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.
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American Water Works Association

Approved American National Standard
ANSI

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

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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 19428.

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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American Water Works Association
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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:

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

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_t, 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.

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

4.2.3 *Step 3: Selection of net thickness and addition of service allowances.* The larger of the thicknesses is given by the design for trench load, Step 2, and 0.20 in. is selected.

Net thickness	=	0.20 in.
Service allowance	=	0.08 in.
Minimum manufacturing thickness	=	0.28 in.

4.2.4 *Step 4: Check deflection.* Entering P_v of 9.0 psi in Table 9, the "Deflection Check" requires D/t_1 of 136. Minimum thickness t_1 for deflection design = $D/(D/t_1) = 32.00/136 = 0.24$ in.

This minimum thickness, 0.24 in., is less than the minimum thickness calculated in Sec. 4.2.3 (0.28 in.); therefore, deflection does not govern.

4.2.5 *Step 5: Add the casting allowance.*

Minimum manufacturing thickness	=	0.28 in.
Casting allowance	=	0.07 in.
Total calculated thickness	=	0.35 in.

4.2.6 *Step 6: Selection of nominal thickness and standard pressure class.* The total calculated thickness of 0.35 in. is larger than 0.34 in., Class 150 (Table 5). Therefore, Class 200 (0.38 in.) is selected for specifying and ordering.

Sec. 4.3 Design Method

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

Calculations are first made for the thickness required to resist the hoop stress from internal pressure. Calculations are then made for the thickness required to resist the bending stress caused by trench load. The larger of the two is selected as the net thickness. A service allowance is added to this net thickness to achieve the minimum thickness t_1.

The minimum thickness required for deflection is then calculated and compared to t_1. The larger of the two is selected as the minimum manufacturing thickness. A casting allowance is added to this minimum manufacturing thickness to obtain the total calculated thickness.

The nominal thickness and the standard pressure class for specifying and ordering are selected from the table of nominal thicknesses for standard pressure classes (Table 5).

The reverse of the preceding procedure is used to determine the rated working pressure and maximum depth of cover for pipe of a given pressure class.

4.3.2 *Trench load P_v.* Trench load is expressed as vertical pressure in pounds per square inch (kilopascals) and is equal to the sum of earth load P_e and truck load P_t.

4.3.3 *Earth load P_e.* Earth load is computed by Eq 4 for the weight of the unit prism of soil with a height equal to the distance from the top of the pipe to the ground surface. The unit weight of backfill soil is taken to be 120 lb/ft^3 (18.85 kN/m^3). If the designer anticipates additional loads, the design load should be increased accordingly.

4.3.4 *Truck load P_t.* The truck loads shown in Table 1 were computed by Eq 5 using the surface-load factors in Table 6 and the reduction factors R from Table 4 for a single AASHTO H-20 truck on unpaved road or flexible pavement, 16,000-lb (71,170-N) wheel load, and 1.5 impact factor. The surface-load factors in Table 6 were calculated by Eq 6 for a single concentrated wheel load centered over an effective pipe length of 3 ft (0.914 m).

4.3.5 *Design for trench load.* Table 7, Table 8, Table 9, Table 10, and Table 11, the diameter-thickness ratio tables used to design for trench load, were computed with Eqs 2 and 3. Eq 2 is based on the bending stress at the bottom of the pipe. The design-bending stress f is 48,000 psi (331 × 10^3 kPa), which provides at least a 1.5 safety factor based on minimum ring yield strength and a 2.0 safety factor based on ultimate strength. Eq 3 is based on the deflection of the pipe ring section. The design deflection Δx is 3 percent of the outside diameter of the pipe, which is well below the deflection that might damage cement linings. Design values of the trench parameters E', K_b, and K_x are given in Table 2.

Tables similar to Table 7, Table 8, Table 9, Table 10, and Table 11 may be compiled for laying conditions other than those shown in this standard by calculating the trench loads P_v for a series of diameter-thickness ratios, D/t and D/t_1, using Eqs 2 and 3 with values of E', K_b, and K_x appropriate to the bedding and backfill conditions.

