PLAINTIFF'S EXHIBIT

CT-347

ANSI A21.51–1976
(AWWA C151–76)

Revision of
A21.51–1971
(AWWA C151–71)

AMERICAN NATIONAL STANDARD

for

DUCTILE-IRON PIPE, CENTRIFUGALLY CAST IN METAL MOLDS OR SAND-LINED MOLDS, FOR WATER OR OTHER LIQUIDS

SECRETARIATS

AMERICAN GAS ASSOCIATION
AMERICAN WATER WORKS ASSOCIATION
NEW ENGLAND WATER WORKS ASSOCIATION

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American National Standard

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Foreword

This foreword is for information only and is not a part of ANSI A21.51 (AWWA C151).

American National Standards Committee A21 on Cast-Iron Pipe and Fittings was organized in 1926 under the sponsorship of the American Gas Association, The American Society for Testing and Materials, the American Water Works Association, and the New England Water Works Association. Since 1972, the co-secretariats have been A.G.A., AWWA, and NEWWA, with AWWA serving as the administrative secretariat. The present scope of Committee A21 activity is

Standardization of specifications for cast-iron and ductile-iron pressure pipe for gas, water and other liquids, and fittings for use with such pipe. These specifications to include design, dimensions, materials, coatings, linings, joints, accessories and methods of inspection and test.

The work of Committee A21 is conducted by subcommittees. The directive to Subcommittee 1—Pipe is that

The scope of the subcommittee activity shall include the periodic review of all current A21 standards for pipe, the preparation of revisions and new standards when needed, as well as other matters pertaining to pipe standards.

The first edition of A21.51, the standard for ductile-iron pipe for water and other liquids, was issued in 1965, and a revision was issued in 1971. Subcommittee 1 reviewed the 1971 edition and submitted a proposed revision to American National Standards Committee A21 in 1975.

Major Revisions

1. An additional minus tolerance of 0.02 in. is permitted along the barrel of the pipe for a distance not to exceed 12 in. The weight tolerance permitted for any single pipe is 6 per cent for pipe 12 in. or smaller and 5 per cent for pipe larger than 12 in.
2. The tables include data for the five standard laying conditions covered in A21.50–1976. Types 1, 2, and 3 replace A, B, and S, respectively, in A21.51–1971. Types 3 and 4 have been added to provide a wider selection of laying conditions.
3. The pipe thickness selection tables have been revised to reflect the changes in the 1976 edition of A21.50, the standard for thickness design of ductile-iron pipe.
4. The standard thickness classes have been renumbered. Class 1 becomes Class 51; Class 2 becomes Class 52; and so on. Class 50 has been added for 6–54-in. pipe, and Class 51 has been added for 3–12-in. pipe.
5. Pipe weights have been adjusted for 3–24-in. push-on joint pipe to reflect lighter bell weights based on push-on joint bells, which are more compatible with the barrel thicknesses of ductile-iron pipe.
6. A table (Table 3) has been added to show rated working pressure and maximum depth of cover of the standard laying conditions and standard thickness classes.

Options

This standard includes certain options that, if desired, must be specified on the purchase order. Also, a number of items must be specified to describe completely the pipe required. The following summarizes the details and

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available options and lists the sections of the standard where they can be found.

1. Size, joint type, thickness or class, and laying length (Tables).
2. a. Special joints (Sec. 51–3.1).
   b. Specifying ductile-iron gland, if required (Sec. 51–3.1).
3. Certification by manufacturer (Sec. 51–4.2).
4. Inspection by purchaser (Sec. 51–5).
5. a. No requirement for outside coating (Sec. 51–8.1).
   b. Cement lining (Sec. 51–8.2). Experience has indicated that bituminous inside coating is not complete protection against loss in pipe capacity caused by tuberculation. Cement linings are recommended for most waters.
   c. No requirement for inside coating (Sec. 51–8.3).
   d. Special coatings and linings (Sec. 51–8.4).
6. Special marking on pipe (Sec. 51–10).
7. Written transcripts of foundry records (Sec. 51–14).
8. Special tests (Sec. 51–15).

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ANSI A21.51–1976
(AWWA C151–76)

Revision of
A21.51–1971
(AWWA C151–71)

American National Standard for

Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids

Sec. 51–1—Scope

This standard covers 3-in. through 54-in. ductile-iron pipe centrifugally cast in metal molds or sand-lined molds for water or other liquids with push-on joints or mechanical joints. This standard may be used for pipe with such other types of joints as may be agreed upon at the time of purchase.

Sec. 51–2—Definitions

Under this standard, the following definitions shall apply:

51–2.1 *Purchaser.* The party entering into a contract or agreement to purchase pipe according to this standard.

51–2.2 *Manufacturer.* The party that produces the pipe.

51–2.3 *Inspector.* The representative of the purchaser, authorized to inspect on behalf of the purchaser to determine whether or not the pipe meets this standard.

51–2.4 *Ductile iron.* A cast ferrous material in which a major part of the carbon content occurs as free carbon in nodular or spheroidal form.

51–2.5 *Mechanical joint.* The gasketed and bolted joint as detailed in ANSI A21.11 (AWWA C111) of latest revision.

51–2.6 *Push-on joint.* The single rubber-gasket joint as described in ANSI A21.11 (AWWA C111) of latest revision.

Sec. 51–3—General Requirements

51–3.1 Pipe with mechanical joints or push-on joints shall conform to the applicable dimensions and weights shown in the tables in this standard and to the applicable requirements of ANSI A21.11 (AWWA C111) of latest revision. Unless otherwise specified, the mechanical-joint glands shall be cast iron in accordance with ANSI A21.11 of latest revision and bolts shall conform to the requirements of the same standard. Pipe with other types of joints shall comply with the joint dimensions and weights agreed upon at the time of purchase but in all other respects shall fulfill the requirements of this standard.

51–3.2 The nominal laying length of the pipe shall be as shown in the tables. A maximum of 20 per cent of the total number of pipe of each size specified in an order may be furnished by as much as 24 in. shorter than the

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nominal laying length, and an additional 10 per cent may be furnished by as much as 6 in. shorter than nominal laying length.

Sec. 51–4—Inspection and Certification by Manufacturer

51–4.1 The manufacturer shall establish the necessary quality-control and inspection practice to ensure compliance with this standard.

51–4.2 The manufacturer shall, if required on the purchase order, furnish a sworn statement that the inspection and all of the specified tests have been made and the results thereof comply with the requirements of this standard.

51–4.3 All pipe shall be clean and sound without defects that could impair service. Repairing of defects by welding or other methods shall not be allowed if such repairs could adversely affect the serviceability of the pipe or its capability to meet strength requirements of this standard.

Sec. 51–5—Inspection by Purchaser

51–5.1 If the purchaser desires to inspect pipe at the manufacturer's plant, the purchaser shall so specify on the purchase order, stating the conditions (such as time and the extent of inspection) under which the inspection shall be made.

51–5.2 The inspector shall have free access to those parts of the manufacturer's plant that are necessary to ensure compliance with this standard. The manufacturer shall make available for the inspector's use such gages as are necessary for inspection. The manufacturer shall provide the inspector with assistance as necessary for handling of pipe.

Sec. 51–6—Delivery and Acceptance

All pipe and accessories shall comply with this standard. Pipe and accessories not complying with this standard shall be replaced by the manufacturer at the agreed point of delivery. The manufacturer shall not be liable for shortages or damaged pipe after acceptance at the agreed point of delivery, except as recorded on the delivery receipt or similar document by the carrier's agent.

Sec. 51–7—Tolerances or Permitted Variations

51–7.1 *Dimensions.* The spigot end, bell, and socket of the pipe and the accessories shall be gaged with suitable gages at sufficiently frequent intervals to ensure that the dimensions comply with the requirements of this standard. The smallest inside diameter of the sockets and the outside of the spigot ends shall be tested with circular gages. Other socket dimensions shall be gaged as may be appropriate.

51–7.2 *Thickness.* Minus thickness tolerances of pipe and bell shall not exceed the following:

Size *in.*	Minus Tolerance *in.*
3–8	0.05
10–12	0.06
14–42	0.07
48	0.08
54	0.09

An additional minus tolerance of 0.02 in. shall be permitted along the barrel of the pipe for a distance not to exceed 12 in.

51–7.3 *Weight.* The weight of any single pipe shall not be less than the tabulated weight by more than 6 per cent for pipe 12 in. or smaller in diameter, or by more than 5 per cent for pipe larger than 12 in. in diameter.

Sec. 51–8—Coatings and Linings

51–8.1 *Outside coating.* The out-

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side coating for use under normal conditions shall be a bituminous coating approximately 1 mil thick. The coating shall be applied to the outside of all pipe, unless otherwise specified. The finished coating shall be continuous, smooth, neither brittle when cold nor sticky when exposed to the sun, and shall be strongly adherent to the pipe.

51-8.2 *Cement-mortar linings.* Cement linings shall be in accordance with ANSI A21.4 (AWWA C104) of latest revision. If desired by the purchaser, cement linings shall be specified in the invitation for bids and on the purchase order.

51-8.3 *Inside coating.* Unless otherwise specified, the inside coating for pipe that is not cement-lined shall be a bituminous material as thick as practicable (at least 1 mil) which conforms to all appropriate requirements for seal coat in ANSI A21.4 of latest revision.

51-8.4 *Special coatings and linings.* For special conditions, other types of coatings and linings may be available. Such special coatings and linings shall be specified in the invitation for bids and on the purchase order.

