 3, under 10 ft (3 m) of cover for a working pressure of 150 psi (1,034 kPa).

4.2.1 *Step 1: Design for internal pressure.*

$$P_i = 2.0 (P_w + P_s) = 2.0 (\text{working pressure} + 100 \text{ psi surge allowance})$$

(If anticipated surge pressures are other than 100 psi [689 kPa], the actual anticipated pressures should be used.)

$$P_i = (2.0)(150 + 100) = 500 \text{ psi}$$

$$t = \frac{P_i D}{2S} = \frac{500 \times 32.00}{2 \times 42,000} = 0.19 \text{ in.}$$

Net thickness t for internal pressure is 0.19 in.

4.2.2 *Step 2: Design for trench load.*

- a. Earth load (Table 1) P_e = 8.3 psi
 Truck load (Table 1) P_t = 0.7 psi
 Trench load, $P_v = P_e + P_t$ = 9.0 psi
- b. Select Table 9 for diameter-thickness ratios for laying condition Type 3.
- c. Entering P_v of 9.0 psi in Table 9, the bending-stress design requires D/t of 163. From Table 5, diameter D of 30-in. pipe is 32.00 in.

$$\text{Net thickness } t \text{ for bending stress} = D/(D/t) = 32.00/163 = 0.20 \text{ in.}$$