4.3.6 *Tables.* Tables for earth load (P_e), truck load (P_t), trench load (P_v), surface load factor (C), and diameter/thickness ratios (D/t and D/t_1) have been incorporated into this standard for reference and simplification of required pipe class determination. If a pipe class determination resulting from use of these tables is in conflict with a pipe class determination resulting from design equations Eqs 1 through 6, the more exact pipe class determination from use of the design equations should govern. Table 14, which is derived from the design equations, can also normally be used to quickly resolve any conflicts. Design equations are as follows:

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

$$P_v = \frac{f}{3\left(\frac{D}{t}\right)\left(\frac{D}{t} - 1\right)\left[K_b - \frac{K_x}{\frac{8E}{E'\left(\frac{D}{t} - 1\right)^3} + 0.732}\right]} \qquad \text{(Eq 3)}$$

$$P_v = \frac{\frac{\Delta x}{D}}{12K_x}\left[\frac{8E}{\left(\frac{D}{t_1} - 1\right)^3} + 0.732\,E'\right] \qquad \text{(Eq 4)}$$

$$P_e = \frac{wH}{a} \qquad \text{(Eq 5)}$$

$$P_t = RF\frac{CP}{bD} \qquad \text{(Eq 6)}$$

$$C = 1 - \frac{2}{\pi}\arcsin\left(H\sqrt{\frac{A^2 + B^2 + H^2}{\left(A^2 + H^2\right)\left(B^2 + H^2\right)}}\right) + \frac{2}{\pi}\left(\frac{A \times H \times B}{\sqrt{A^2 + H^2 + B^2}}\right)\left(\frac{1}{A^2 + H^2} + \frac{1}{B^2 + H^2}\right) \qquad \text{(Eq 7)}$$

NOTE: In Eq 7, angles are in radians.

Sec. 4.4 Explanation of Symbols Used in Design Equations

A = Outside radius of pipe. For A in feet, D in inches: $A = D/24$ (For A in m, D in mm: $A = D/2{,}000$)

a = Conversion factor. For pounds per square foot to pounds per square inch: $a = 144$ (For kilonewtons per square meter to kilopascals: $a = 1$)

B = 1.5 ft (0.457 m)

b = Effective pipe length: 36 in. (0.914 m)

C = Surface-load factor: see Table 6

D = Outside diameter, in inches (mm): see Table 5

E = Modulus of elasticity: 24×10^6 psi (165.5×10^6 kPa)

E' = Modulus of soil reaction, in psi (kPa): see Table 2

F = Impact factor: 1.5

f = Design-bending stress: 48,000 psi (331×10^3 kPa)

H = Depth of cover, in ft (m)

K_b = Bending moment coefficient: see Table 2

K_x = Deflection coefficient: see Table 2

P = Wheel load: 16,000 lb (71,170 N)

P_e = Earth load, in psi (kPa)

P_i = Design internal pressure, psi (kPa):
P_i = 2 (working pressure + 100 psi [689 kPa] surge allowance)

P_t = Truck load, in psi (kPa)

P_v = Trench load, in psi (kPa): $P_v = P_e + P_t$

R = Reduction factor, which accounts for the part of the pipe directly below the wheels that is aided in carrying the truck load by adjacent parts of the pipe that receive little or no load from the wheels: see Table 4

S = Minimum yield strength in tension: 42,000 psi (289,590 kPa)

t = Net thickness, in inches (mm)

t_1 = Minimum manufacturing thickness, in inches: $t_1 = t + 0.08$ (in mm: $t_1 = t + 2$)

w = Soil weight: 120 lb/ft^3 (18.85 kN/m^3)

Δx = Design deflection, in inches (mm): $\Delta x = 0.03D$

Sec. 4.5 Special Thickness Classes

For design conditions not covered in Table 12, Table 13, and Table 14, special (formerly standard) thickness classes shown in Table 15 continue to be available.

SECTION 5: VERIFICATION

This standard has no applicable information for this section.

SECTION 6: DELIVERY

This standard has no applicable information for this section.