Sec. 51-9—Hydrostatic Test

Each pipe shall be subjected to a hydrostatic test of not less than 500 psi. This test may be made either before or after the outside coating and inside coating have been applied, but shall be made before the application of cement lining or of a special lining.

The pipe shall be under the full test pressure for at least 10 s. Suitable controls and recording devices shall be provided so that the test pressure and duration may be adequately ascertained. Any pipe that leaks or does not withstand the test pressure shall be rejected.

In addition to the hydrostatic test before application of a cement lining or special lining, the pipe may be retested, at the manufacturer's option, after application of such lining.

Sec. 51-10—Marking Pipe

The weight, class or nominal thickness, and casting period shall be shown on each pipe. The manufacturer's mark, the year in which the pipe was produced, and the letters "DI" or "DUCTILE" shall be cast or stamped on the pipe. When specified on the purchase order, initials not exceeding four in number shall be cast or stamped on the pipe. All required markings shall be clear and legible, and all cast marks shall be on or near the bell. All letters and numerals on pipe sizes 14 in. and larger shall be not less than $\frac{1}{2}$ in. in height.

Sec. 51-11—Weighing Pipe

Each pipe shall be weighed before the application of any lining or coating other than the bituminous coating and the weight shown on the outside or inside of the bell or spigot end.

Sec. 51-12—Acceptance Tests

The standard acceptance tests for the physical characteristics of the pipe shall be as follows:

51-12.1 *Tensile test.* A tensile test specimen shall be cut longitudinally from the midsection of the pipe wall. This specimen shall be machined and tested in accordance with Fig. 1 and ASTM E8-69, "Tension Testing of Metallic Materials." The yield strength shall be determined by the 0.2 per cent offset, halt-of-pointer, or extension-under-load method. If check tests are to be made, the 0.2 per cent offset

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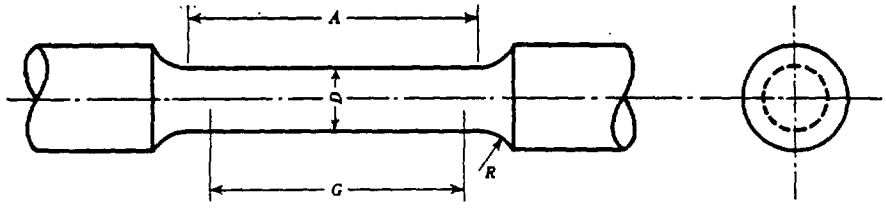


Fig. 1. Tensile-Test Specimen

The tensile-test specimen dimensions are given in the following table:

Dimension	Standard Specimen 0.500 in. round	Small-Size Specimens Proportional to Standard			
		0.350 in. round	0.250 in. round	0.175 in. round	0.125 in. round
	Dimensions—*in*				
*T**	0.71 and greater	0.50–0.70	0.35–0.49	0.25–0.34	0.18–0.24
G	2.000 ± 0.005	1.400 ± 0.005	1.000 ± 0.005	0.700 ± 0.005	0.500 ± 0.005
D	0.500 ± 0.010	0.350 ± 0.007	0.250 ± 0.005	0.175 ± 0.005	0.125 ± 0.005
R	$\frac{3}{8}$ (min.)	$\frac{1}{4}$ (min.)	$\frac{3}{16}$ (min.)	$\frac{3}{32}$ (min.)	$\frac{3}{32}$ (min.)
A	$2\frac{1}{4}$ (min.)	$1\frac{3}{4}$ (min.)	$1\frac{1}{4}$ (min.)	$\frac{3}{4}$ (min.)	$\frac{3}{4}$ (min.)

* Thickness of the section from the wall of the pipe from which the tensile specimen is to be machined.

Note. 1. The reduced section *A* may have a gradual taper from the ends toward the center with the ends not more than 0.005 in. larger in diameter than the center on the standard specimen and not more than 0.003 in. larger in diameter than the center on the small size specimens.

Note. 2. If desired, on the small size specimens the length of the reduced section may be increased to accommodate an extensometer. However, reference marks for the measurement of elongation should nevertheless be spaced at the indicated gage length *G*.

Note. 3. The gage length and fillets shall be as shown, but the ends may be of any form to fit the holders of the testing machine in such a way that the load shall be axial. If the ends are to be held in grips it is desirable, if possible, to make the length of the grip section great enough to allow the specimen to extend into the grips a distance equal to two thirds or more of the length of the grips.

method shall be used. All specimens shall be tested at room temperature [70F ± 10 (21C ± 6)].

51-12.1.1 *Acceptance values.* The acceptance values for test specimens shall be as follows:

Grade of iron: 60–42–10

1. Minimum tensile strength: 60 000 psi.
2. Minimum yield strength: 42 000 psi.
3. Minimum elongation: 10 per cent.

51-12.2 *Impact test.* Tests shall be made in accordance with ASTM E23-72 "Notched Charpy Tests," except that specimens shall be 0.500 in. by full thickness of pipe wall. The notched impact test specimen shall be in accordance with Fig. 2. If the pipe wall thickness exceeds 0.40 in., the impact specimen may be machined to a nominal thickness of 0.40 in. In all tests, impact values are to be corrected to 0.40-in. wall thickness by calculations as follows:

$$\text{Impact value (corrected)} = \frac{0.40}{t} \times \text{impact value (actual)}$$

in which t is the thickness of the specimen in inches (wall thickness of pipe).

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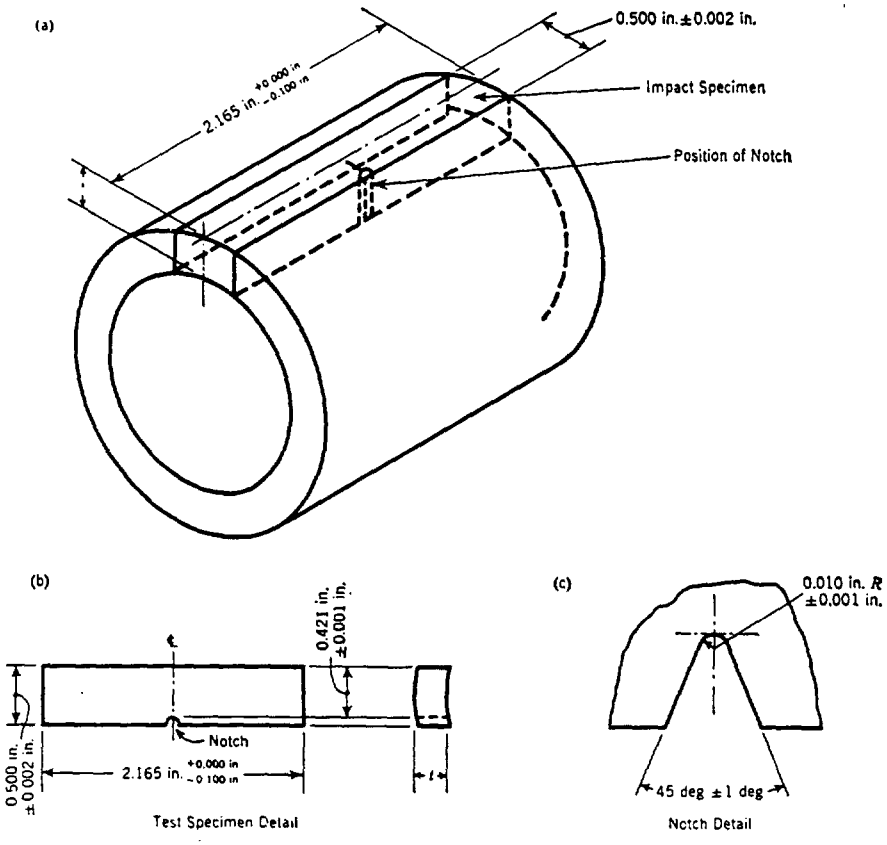


Fig. 2. Impact Test Specimen

In Diagrams (a) and (b) the symbol t *is for the pipe-wall thickness.*

The Charpy test machine anvil shall not be moved to compensate for the variation of cross section dimensions of the test specimen.

51-12.2.1 *Acceptance value.* The corrected acceptance value for notched impact test specimens shall be a minimum of 7 ft-lb for tests conducted at 70 F ± 10 (21C ± 6).

51-12.3 *Sampling.* At least one tensile and impact sample shall be taken during each casting period of approximately 3 hr. Samples shall be selected to represent extremes of pipe diameters and thicknesses properly.

Sec. 51-13—Additional Control Tests by Manufacturer

Low-temperature impact tests shall be made from at least one third of the test pipe specified in Sec. 51-12.3 to ensure compliance with a minimum corrected value of 3 ft-lb for tests conducted at −40 F (−40C). Test specimens shall be prepared and tested in accordance with Sec. 51-12.2.

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In addition, the manufacturer shall conduct such other control tests as necessary to assure continuing compliance with this standard.

Sec. 51–14—Foundry Records

The results of the acceptance tests (Sec. 51–12) and low-temperature impact tests (Sec. 51–13) shall be recorded and retained for one year and shall be available to the purchaser at the foundry. Written transcripts shall be furnished, if specified on the purchase order.

Sec. 51–15—Additional Tests Required by Purchaser

When tests other than those required in this standard are required by the purchaser, such tests shall be specified in the invitation for bids and on the purchase order.

Sec. 51–16—Defective Specimens and Retests

When any physical-test specimen shows defective machining or lack of continuity of metal, it shall be discarded and replaced by another specimen. When any sound test specimen fails to meet the specified requirements, the pipe from which it was taken shall be rejected, and a retest may be made on two additional sound specimens from pipe cast in the same period as the specimen that failed. Both of the additional specimens shall meet the prescribed tests to qualify the pipe produced in that period.

Sec. 51–17—Rejection of Pipe

If the results of any physical acceptance test fail to meet the requirements of Sec. 51–12 or Sec. 51–16, the pipe cast in the same period shall be rejected, except as provided in Sec. 51–18.

Sec. 51–18—Determining Rejection

The manufacturer may determine the amount of rejection by making similar additional tests of pipe of the same size until the rejected lot is bracketed, in order of manufacture, by an acceptable test at each end of the interval in question. When pipe of one size is rejected from a casting period, the acceptability of pipe of different sizes from that same period may be established by making the acceptance tests for these sizes as specified in Sec. 51–12.

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TABLE 51.1

*Standard Thickness for Earth Load Plus Truck Load**

Size *in.*	Depth of Cover *ft.*	Laying Condition									
		Type 1†		Type 2†		Type 3†		Type 4†		Type 5†	
		Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class
3	2.5	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	3	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	4	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	5	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	6	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	7	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	8	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	9	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	10	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	12	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	14	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	16	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	20	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	24	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	28	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
	32	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
4	2.5	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	3	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	4	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	5	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	6	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	7	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	8	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	9	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	10	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	12	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	14	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	16	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	20	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	24	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	28	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
	32	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
6	2.5	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	3	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	4	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	5	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	6	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	7	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	8	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	9	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	10	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	12	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	14	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	16	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	20	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	24	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	28	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	32	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
	2.5	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	3	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	4	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	5	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	6	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	7	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	8	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	9	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	10	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	12	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	14	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	16	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	20	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	24	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
	28	0.30	51	0.27	50	0.27	50	0.27	50	0.27	50
	32	0.30	51	0.30	51	0.27	50	0.27	50	0.27	50

* Truckloads used in computing this table are based on a single H-20 truck with 16 000-lb wheel load and 1.5 impact factor.

† See corresponding illustrations in Fig. 3 of types of laying conditions.

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TABLE 51.1—(*cont.*)

Size in.	Depth of Cover ft.	Laying Condition									
		Type 1†		Type 2†		Type 3†		Type 4†		Type 5†	
		Thickness in.	Thickness Class	Thickness in.	Thickness Class	Thickness in.	Thickness Class	Thickness in.	Thickness Class	Thickness in.	Thickness Class
10	2.5	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	3	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	4	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	5	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	6	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	7	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	8	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	9	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	10	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	12	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	14	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	16	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
	20	0.32	51	0.29	50	0.29	50	0.29	50	0.29	50
	24	0.32	51	0.29	50	0.29	50	0.29	50	0.29	50
	28	0.35	52	0.32	51	0.29	50	0.29	50	0.29	50
	32	0.35	52	0.32	51	0.32	51	0.29	50	0.29	50
12	2.5	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	3	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	4	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	5	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	6	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	7	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	8	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	9	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	10	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	12	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	14	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	16	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
	20	0.34	51	0.31	50	0.31	50	0.31	50	0.31	50
	24	0.37	52	0.34	51	0.31	50	0.31	50	0.31	50
	28	0.37	52	0.34	51	0.34	51	0.31	50	0.31	50
	32	0.40	53	0.37	52	0.34	51	0.31	50	0.31	50
14	2.5	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	3	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	4	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	5	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	6	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	7	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	8	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	9	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	10	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	12	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	14	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
	16	0.36	51	0.33	50	0.33	50	0.33	50	0.33	50
	20	0.39	52	0.36	51	0.33	50	0.33	50	0.33	50
	24	0.39	52	0.39	52	0.33	50	0.33	50	0.33	50
	28	0.42	53	0.39	52	0.36	51	0.33	50	0.33	50
	32	0.45	54	0.42	53	0.39	52	0.33	50	0.33	50
16	2.5	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
	3	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
	4	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
	5	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
	6	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
	7	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
	8	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
	9	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
	10	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
	12	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
	14	0.37	51	0.34	50	0.34	50	0.34	50	0.34	50
	16	0.37	51	0.34	50	0.34	50	0.34	50	0.34	50
	20	0.40	52	0.37	51	0.34	50	0.34	50	0.34	50
	24	0.43	53	0.40	52	0.37	51	0.34	50	0.34	50
	28	0.46	54	0.43	53	0.40	52	0.34	50	0.34	50
	32	0.49	55	0.46	54	0.43	53	0.37	51	0.34	50

† See corresponding illustrations in Fig. 3 of types of laying conditions.

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TABLE 51.1—(*cont.*)

Size *in.*	Depth of Cover *ft.*	Laying Condition									
		Type 1†		Type 2†		Type 3†		Type 4†		Type 5†	
		Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class
18	2.5	0.35	50	0.35	50	0.35	50	0.35	50	0.35	50
	3	0.35	50	0.35	50	0.35	50	0.35	50	0.35	50
	4	0.35	50	0.35	50	0.35	50	0.35	50	0.35	50
	5	0.35	50	0.35	50	0.35	50	0.35	50	0.35	50
	6	0.35	50	0.35	50	0.35	50	0.35	50	0.35	50
	7	0.35	50	0.35	50	0.35	50	0.35	50	0.35	50
	8	0.35	50	0.35	50	0.35	50	0.35	50	0.35	50
	9	0.35	50	0.35	50	0.35	50	0.35	50	0.35	50
	10	0.35	50	0.35	50	0.35	50	0.35	50	0.35	50
	12	0.38	51	0.35	50	0.35	50	0.35	50	0.35	50
	14	0.38	51	0.35	50	0.35	50	0.35	50	0.35	50
	16	0.41	52	0.38	51	0.35	50	0.35	50	0.35	50
	20	0.44	53	0.41	52	0.35	50	0.35	50	0.35	50
	24	0.47	54	0.44	53	0.41	52	0.35	50	0.35	50
	28	0.50	55	0.47	54	0.44	53	0.35	50	0.35	50
	32	0.53	56	0.50	55	0.47	54	0.38	51	0.35	50
20	2.5	0.39	51	0.36	50	0.36	50	0.36	50	0.36	50
	3	0.36	50	0.36	50	0.36	50	0.36	50	0.36	50
	4	0.36	50	0.36	50	0.36	50	0.36	50	0.36	50
	5	0.36	50	0.36	50	0.36	50	0.36	50	0.36	50
	6	0.36	50	0.36	50	0.36	50	0.36	50	0.36	50
	7	0.36	50	0.36	50	0.36	50	0.36	50	0.36	50
	8	0.36	50	0.36	50	0.36	50	0.36	50	0.36	50
	9	0.36	50	0.36	50	0.36	50	0.36	50	0.36	50
	10	0.36	50	0.36	50	0.36	50	0.36	50	0.36	50
	12	0.39	51	0.36	50	0.36	50	0.36	50	0.36	50
	14	0.42	52	0.36	50	0.36	50	0.36	50	0.36	50
	16	0.42	52	0.39	51	0.36	50	0.36	50	0.36	50
	20	0.48	54	0.42	52	0.39	51	0.36	50	0.36	50
	24	0.51	55	0.48	54	0.42	52	0.36	50	0.36	50
	28	0.54	56	0.51	55	0.45	53	0.39	51	0.36	50
	32	—	—	0.54	56	0.48	54	0.42	52	0.36	50
24	2.5	0.41	51	0.38	50	0.38	50	0.38	50	0.38	50
	3	0.38	50	0.38	50	0.38	50	0.38	50	0.38	50
	4	0.38	50	0.38	50	0.38	50	0.38	50	0.38	50
	5	0.38	50	0.38	50	0.38	50	0.38	50	0.38	50
	6	0.38	50	0.38	50	0.38	50	0.38	50	0.38	50
	7	0.38	50	0.38	50	0.38	50	0.38	50	0.38	50
	8	0.38	50	0.38	50	0.38	50	0.38	50	0.38	50
	9	0.41	51	0.38	50	0.38	50	0.38	50	0.38	50
	10	0.41	51	0.38	50	0.38	50	0.38	50	0.38	50
	12	0.44	52	0.38	50	0.38	50	0.38	50	0.38	50
	14	0.47	53	0.41	51	0.38	50	0.38	50	0.38	50
	16	0.50	54	0.44	52	0.38	50	0.38	50	0.38	50
	20	0.53	55	0.50	54	0.44	52	0.38	50	0.38	50
	24	0.56	56	0.53	55	0.47	53	0.41	51	0.38	50
	28	—	—	0.56	56	0.53	55	0.44	52	0.38	50
	32	—	—	—	—	0.56	56	0.47	53	0.41	51
30	2.5	‡	‡	0.39	50	0.39	50	0.39	50	0.39	50
	3			0.39	50	0.39	50	0.39	50	0.39	50
	4			0.39	50	0.39	50	0.39	50	0.39	50
	5			0.39	50	0.39	50	0.39	50	0.39	50
	6			0.39	50	0.39	50	0.39	50	0.39	50
	7			0.39	50	0.39	50	0.39	50	0.39	50
	8			0.39	50	0.39	50	0.39	50	0.39	50
	9			0.39	50	0.39	50	0.39	50	0.39	50
	10			0.39	50	0.39	50	0.39	50	0.39	50
	12			0.43	51	0.39	50	0.39	50	0.39	50
	14			0.47	52	0.39	50	0.39	50	0.39	50
	16			0.51	53	0.43	51	0.39	50	0.39	50
	20			0.59	55	0.51	53	0.43	51	0.39	50
	24			0.63	56	0.55	54	0.47	52	0.39	50
	28			—	—	0.63	56	0.51	53	0.43	51
	32			—	—	—	—	0.55	54	0.47	52

† See corresponding illustrations in Fig. 3 of types of laying conditions.
‡ For pipe 30 in. and larger, consideration should be given to the use of laying conditions other than Type 1.