Table 1 Earth loads P_e, truck loads P_t, and trench loads P_v—*psi*

Depth of Cover		3-in. Pipe		4-in. Pipe		6-in. Pipe		8-in. Pipe	
ft	P_e	P_t	P_v	P_t	P_v	P_t	P_v	P_t	P_v
2.5	2.1	9.9	12.0	9.9	12.0	9.9	12.0	9.8	11.9
3	2.5	7.4	9.9	7.4	9.9	7.3	9.8	7.3	9.8
4	3.3	4.4	7.7	4.5	7.8	4.4	7.7	4.4	7.7
5	4.2	3.0	7.2	3.0	7.2	3.0	7.2	3.0	7.2
6	5.0	2.1	7.1	2.1	7.1	2.1	7.1	2.1	7.1
7	5.8	1.6	7.4	1.6	7.4	1.6	7.4	1.6	7.4
8	6.7	1.2	7.9	1.2	7.9	1.2	7.9	1.2	7.9
9	7.5	1.0	8.5	1.0	8.5	1.0	8.5	1.0	8.5
10	8.3	0.8	9.1	0.8	9.1	0.8	9.1	0.8	9.1
12	10.0	0.6	10.6	0.6	10.6	0.6	10.6	0.6	10.6
14	11.7	0.4	12.1	0.4	12.1	0.4	12.1	0.4	12.1
16	13.3	0.3	13.6	0.3	13.6	0.3	13.6	0.3	13.6
20	16.7	0.2	16.9	0.2	16.9	0.2	16.9	0.2	16.9
24	20.0	0.2	20.2	0.1	20.1	0.1	20.1	0.1	20.1
28	23.3	0.1	23.4	0.1	23.4	0.1	23.4	0.1	23.4
32	26.7	0.1	26.8	0.1	26.8	0.1	26.8	0.1	26.8

Depth of Cover		10-in. Pipe		12-in. Pipe		14-in. Pipe		16-in. Pipe	
ft	P_e	P_t	P_v	P_t	P_v	P_t	P_v	P_t	P_v
2.5	2.1	9.7	11.8	9.6	11.7	8.7	10.8	8.2	10.3
3	2.5	7.2	9.7	7.2	9.7	6.6	9.1	6.2	8.7
4	3.3	4.4	7.7	4.4	7.7	4.4	7.7	4.1	7.4
5	4.2	2.9	7.1	2.9	7.1	2.9	7.1	2.8	7.0
6	5.0	2.1	7.1	2.1	7.1	2.1	7.1	2.0	7.0
7	5.8	1.6	7.4	1.6	7.4	1.6	7.4	1.5	7.3
8	6.7	1.2	7.9	1.2	7.9	1.2	7.9	1.2	7.9
9	7.5	1.0	8.5	1.0	8.5	1.0	8.5	1.0	8.5
10	8.3	0.8	9.1	0.8	9.1	0.8	9.1	0.8	9.1
12	10.0	0.5	10.5	0.5	10.5	0.5	10.5	0.5	10.5
14	11.7	0.4	12.1	0.4	12.1	0.4	12.1	0.4	12.1
16	13.3	0.3	13.6	0.3	13.6	0.3	13.6	0.3	13.6
20	16.7	0.2	16.9	0.2	16.9	0.2	16.9	0.2	16.9
24	20.0	0.1	20.1	0.1	20.1	0.1	20.1	0.1	20.1
28	23.3	0.1	23.4	0.1	23.4	0.1	23.4	0.1	23.4
32	26.7	0.1	26.8	0.1	26.8	0.1	26.8	0.1	26.8

(continued)