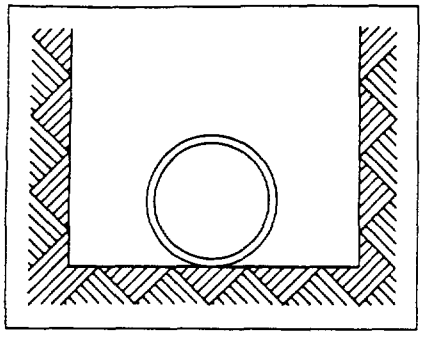
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TABLE 51.1—(*cont.*)

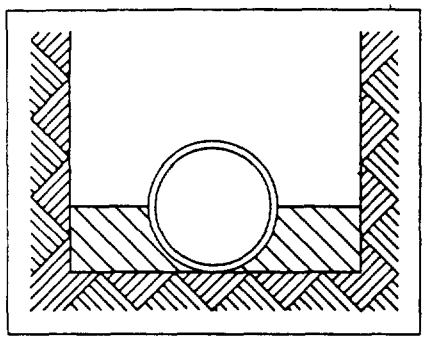
Size *in.*	Depth of Cover *ft.*	Laying Condition									
		Type 1†		Type 2†		Type 3†		Type 4†		Type 5†	
		Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class	Thickness *in.*	Thickness Class
36	2.5	‡	‡	0.43	50	0.43	50	0.43	50	0.43	50
	3			0.43	50	0.43	50	0.43	50	0.43	50
	4			0.43	50	0.43	50	0.43	50	0.43	50
	5			0.43	50	0.43	50	0.43	50	0.43	50
	6			0.43	50	0.43	50	0.43	50	0.43	50
	7			0.43	50	0.43	50	0.43	50	0.43	50
	8			0.43	50	0.43	50	0.43	50	0.43	50
	9			0.43	50	0.43	50	0.43	50	0.43	50
	10			0.43	50	0.43	50	0.43	50	0.43	50
	12			0.48	51	0.43	50	0.43	50	0.43	50
	14			0.53	52	0.48	51	0.43	50	0.43	50
	16			0.58	53	0.48	51	0.43	50	0.43	50
	20			0.63	54	0.58	53	0.48	51	0.43	50
	24			0.73	56	0.63	54	0.53	52	0.43	50
	28			—	—	0.68	55	0.58	53	0.48	51
	32			—	—	—	—	0.63	54	0.53	52
42	2.5	‡	‡	0.47	50	0.47	50	0.47	50	0.47	50
	3			0.47	50	0.47	50	0.47	50	0.47	50
	4			0.47	50	0.47	50	0.47	50	0.47	50
	5			0.47	50	0.47	50	0.47	50	0.47	50
	6			0.47	50	0.47	50	0.47	50	0.47	50
	7			0.47	50	0.47	50	0.47	50	0.47	50
	8			0.47	50	0.47	50	0.47	50	0.47	50
	9			0.47	50	0.47	50	0.47	50	0.47	50
	10			0.53	51	0.47	50	0.47	50	0.47	50
	12			0.53	51	0.47	50	0.47	50	0.47	50
	14			0.59	52	0.53	51	0.47	50	0.47	50
	16			0.65	53	0.59	52	0.47	50	0.47	50
	20			0.71	54	0.65	53	0.59	52	0.47	50
	24			0.83	56	0.71	54	0.65	53	0.47	50
	28			—	—	0.77	55	0.71	54	0.59	52
	32			—	—	—	—	0.71	54	0.65	53
48	2.5	‡	‡	0.51	50	0.51	50	0.51	50	0.51	50
	3			0.51	50	0.51	50	0.51	50	0.51	50
	4			0.51	50	0.51	50	0.51	50	0.51	50
	5			0.51	50	0.51	50	0.51	50	0.51	50
	6			0.51	50	0.51	50	0.51	50	0.51	50
	7			0.51	50	0.51	50	0.51	50	0.51	50
	8			0.51	50	0.51	50	0.51	50	0.51	50
	9			0.51	50	0.51	50	0.51	50	0.51	50
	10			0.58	51	0.51	50	0.51	50	0.51	50
	12			0.58	51	0.51	50	0.51	50	0.51	50
	14			0.65	52	0.58	51	0.51	50	0.51	50
	16			0.72	53	0.65	52	0.58	51	0.51	50
	20			0.79	54	0.72	53	0.65	52	0.51	50
	24			0.93	56	0.79	54	0.72	53	0.58	51
	28			—	—	0.86	55	0.79	54	0.65	52
	32			—	—	—	—	0.86	55	0.72	53
54	2.5	‡	‡	0.57	50	0.57	50	0.57	50	0.57	50
	3			0.57	50	0.57	50	0.57	50	0.57	50
	4			0.57	50	0.57	50	0.57	50	0.57	50
	5			0.57	50	0.57	50	0.57	50	0.57	50
	6			0.57	50	0.57	50	0.57	50	0.57	50
	7			0.57	50	0.57	50	0.57	50	0.57	50
	8			0.57	50	0.57	50	0.57	50	0.57	50
	9			0.57	50	0.57	50	0.57	50	0.57	50
	10			0.65	51	0.57	50	0.57	50	0.57	50
	12			0.65	51	0.57	50	0.57	50	0.57	50
	14			0.73	52	0.65	51	0.57	50	0.57	50
	16			0.81	53	0.73	52	0.65	51	0.57	50
	20			0.89	54	0.81	53	0.73	52	0.57	50
	24			1.05	56	0.89	54	0.81	53	0.65	51
	28			—	—	0.97	55	0.89	54	0.73	52
	32			—	—	—	—	0.97	55	0.81	53

† See corresponding illustrations in Fig. 3 of types of laying conditions.
‡ For pipe 30 in. and larger, consideration should be given to the use of laying conditions other than Type 1.

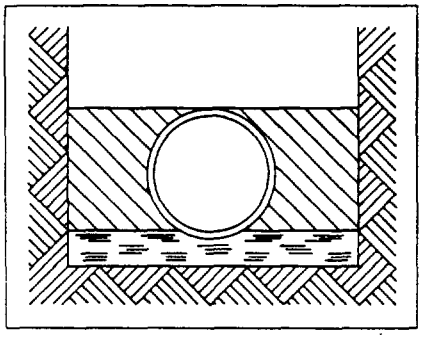
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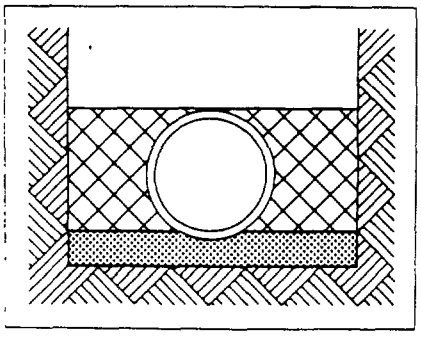
*Type 1** Flat-bottom trench.† Loose backfill.



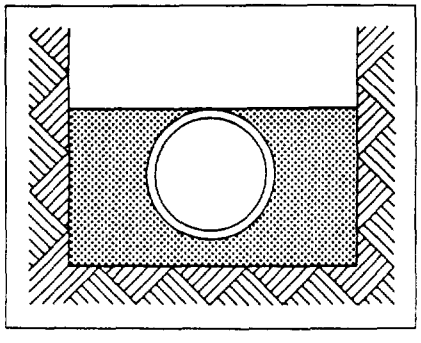
Type 2 Flat-bottom trench.† Backfill lightly consolidated to centerline of pipe.



Type 3 Pipe bedded in 4-in.-minimum loose soil.‡ Backfill lightly consolidated to top of pipe.



Type 4 Pipe bedded in sand, gravel, or crushed stone to depth of ⅛ pipe diameter, 4-in. minimum. Backfill compacted to top of pipe. (Approx. 80 per cent Standard Proctor, AASHTO § T-99)



Type 5 Pipe bedded to its centerline in compacted granular material, 4-in. minimum under pipe. Compacted granular or select ‡ material to top of pipe. (Approx. 90 per cent Standard Proctor, AASHTO § T-99)

Fig. 3. Standard Laying Conditions

* For pipe 30 in. and larger, consideration should be given to the use of laying conditions other than Type 1.
† "Flat-bottom" is defined as undisturbed earth.
‡ "Loose soil" or "select material" is defined as native soil excavated from the trench, free of rocks, foreign materials, and frozen earth.
§ American Association of State Highway and Transportation Officials, 341 National Press Bldg., Washington, D.C. 20004.

CTD014634

TABLE 51.2

Standard Thickness for Internal Pressure

Pipe Size in.	Rated Water Working Pressure*—psi									
	150		200		250		300		350	
	Thickness in.	Thickness Class	Thickness in.	Thickness Class	Thickness in.	Thickness Class	Thickness in.	Thickness Class	Thickness in.	Thickness Class
3	0.25	51	0.25	51	0.25	51	0.25	51	0.25	51
4	0.26	51	0.26	51	0.26	51	0.26	51	0.26	51
6	0.25	50	0.25	50	0.25	50	0.25	50	0.25	50
8	0.27	50	0.27	50	0.27	50	0.27	50	0.27	50
10	0.29	50	0.29	50	0.29	50	0.29	50	0.29	50
12	0.31	50	0.31	50	0.31	50	0.31	50	0.31	50
14	0.33	50	0.33	50	0.33	50	0.33	50	0.33	50
16	0.34	50	0.34	50	0.34	50	0.34	50	0.34	50
18	0.35	50	0.35	50	0.35	50	0.35	50	0.35	50
20	0.36	50	0.36	50	0.36	50	0.36	50	0.39	51
24	0.38	50	0.38	50	0.38	50	0.41	51	0.44	52
30	0.39	50	0.39	50	0.43	51	0.47	52	0.51	53
36	0.43	50	0.43	50	0.48	51	0.53	52	0.58	53
42	0.47	50	0.47	50	0.53	51	0.59	52	0.65	53
48	0.51	50	0.51	50	0.58	51	0.65	52	0.72	53
54	0.57	50	0.57	50	0.65	51	0.73	52	0.81	53

* These pipe are adequate for the rated working pressure plus a surge allowance of 100 psi.

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TABLE 51.3

Rated Working Pressure and Maximum Depth of Cover

Pipe Size *in.*	Thickness Class	Nominal Thickness *in.*	Rated Water Working Pressure* *psi*	Laying Condition				
				Type 1	Type 2	Type 3	Type 4	Type 5
				Maximum Depth of Cover—*ft*†				
3	51	0.25	350	98	100‡	100‡	100‡	100‡
	52	0.28	350	100‡	100‡	100‡	100‡	100‡
	53	0.31	350	100‡	100‡	100‡	100‡	100‡
	54	0.34	350	100‡	100‡	100‡	100‡	100‡
	55	0.37	350	100‡	100‡	100‡	100‡	100‡
	56	0.40	350	100‡	100‡	100‡	100‡	100‡
4	51	0.26	350	76	86	96	100‡	100‡
	52	0.29	350	100‡	100‡	100‡	100‡	100‡
	53	0.32	350	100‡	100‡	100‡	100‡	100‡
	54	0.35	350	100‡	100‡	100‡	100‡	100‡
	55	0.38	350	100‡	100‡	100‡	100‡	100‡
	56	0.41	350	100‡	100‡	100‡	100‡	100‡
6	50	0.25	350	32	38	44	56	75
	51	0.28	350	49	57	64	80	100‡
	52	0.31	350	67	77	86	100‡	100‡
	53	0.34	350	91	100‡	100‡	100‡	100‡
	54	0.37	350	100‡	100‡	100‡	100‡	100‡
	55	0.40	350	100‡	100‡	100‡	100‡	100‡
	56	0.43	350	100‡	100‡	100‡	100‡	100‡
8	50	0.27	350	25	30	36	46	64
	51	0.30	350	36	42	49	61	81
	52	0.33	350	47	54	62	77	99
	53	0.36	350	64	73	82	100‡	100‡
	54	0.39	350	80	91	100‡	100‡	100‡
	55	0.42	350	98	100‡	100‡	100‡	100‡
	56	0.45	350	100‡	100‡	100‡	100‡	100‡
10	50	0.29	350	19	24	29	38	55
	51	0.32	350	27	32	38	49	66
	52	0.35	350	35	41	47	59	79
	53	0.38	350	45	52	59	74	95
	54	0.41	350	57	65	74	91	100‡
	55	0.44	350	67	77	86	100‡	100‡
	56	0.47	350	81	92	100‡	100‡	100‡
12	50	0.31	350	17	22	27	36	52
	51	0.34	350	23	28	33	43	60
	52	0.37	350	30	35	41	53	71
	53	0.40	350	36	42	49	61	81
	54	0.43	350	45	52	59	74	95
	55	0.46	350	54	62	71	87	100‡
	56	0.49	350	64	73	83	100‡	100‡
14	50	0.33	350	15	19	24	33	49
	51	0.36	350	19	23	28	38	55
	52	0.39	350	24	29	34	44	62
	53	0.42	350	30	35	41	53	71
	54	0.45	350	36	42	49	61	81
	55	0.48	350	43	50	57	71	92
	56	0.51	350	52	59	67	83	100‡
15	50	0.34	350	13	17	21	30	47
	51	0.37	350	16	21	25	34	51
	52	0.40	350	20	25	30	40	57
	53	0.43	350	25	30	36	46	64
	54	0.46	350	30	35	41	53	71
	55	0.49	350	35	41	47	59	79
	56	0.52	350	41	48	55	68	89
18	50	0.35	350	11	15	20	29	42
	51	0.38	350	14	19	23	32	49
	52	0.41	350	18	22	27	36	53
	53	0.44	350	22	26	31	41	58
	54	0.47	350	25	30	36	46	64
	55	0.50	350	30	35	41	53	71
	56	0.53	350	35	41	47	59	79

* These pipe are adequate for the rated working pressure plus a surge allowance of 100 psi. Ductile-iron pipe for working pressures higher than 350 psi is available.

† An allowance for a single H-20 truck with 1.5 impact factor is included for all depths of cover

‡ Calculated maximum depth of cover exceeds 100 ft.

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TABLE 51.3—(*cont.*)

Pipe Size *in.*	Thickness Class	Nominal Thickness *in.*	Rated Water Working Pressure* *psi*	Laying Condition				
				Type 1	Type 2	Type 3	Type 4	Type 5
				Maximum Depth of Cover—*ft*†				
20	50	0.36	300	10	14	18	27	38
	51	0.39	350	13	17	21	30	44
	52	0.42	350	16	20	25	34	50
	53	0.45	350	19	23	28	38	54
	54	0.48	350	22	27	32	42	59
	55	0.51	350	26	31	37	47	65
	56	0.54	350	30	35	41	53	71
24	50	0.38	250	8	12	17	23	31
	51	0.41	300	10	15	19	27	36
	52	0.44	350	13	17	21	30	41
	53	0.47	350	15	19	24	33	47
	54	0.50	350	18	22	27	36	53
	55	0.53	350	20	25	30	40	57
	56	0.56	350	24	29	34	44	61
30	50	0.39	200	§	10	14	18	25
	51	0.43	250		12	16	21	29
	52	0.47	300		14	19	24	33
	53	0.51	350		17	21	29	38
	54	0.55	350		19	24	33	44
	55	0.59	350		22	27	36	51
	56	0.63	350		26	31	41	57
36	50	0.43	200		10	13	17	25
	51	0.48	250		12	16	20	28
	52	0.53	300		15	19	24	32
	53	0.58	350		17	21	28	37
	54	0.63	350		20	25	33	43
	55	0.68	350		23	28	37	50
	56	0.73	350		26	31	41	59
42	50	0.47	200	§	9	13	16	24
	51	0.53	250		12	15	19	27
	52	0.59	300		14	18	22	30
	53	0.65	350		17	22	27	35
	54	0.71	350		20	24	32	42
	55	0.77	350		23	28	38	48
	56	0.83	350		26	31	41	57
48	50	0.51	200		9	12	15	23
	51	0.58	250		12	14	18	26
	52	0.65	300		14	18	21	30
	53	0.72	350		17	21	25	34
	54	0.79	350		20	24	30	40
	55	0.86	350		23	28	37	47
	56	0.93	350		26	31	41	55
54	50	0.57	200		9	12	15	23
	51	0.65	250		12	14	18	25
	52	0.73	300		14	17	21	29
	53	0.81	350		17	21	25	34
	54	0.89	350		20	25	30	40
	55	0.97	350		23	28	37	47
	56	1.05	350		27	32	42	55

* These pipe are adequate for the rated working pressure plus a surge allowance of 100 psi. Ductile-iron pipe for working pressures higher than 350 psi is available.

† An allowance for a single H-20 truck with 1.5 impact factor is included for all depths of cover.