Table 1 Earth loads P_e, truck loads P_t, and trench loads P_v—psi *(Continued)*

Depth of Cover		18-in. Pipe		20-in. Pipe		24-in. Pipe		30-in. Pipe		36-in. Pipe	
ft	P_e	P_t	P_v	P_t	P_v	P_t	P_v	P_t	P_v	P_t	P_v
2.5	2.1	7.8	9.9	7.5	9.6	7.1	9.2	6.7	8.8	6.2	8.3
3	2.5	5.9	8.4	5.7	8.2	5.4	7.9	5.2	7.7	4.9	7.4
4	3.3	3.9	7.2	3.9	7.2	3.6	6.9	3.5	6.8	3.4	6.7
5	4.2	2.6	6.8	2.6	6.8	2.4	6.6	2.4	6.6	2.3	6.5
6	5.0	1.9	6.9	1.9	6.9	1.7	6.7	1.7	6.7	1.7	6.7
7	5.8	1.4	7.2	1.4	7.2	1.3	7.1	1.3	7.1	1.3	7.1
8	6.7	1.2	7.9	1.1	7.8	1.1	7.8	1.1	7.8	1.1	7.8
9	7.5	1.0	8.5	0.9	8.4	0.9	8.4	0.9	8.4	0.8	8.3
10	8.3	0.8	9.1	0.7	9.0	0.7	9.0	0.7	9.0	0.7	9.0
12	10.0	0.5	10.5	0.5	10.5	0.5	10.5	0.5	10.5	0.5	10.5
14	11.7	0.4	12.1	0.4	12.1	0.4	12.1	0.4	12.1	0.4	12.1
16	13.3	0.3	13.6	0.3	13.6	0.3	13.6	0.3	13.6	0.3	13.6
20	16.7	0.2	16.9	0.2	16.9	0.2	16.9	0.2	16.9	0.2	16.9
24	20.0	0.1	20.1	0.1	20.1	0.1	20.1	0.1	20.1	0.1	20.1
28	23.3	0.1	23.4	0.1	23.4	0.1	23.4	0.1	23.4	0.1	23.4
32	26.7	0.1	26.8	0.1	26.8	0.1	26.8	0.1	26.8	0.1	26.8

Depth of Cover		42-in. Pipe		48-in. Pipe		54-in. Pipe		60-in. Pipe		64-in. Pipe	
ft	P_e	P_t	P_v	P_t	P_v	P_t	P_v	P_t	P_v	P_t	P_v
2.5	2.1	5.8	7.9	5.4	7.5	5.0	7.1	4.8	6.9	4.5	6.6
3	2.5	4.6	7.1	4.4	6.9	4.1	6.6	3.9	6.4	3.8	6.3
4	3.3	3.3	6.6	3.1	6.4	3.0	6.3	2.9	6.2	2.8	6.1
5	4.2	2.3	6.5	2.2	6.4	2.1	6.3	2.1	6.3	2.1	6.3
6	5.0	1.7	6.7	1.6	6.6	1.6	6.6	1.6	6.6	1.5	6.5
7	5.8	1.3	7.1	1.2	7.0	1.2	7.0	1.2	7.0	1.2	7.0
8	6.7	1.0	7.7	1.0	7.7	1.0	7.7	1.0	7.7	1.0	7.7
9	7.5	0.8	8.3	0.8	8.3	0.8	8.3	0.8	8.3	0.8	8.3
10	8.3	0.7	9.0	0.7	9.0	0.7	9.0	0.7	9.0	0.7	9.0
12	10.0	0.5	10.5	0.5	10.5	0.5	10.5	0.5	10.5	0.5	10.5
14	11.7	0.4	12.1	0.4	12.1	0.4	12.1	0.4	12.1	0.4	12.1
16	13.3	0.3	13.6	0.3	13.6	0.3	13.6	0.3	13.6	0.3	13.6
20	16.7	0.2	16.9	0.2	16.9	0.2	16.9	0.2	16.9	0.2	16.9
24	20.0	0.1	20.1	0.1	20.1	0.1	20.1	0.1	20.1	0.1	20.1
28	23.3	0.1	23.4	0.1	23.4	0.1	23.4	0.1	23.4	0.1	23.4
32	26.7	0.1	26.8	0.1	26.8	0.1	26.8	0.1	26.8	0.1	26.8

NOTE: To convert inches (in.) to millimeters (mm), multiply by 25.4; to convert feet (ft) to meters (m), multiply by 0.3048; to convert pounds per square inch (psi) to kilopascals (kPa), multiply by 6.895.

Table 2 Design values for standard laying conditions

Laying Condition*	Description	E' *psi*	Bedding Angle Degree	K_b	K_x
Type 1†	Flat-bottom trench.‡ Loose backfill.	150	30	0.235	0.108
Type 2	Flat-bottom trench. Backfill lightly consolidated to centerline of pipe.	300	45	0.210	0.105
Type 3	Pipe bedded in 4-in.-minimum loose soil.§ Backfill lightly consolidated to top of pipe.	400	60	0.189	0.103
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. (Approximately 80% Standard Proctor, AASHTO T-99)¶	500	90	0.157	0.096
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. (Approximately 90% Standard Proctor, AASHTO T-99)¶	700	150	0.128	0.085

* See Figure 1.