§ For pipe 30 in. and larger, consideration should be given to the use of laying conditions other than Type 1

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TABLE 51.4

Standard Dimensions and Weights of Push-On-Joint Ductile-Iron Pipe

Size *in.*	Thickness Class	Thickness *in.*	OD* *in.*	Wt. of Barrel Per Ft *lb*	Wt. of Bell *lb*	18-Ft Laying Length		20-Ft Laying Length	
						Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*	Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*
3§	51	0.25	3.96	8.9	9	170	9.4	185	9.4
	52	0.28	3.96	9.9	9	185	10.4	205	10.4
	53	0.31	3.96	10.9	9	205	11.4	225	11.4
	54	0.34	3.96	11.8	9	220	12.3	245	12.2
	55	0.37	3.96	12.8	9	240	13.3	265	13.2
	56	0.40	3.96	13.7	9	255	14.2	285	14.2
4	51	0.26	4.80	11.3	11	215	11.9	235	11.8
	52	0.29	4.80	12.6	11	240	13.2	265	13.2
	53	0.32	4.80	13.8	11	260	14.4	285	14.4
	54	0.35	4.80	15.0	11	280	15.6	310	15.6
	55	0.38	4.80	16.1	11	300	16.7	335	16.6
	56	0.41	4.80	17.3	11	320	17.9	355	17.8
6	50	0.25	6.90	16.0	18	305	17.0	340	16.9
	51	0.28	6.90	17.8	18	340	18.8	375	18.7
	52	0.31	6.90	19.6	18	370	20.6	410	20.5
	53	0.34	6.90	21.4	18	405	22.4	445	22.3
	54	0.37	6.90	23.2	18	435	24.2	480	24.1
	55	0.40	6.90	25.0	18	470	26.0	520	25.9
	56	0.43	6.90	26.7	18	500	27.7	550	27.6
8	50	0.27	9.05	22.8	26	435	24.2	480	24.1
	51	0.30	9.05	25.2	26	480	26.6	530	26.5
	52	0.33	9.05	27.7	26	525	29.1	580	29.0
	53	0.36	9.05	30.1	26	570	31.5	630	31.4
	54	0.39	9.05	32.5	26	610	33.9	675	33.8
	55	0.42	9.05	34.8	26	650	36.2	720	36.1
	56	0.45	9.05	37.2	26	695	38.6	770	38.5
10	50	0.29	11.10	30.1	34	575	32.0	635	31.8
	51	0.32	11.10	33.2	34	630	35.1	700	34.9
	52	0.35	11.10	36.2	34	685	38.1	760	37.9
	53	0.38	11.10	39.2	34	740	41.1	820	40.9
	54	0.41	11.10	42.1	34	790	44.0	875	43.8
	55	0.44	11.10	45.1	34	845	47.0	935	46.8
	56	0.47	11.10	48.0	34	900	49.9	995	49.7

* Tolerance of OD of spigot end: 3–12 in., ±0.06 in.; 14–24 in., +0.05 in., −0.08 in.; 30–54 in., +0.08 in., −0.06 in.

† Including bell; calculated weight of pipe rounded off to nearest 5 lb.

‡ Including bell; average weight, per foot, based on calculated weight of pipe before rounding.

§ Pipe of 3-in. size also available in 12-ft laying length with following weights:

Thickness Class	Thickness *in.*	Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*
51	0.25	115	9.6
52	0.28	130	10.6
53	0.31	140	11.6
54	0.34	150	12.6
55	0.37	165	13.6
56	0.40	175	14.4

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TABLE 51.4—(*cont.*)

Size *in.*	Thickness Class	Thickness *in.*	OD* *in.*	Wt. of Barrel Per Ft *lb*	Wt. of Bell *lb*	18-Ft Laying Length		20-Ft Laying Length	
						Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*	Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*
12	50	0.31	13.20	38.4	43	735	40.8	810	40.6
	51	0.34	13.20	42.0	43	800	44.4	885	44.2
	52	0.37	13.20	45.6	43	865	48.0	955	47.8
	53	0.40	13.20	49.2	43	930	51.6	1 025	51.4
	54	0.43	13.20	52.8	43	995	55.2	1 100	55.0
	55	0.46	13.20	56.3	43	1 055	58.7	1 170	58.4
	56	0.49	13.20	59.9	43	1 120	62.3	1 240	62.0
14	50	0.33	15.30	47.5	63	920	51.0	015	50.6
	51	0.36	15.30	51.7	63	995	55.2	1 095	54.8
	52	0.39	15.30	55.9	63	1 070	59.4	1 180	59.0
	53	0.42	15.30	60.1	63	1 145	63.6	1 265	63.2
	54	0.45	15.30	64.2	63	1 220	67.7	1 345	67.4
	55	0.48	15.30	68.4	63	1 295	71.9	1 430	71.6
	56	0.51	15.30	72.5	63	1 370	76.0	1 515	75.6
16	50	0.34	17.40	55.8	76	1 080	60.0	1 190	59.6
	51	0.37	17.40	60.6	76	1 165	64.8	1 290	64.4
	52	0.40	17.40	65.4	76	1 255	69.6	1 385	69.2
	53	0.43	17.40	70.1	76	1 340	74.3	1 480	73.9
	54	0.46	17.40	74.9	76	1 425	79.1	1 575	78.7
	55	0.49	17.40	79.7	76	1 510	83.9	1 670	83.5
	56	0.52	17.40	84.4	76	1 595	88.6	1 765	88.2
18	50	0.35	19.50	64.4	87	1 245	69.2	1 375	68.8
	51	0.38	19.50	69.8	87	1 345	74.6	1 485	74.2
	52	0.41	19.50	75.2	87	1 440	80.0	1 590	79.6
	53	0.44	19.50	80.6	87	1 540	85.4	1 700	85.0
	54	0.47	19.50	86.0	87	1 635	90.8	1 805	90.4
	55	0.50	19.50	91.3	87	1 730	96.1	1 915	95.6
	56	0.53	19.50	96.7	87	1 830	101.5	2 020	101.0
20	50	0.36	21.60	73.5	97	1 420	78.9	1 565	78.4
	51	0.39	21.60	79.5	97	1 530	84.9	1 685	84.4
	52	0.42	21.60	85.5	97	1 635	90.9	1 805	90.4
	53	0.45	21.60	91.5	97	1 745	96.9	1 925	96.4
	54	0.48	21.60	97.5	97	1 850	102.9	2 045	102.4
	55	0.51	21.60	103.4	97	1 960	108.8	2 165	108.2
	56	0.54	21.60	109.3	97	2 065	114.7	2 285	114.2

* Tolerance of OD of spigot end: 3–12 in., ±0.06 in.; 14–24 in., +0.05 in., −0.08 in.; 30–54 in., +0.08 in. −0.06 in.
† Including bell; calculated weight of pipe rounded off to nearest 5 lb.
‡ Including bell; average weight per foot, based on calculated weight of pipe before rounding.

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TABLE 51.4—(*cont.*)

Size *in.*	Thickness Class	Thickness *in.*	OD* *in.*	Wt. of Barrel Per Ft *lb*	Wt. of Bell *lb*	18-Ft Laying Length		20-Ft Laying Lentgh	
						Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*	Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*
24	50	0.38	25.80	92.9	120	1 790	99.6	1 980	98.9
	51	0.41	25.80	100.1	120	1 920	106.8	2 120	106.1
	52	0.44	25.80	107.3	120	2 050	114.0	2 265	113.3
	53	0.47	25.80	114.4	120	2 180	121.1	2 410	120.4
	54	0.50	25.80	121.6	120	2 310	128.3	2 550	127.6
	55	0.53	25.80	128.8	120	2 440	135.5	2 695	134.8
	56	0.56	25.80	135.9	120	2 565	142.6	2 840	141.9
30	50	0.39	32.00	118.5	**	2 350	130.5	2 535	126.6
	51	0.43	32.00	130.5		2 565	142.5	2 775	138.6
	52	0.47	32.00	142.5		2 780	154.5	3 015	150.6
	53	0.51	32.00	154.4		2 995	166.4	3 250	162.6
	54	0.55	32.00	166.3		3 210	178.3	3 490	174.4
	55	0.59	32.00	178.2		3 425	190.2	3 725	186.4
	56	0.63	32.00	190.0		3 635	202.0	3 965	198.2
36	50	0.43	38.30	156.5	††	3 110	172.7	3 345	167.3
	51	0.48	38.30	174.5		3 435	190.7	3 705	185.3
	52	0.53	38.30	192.4		3 755	208.6	4 065	203.2
	53	0.58	38.30	210.3		4 075	226.5	4 420	221.1
	54	0.63	38.30	228.1		4 400	244.3	4 780	238.9
	55	0.68	38.30	245.9		4 720	262.1	5 135	256.7
	56	0.73	38.30	263.7		5 040	279.9	5 490	274.5
42	50	0.47	44.50	198.9	261			4 240	212.0
	51	0.53	44.50	224.0	261			4 740	237.0
	52	0.59	44.50	249.1	261			5 245	262.2
	53	0.65	44.50	274.0	261			5 740	287.0
	54	0.71	44.50	298.9	261			6 240	312.0
	55	0.77	44.50	323.7	261			6 735	336.8
	56	0.83	44.50	348.4	261			7 230	361.4
48	50	0.51	50.80	246.6	316			5 250	262.4
	51	0.58	50.80	280.0	316			5 915	295.8
	52	0.65	50.80	313.4	316			6 585	329.2
	53	0.72	50.80	346.6	316			7 250	362.4
	54	0.79	50.80	379.8	316			7 910	395.6
	55	0.86	50.80	412.9	316			8 575	428.7
	56	0.93	50.80	445.9	316			9 235	461.7
54	50	0.57	57.10	309.8	370			6 565	328.3
	51	0.65	57.10	352.7	370			7 425	371.2
	52	0.73	57.10	395.6	370			8 280	414.1
	53	0.81	57.10	438.3	370			9 135	456.8
	54	0.89	57.10	480.9	370			9 990	499.4
	55	0.97	57.10	523.4	370			10 840	541.9
	56	1.05	57.10	565.8	370			11 685	584.3

* Tolerances of OD of spigot end: 3–12 in., ±0.06 in.; 14–24 in., +0.05 in., −0.08 in.; 30–54 in., +0.08 in., −0.06 in.
† Including bell; calculated weight of pipe rounded off to nearest 5 lb.
‡ Including bell; average weight per foot, based on calculated weight of pipe before rounding.
** Weight of 30-in. bell is 216 lb for 18-ft pipe and 163 lb for 20-ft pipe.
†† Weight of 36-in. bell is 292 lb for 18-ft pipe and 216 lb for 20-ft pipe.

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TABLE 51.5

Standard Dimensions and Weights of Mechanical-Joint Ductile-Iron Pipe

Size *in.*	Thickness Class	Thickness *in.*	OD* *in.*	Wt. of Barrel Per Ft *lb*	Wt. of Bell *lb*	18-ft Laying Length		20-ft Laying Length	
						Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*	Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*
3§	51	0.25	3.96	8.9	11	170	9.5	190	9.4
	52	0.28	3.96	9.9	11	190	10.5	210	10.4
	53	0.31	3.96	10.9	11	205	11.5	230	11.4
	54	0.34	3.96	11.8	11	225	12.4	245	12.4
	55	0.37	3.96	12.8	11	240	13.4	265	13.4
	56	0.40	3.96	13.7	11	260	14.3	285	14.2
4	51	0.26	4.80	11.3	16	220	12.2	240	12.1
	52	0.29	4.80	12.6	16	245	13.5	270	13.4
	53	0.32	4.80	13.8	16	265	14.7	290	14.6
	54	0.35	4.80	15.0	16	285	15.9	315	15.8
	55	0.38	4.80	16.1	16	305	17.0	340	16.9
	56	0.41	4.80	17.3	16	325	18.2	360	18.1
6	50	0.25	6.90	16.0	22	310	17.2	340	17.1
	51	0.28	6.90	17.8	22	340	19.0	380	18.9
	52	0.31	6.90	19.6	22	375	20.8	415	20.7
	53	0.34	6.90	21.4	22	405	22.6	450	22.5
	54	0.37	6.90	23.2	22	440	24.4	485	24.3
	55	0.40	6.90	25.0	22	470	26.2	520	26.1
	56	0.43	6.90	26.7	22	505	27.9	555	27.8
8	50	0.27	9.05	22.8	29	440	24.4	485	24.2
	51	0.30	9.05	25.2	29	485	26.8	535	26.6
	52	0.33	9.05	27.7	29	530	29.3	585	29.2
	53	0.36	9.05	30.1	29	570	31.7	630	31.6
	54	0.39	9.05	32.5	29	615	34.1	680	34.0
	55	0.42	9.05	34.8	29	655	36.4	725	36.2
	56	0.45	9.05	37.2	29	700	38.8	775	38.6
10	50	0.29	11.10	30.1	39	580	32.3	640	32.0
	51	0.32	11.10	33.2	39	635	35.4	705	35.2
	52	0.35	11.10	36.2	39	690	38.4	765	38.2
	53	0.38	11.10	39.2	39	745	41.4	825	41.2
	54	0.41	11.10	42.1	39	795	44.3	880	44.0
	55	0.44	11.10	45.1	39	850	47.3	940	47.0
	56	0.47	11.10	48.0	39	905	50.2	1 000	50.0
12	50	0.31	13.20	38.4	49	740	41.1	815	40.8
	51	0.34	13.20	42.0	49	805	44.7	890	44.4
	52	0.37	13.20	45.6	49	870	48.3	960	48.0
	53	0.40	13.20	49.2	49	935	51.9	1 035	51.6
	54	0.43	13.20	52.8	49	1 000	55.5	1 105	55.2
	55	0.46	13.20	56.3	49	1 060	59.0	1 175	58.8
	56	0.49	13.20	59.9	49	1 125	62.6	1 245	62.3
14	50	0.33	15.30	47.5	76	930	51.7	1 025	51.3
	51	0.36	15.30	51.7	76	1 005	55.9	1 110	55.5
	52	0.39	15.30	55.9	76	1 080	60.1	1 195	59.7
	53	0.42	15.30	60.1	76	1 160	64.3	1 280	63.9
	54	0.45	15.30	64.2	76	1 230	68.4	1 360	68.0
	55	0.48	15.30	68.4	76	1 305	72.6	1 445	72.2
	56	0.51	15.30	72.5	76	1 380	76.7	1 525	76.3

* Tolerances of OD of spigot end: 3–12 in., ±0.06 in.; 14–24 in., +0.05 in., −0.08 in.; 30–48 in., +0.08 in., −0.06 in.
† Including bell; calculated weight of pipe rounded off to nearest 5 lb.
‡ Including bell; average weight, per foot, based on calculated weight of pipe before rounding.
§ Pipe of 3-in. size also available in 12-ft laying length with following weights:

Thickness Class	Thickness *in.*	Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*
51	0.25	120	9.8
52	0.28	130	10.8
53	0.31	140	11.8
54	0.34	155	12.7
55	0.37	165	13.7
56	0.40	175	14.6

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TABLE 51.5—(*cont.*)

Size *in.*	Thickness Class	Thickness *in.*	OD* *in.*	Wt. of Barrel Per Ft *lb*	Wt. of Bell†† *lb*	18-ft Laying Length		20-ft Laying Length	
						Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*	Wt. Per Lgth.† *lb*	Avg. Wt. Per Ft‡ *lb*
16	50	0.34	17.40	55.8	93	1 095	61.0	1 210	60.4
	51	0.37	17.40	60.6	93	1 185	65.8	1 305	65.2
	52	0.40	17.40	65.4	93	1 270	70.6	1 400	70.0
	53	0.43	17.40	70.1	93	1 355	75.3	1 495	74.8
	54	0.46	17.40	74.9	93	1 440	80.1	1 590	79.6
	55	0.49	17.40	79.7	93	1 530	84.9	1 685	84.4
	56	0.52	17.40	84.4	93	1 610	89.6	1 780	89.0
18	50	0.35	19.50	64.4	111	1 270	70.6	1 400	70.0
	51	0.38	19.50	69.8	111	1 365	76.0	1 505	75.4
	52	0.41	19.50	75.2	111	1 465	81.4	1 615	80.8
	53	0.44	19.50	80.6	111	1 561	86.8	1 725	86.2
	54	0.47	19.50	86.0	111	1 661	92.2	1 830	91.6
	55	0.50	19.50	91.3	111	1 755	97.5	1 935	96.8
	56	0.53	19.50	96.7	111	1 850	102.9	2 045	102.2
20	50	0.36	21.60	73.5	131	1 455	80.8	1 600	80.0
	51	0.39	21.60	79.5	131	1 560	86.8	1 720	86.0
	52	0.42	21.60	85.5	131	1 670	92.8	1 840	92.0
	53	0.45	21.60	91.5	131	1 780	98.8	1 960	98.0
	54	0.48	21.60	97.5	131	1 885	104.8	2 080	104.0
	55	0.51	21.60	103.4	131	1 990	110.7	2 200	110.0
	56	0.54	21.60	109.3	131	2 100	116.6	2 315	115.8
24	50	0.38	25.80	92.9	174	1 845	102.6	2 030	101.6
	51	0.41	25.80	100.1	174	1 975	109.8	2 175	108.8
	52	0.44	25.80	107.3	174	2 105	117.0	2 320	116.0
	53	0.47	25.80	114.4	174	2 235	124.1	2 460	123.1
	54	0.50	25.80	121.6	174	2 365	131.3	2 605	130.3
	55	0.53	25.80	128.8	174	2 490	138.5	2 750	137.5
	56	0.56	25.80	135.9	174	2 620	145.6	2 890	144.6
30	50	0.39	32.00	118.5	216	2 350	130.5	2 585	129.3
	51	0.43	32.00	130.5	216	2 565	142.5	2 825	141.3
	52	0.47	32.00	142.5	216	2 780	154.5	3 065	153.3
	53	0.51	32.00	154.4	216	2 995	166.4	3 305	165.2
	54	0.55	32.00	166.3	216	3 210	178.3	3 540	177.1
	55	0.59	32.00	178.2	216	3 425	190.2	3 780	189.0
	56	0.63	32.00	190.0	216	3 635	202.0	4 015	200.8
36	50	0.43	38.30	156.5	310	3 125	173.7	3 440	172.0
	51	0.48	38.30	174.5	310	3 450	191.7	3 800	190.0
	52	0.53	38.30	192.4	310	3 775	209.6	4 160	207.9
	53	0.58	38.30	210.3	310	4 095	227.5	4 515	225.8
	54	0.63	38.30	228.1	310	4 415	245.3	4 870	243.6
	55	0.68	38.30	245.9	310	4 735	263.1	5 230	261.4
	56	0.73	38.30	263.7	310	5 055	280.9	5 585	279.2
42	50	0.47	44.50	198.9	405			4 385	219.2
	51	0.53	44.50	224.0	405			4 885	244.2
	52	0.59	44.50	249.1	405			5 385	269.4
	53	0.65	44.50	274.0	405			5 885	294.2
	54	0.71	44.50	298.9	405			6 385	319.2
	55	0.77	44.50	323.7	405			6 880	344.0
	56	0.83	44.50	348.4	405			7 375	368.6
48	50	0.51	50.80	246.6	505			5 435	271.8
	51	0.58	50.80	280.0	505			6 105	305.2
	52	0.65	50.80	313.4	505			6 775	338.6
	53	0.72	50.80	346.6	505			7 435	371.8
	54	0.79	50.80	379.8	505			8 100	405.0
	55	0.86	50.80	412.9	505			8 765	438.2
	56	0.93	50.80	445.9	505			9 425	471.2

* Tolerances of OD of spigot end: 3–12 in., ±0.06 in.; 14–24 in., +0.05 in., −0.08 in.; 30–48 in., +0.08 in., −0.06 in.