† For pipe 14 in. (350 mm) 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 material, and frozen earth."

¶ 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. Available from the American Association of State Highway and Transportation Officials, 555 12th Street NW, Suite 1000; Washington, D.C. 20004.

** Granular materials are defined per the AASHTO Soil Classification System (ASTM D3282) or the Unified Soil Classification System (ASTM D2487), with the exception that gravel bedding/backfill adjacent to the pipe is limited to 2-in. maximum particle size per ANSI/AWWA C600.

Notes:

1. Consideration of the pipe-zone embedment conditions included in this table may be influenced by factors other than pipe strength. For additional information, see ANSI/AWWA C600, Installation of Ductile-Iron Mains and Their Appurtenances.
2. To convert pounds per square inch (psi) to kilopascals (kPa), multiply by 6.895.

Table 3 Allowances for casting tolerance

Size *in.*	Casting Allowance *in.*
3–8	0.05
10–12	0.06
14–42	0.07
48	0.08
54–64	0.09

Note: To convert inches (in.) to millimeters (mm), multiply by 25.4.

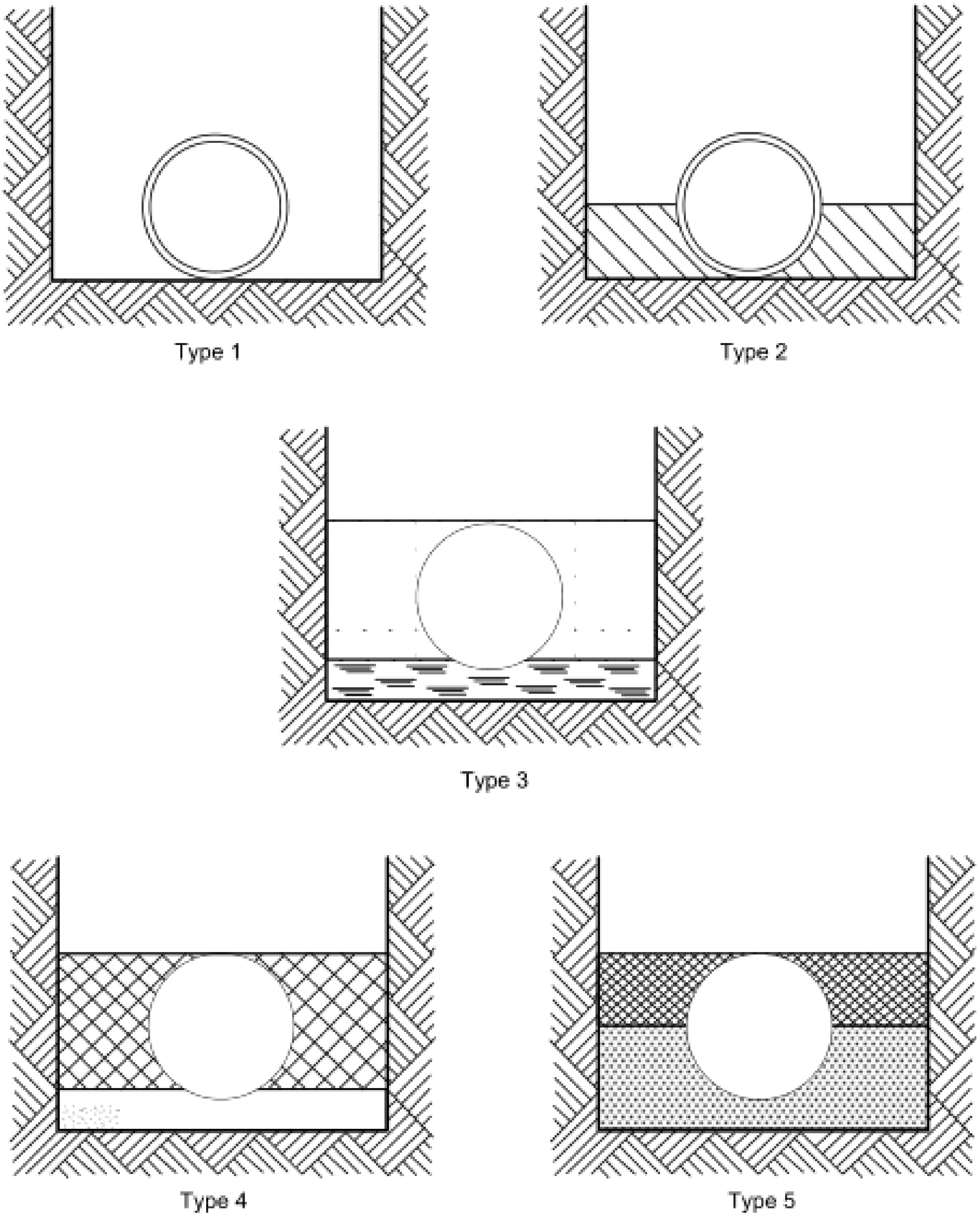

Figure 1 Standard pipe laying conditions (see Table 2)

Table 4 Reduction factors *R* for truck load calculations

Size *in.*	Depth of Cover—*ft* <4	4–7	>7–10	>10
	Reduction Factor			
3–12	1.00	1.00	1.00	1.00
14	0.92	1.00	1.00	1.00
16	0.88	0.95	1.00	1.00
18	0.85	0.90	1.00	1.00
20	0.83	0.90	0.95	1.00
24–30	0.81	0.85	0.95	1.00
36–64	0.80	0.85	0.90	1.00

Table 5 Nominal thicknesses for standard pressure classes of ductile-iron pipe

Size	Outside Diameter	Pressure Class				
		150	200	250	300	350
in.	*in.*	Nominal Thickness—*in.*				
3	3.96	—	—	—	—	0.25*
4	4.80	—	—	—	—	0.25*
6	6.90	—	—	—	—	0.25*
8	9.05	—	—	—	—	0.25*
10	11.10	—	—	—	—	0.26
12	13.20	—	—	—	—	0.28