†† The mechanical joint bell for 30–48 in. sizes of ductile-iron pipe have thicknesses different from those shown in ANSI A21.11 (AWWA C111), which are based on gray-iron pipe. These reduced thicknesses provide a lighter weight bell, which is compatible with the wall thicknesses of ductile-iron pipe. The internal socket dimensions, bolt circle and bolt holes of the redesigned bell remain identical to those specified in A21.11 (AWWA C111) to assure interchangeability of the joint.

† Including bell; calculated weight of pipe rounded off to nearest 5 lb.

‡ Including bell; average weight per foot, based on calculated weight of pipe before rounding.

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Appendix

This appendix is for information and is not a part of ANSI A21.51 (AWWA C151).

TABLE A.1

Pipe Thicknesses Required for Different Tap Sizes as per ANSI B2.1 for Standard Taper Pipe Threads With Two, Three, and Four Full Threads

Pipe Size in.	No. of Threads	Tap Size—in.									
		¼	⅜	½	¾	1	1¼	1½	2	2½	3	3½	4
		Pipe Thickness—in.											
3	2	0.18	0.21	0.28									
3	3	0.26	0.29	0.37									
3	4	0.33	0.36	0.46									
4	2	0.17	0.19	0.26	0.31								
4	3	0.25	0.27	0.35	0.40								
4	4	0.32	0.34	0.44	0.49								
6	2	0.17	0.18	0.23	0.27	0.30							
6	3	0.25	0.26	0.32	0.36	0.39							
6	4	0.32	0.33	0.41	0.45	0.48							
8	2	0.16	0.17	0.22	0.24	0.27	0.33						
8	3	0.24	0.25	0.31	0.33	0.36	0.42						
8	4	0.31	0.32	0.40	0.42	0.45	0.51						
10	2	0.15	0.17	0.21	0.23	0.25	0.30	0.44					
10	3	0.23	0.25	0.30	0.32	0.34	0.39	0.56					
10	4	0.30	0.32	0.39	0.41	0.43	0.48	0.69					
12	2	0.15	0.16	0.20	0.22	0.24	0.28	0.40	0.48				
12	3	0.23	0.24	0.29	0.31	0.33	0.37	0.52	0.60				
12	4	0.30	0.31	0.38	0.40	0.42	0.46	0.65	0.73				
14	2	0.15	0.16	0.20	0.22	0.23	0.26	0.38	0.45	0.51	0.58		
14	3	0.23	0.24	0.29	0.31	0.32	0.35	0.50	0.58	0.64	0.70		
14	4	0.30	0.31	0.38	0.40	0.41	0.44	0.63	0.70	0.76	0.83		
16	2	0.15	0.16	0.20	0.21	0.22	0.25	0.37	0.43	0.48	0.54		
16	3	0.23	0.24	0.29	0.30	0.31	0.34	0.50	0.56	0.60	0.66		
16	4	0.30	0.31	0.38	0.39	0.40	0.43	0.62	0.68	0.73	0.79		
18	2	0.15	0.15	0.19	0.21	0.22	0.24	0.35	0.41	0.46	0.51		
18	3	0.23	0.23	0.28	0.30	0.31	0.33	0.48	0.54	0.58	0.64		
18	4	0.30	0.30	0.37	0.39	0.40	0.42	0.60	0.66	0.71	0.76		
20	2	0.15	0.15	0.19	0.20	0.21	0.23	0.34	0.39	0.44	0.49		
20	3	0.23	0.23	0.28	0.29	0.30	0.32	0.46	0.52	0.56	0.62		
20	4	0.30	0.30	0.37	0.38	0.39	0.41	0.59	0.64	0.69	0.74		
24	2	0.14	0.15	0.19	0.20	0.21	0.22	0.32	0.37	0.40	0.45		
24	3	0.22	0.23	0.28	0.29	0.30	0.31	0.44	0.50	0.52	0.58		
24	4	0.29	0.30	0.37	0.38	0.39	0.40	0.57	0.62	0.65	0.70		
30	2	0.14	0.15	0.19	0.19	0.20	0.21	0.31	0.34	0.37	0.41		
30	3	0.22	0.23	0.28	0.28	0.29	0.30	0.44	0.46	0.50	0.54		
30	4	0.29	0.30	0.37	0.37	0.38	0.39	0.56	0.59	0.62	0.66		
36	2	0.14	0.14	0.18	0.19	0.20	0.21	0.30	0.33	0.35	0.38		
36	3	0.22	0.22	0.27	0.28	0.29	0.30	0.42	0.46	0.48	0.50		
36	4	0.29	0.29	0.36	0.37	0.38	0.39	0.55	0.58	0.60	0.63		
42	2	0.14	0.14	0.18	0.19	0.19	0.20	0.29	0.32	0.34	0.36		
42	3	0.22	0.22	0.27	0.28	0.28	0.29	0.42	0.44	0.46	0.48		
42	4	0.29	0.29	0.36	0.37	0.37	0.38	0.54	0.57	0.59	0.61		
48	2	0.14	0.14	0.18	0.18	0.19	0.20	0.29	0.31	0.32	0.35		
48	3	0.22	0.22	0.27	0.27	0.28	0.29	0.42	0.44	0.44	0.48		
48	4	0.29	0.29	0.36	0.36	0.37	0.38	0.54	0.56	0.57	0.60		
54	2	0.14	0.14	0.17	0.18	0.18	0.19	0.28	0.30	0.32	0.34		
54	3	0.21	0.21	0.26	0.27	0.27	0.28	0.41	0.43	0.44	0.47		
54	4	0.29	0.29	0.35	0.35	0.36	0.37	0.53	0.55	0.57	0.59		

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TABLE A.2

Pipe Thicknesses Required for Different Tap Sizes as per AWWA C800 for Standard Corporation Stop Threads With Two, Three, and Four Full Threads*

Pipe Size in.	No. of Threads	Tap Size—in.						
		¾	1	1¼	1½	1¾	1¾	2
		Pipe Thickness—in.						
3	2	0.21	0.24	0.25	0.33			
3	3	0.29	0.32	0.33	0.41			
3	4	0.36	0.39	0.40	0.49			
4	2	0.19	0.22	0.23	0.30	0.36		
4	3	0.27	0.30	0.31	0.38	0.45		
4	4	0.34	0.37	0.38	0.46	0.54		
6	2	0.18	0.20	0.20	0.26	0.30	0.35	
6	3	0.26	0.28	0.28	0.34	0.39	0.44	
6	4	0.33	0.35	0.35	0.42	0.48	0.53	
8	2	0.17	0.18	0.19	0.24	0.27	0.31	0.39
8	3	0.25	0.26	0.27	0.32	0.36	0.40	0.48
8	4	0.32	0.33	0.34	0.40	0.45	0.49	0.57
10	2	0.17	0.17	0.18	0.23	0.25	0.28	0.35
10	3	0.25	0.25	0.26	0.31	0.34	0.37	0.44
10	4	0.32	0.32	0.33	0.39	0.43	0.46	0.53
12	2	0.16	0.17	0.17	0.22	0.24	0.26	0.32
12	3	0.24	0.25	0.25	0.30	0.33	0.35	0.41
12	4	0.31	0.32	0.32	0.38	0.42	0.44	0.50
14	2	0.16	0.17	0.17	0.22	0.24	0.25	0.30
14	3	0.24	0.25	0.25	0.29	0.32	0.34	0.39
14	4	0.31	0.32	0.32	0.37	0.41	0.43	0.48
16	2	0.16	0.16	0.17	0.21	0.22	0.24	0.28
16	3	0.24	0.24	0.25	0.29	0.31	0.33	0.37
16	4	0.31	0.31	0.32	0.37	0.40	0.42	0.46
18	2	0.15	0.16	0.16	0.20	0.21	0.23	0.27
18	3	0.23	0.24	0.24	0.28	0.30	0.32	0.36
18	4	0.30	0.31	0.31	0.36	0.39	0.41	0.45
20	2	0.15	0.16	0.16	0.20	0.21	0.23	0.26
20	3	0.23	0.24	0.24	0.28	0.30	0.32	0.35
20	4	0.30	0.31	0.31	0.36	0.39	0.41	0.44
24	2	0.15	0.15	0.16	0.19	0.21	0.22	0.24
24	3	0.23	0.23	0.24	0.27	0.30	0.31	0.33
24	4	0.30	0.30	0.31	0.35	0.39	0.40	0.42
30	2	0.15	0.15	0.16	0.19	0.20	0.21	0.23
30	3	0.23	0.23	0.24	0.27	0.29	0.30	0.32
30	4	0.30	0.30	0.31	0.35	0.38	0.39	0.41
36	2	0.14	0.15	0.15	0.19	0.20	0.20	0.22
36	3	0.22	0.23	0.23	0.27	0.29	0.29	0.31
36	4	0.29	0.30	0.30	0.35	0.38	0.38	0.40
42	2	0.14	0.14	0.15	0.18	0.19	0.20	0.21
42	3	0.22	0.22	0.23	0.26	0.28	0.29	0.30
42	4	0.29	0.29	0.30	0.34	0.37	0.38	0.39
48	2	0.14	0.14	0.15	0.18	0.18	0.19	0.20
48	3	0.22	0.22	0.23	0.26	0.27	0.28	0.29
48	4	0.29	0.29	0.30	0.34	0.36	0.37	0.38
54	2	0.14	0.14	0.14	0.17	0.18	0.19	0.20
54	3	0.22	0.22	0.22	0.25	0.27	0.28	0.29
54	4	0.29	0.29	0.29	0.34	0.36	0.36	0.38

* This thread is commonly known to the trade as the Mueller thread.

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