14	15.30	—	—	0.28	0.30	0.31
16	17.40	—	—	0.30	0.32	0.34
18	19.50	—	—	0.31	0.34	0.36
20	21.60	—	—	0.33	0.36	0.38
24	25.80	—	0.33	0.37	0.40	0.43
30	32.00	0.34	0.38	0.42	0.45	0.49
36	38.30	0.38	0.42	0.47	0.51	0.56
42	44.50	0.41	0.47	0.52	0.57	0.63
48	50.80	0.46	0.52	0.58	0.64	0.70
54	57.56	0.51	0.58	0.65	0.72	0.79
60	61.61	0.54	0.61	0.68	0.76	0.83
64	65.67	0.56	0.64	0.72	0.80	0.87

* Calculated thicknesses for these sizes and pressure ratings are less than those shown above. (See Table 13 for actual calculated thicknesses.) Presently, these are the lowest nominal thicknesses available in these sizes.

Pressure classes are defined as the rated water working pressure of the pipe in pounds per square inch (psi). The thicknesses shown are adequate for the rated water working pressure plus a surge allowance of 100 psi (689 kPa). Calculations are based on a minimum yield strength in tension of 42,000 psi (289,590 kPa) and 2.0 safety factor times the sum of working pressure and 100-psi (689-kPa) surge allowance.

Thickness can be calculated for rated water working pressure and surges other than the above by use of the formula shown in Sec. 4.1.1.

Ductile-iron pipe is available for water working pressures greater than 350 psi (2,413 kPa). Pipe is available with thicknesses greater than Pressure Class 350. See Table 15.

Lowest nominal thicknesses shown in Table 1 of ANSI/AWWA C115/A21.15 for threaded flanged pipe are still required. Lowest nominal thicknesses shown in ANSI/AWWA C606 for pipe with grooved and shouldered joints are still required.

NOTE: To convert inches (in.) to millimeters (mm), multiply by 25.4.

Table 6 Surface-load factors for single truck on unpaved road

Depth of Cover *ft*	Pipe Size—*in.*								
	3	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
	Surface Load Factor—*C*								
2.5	0.0589	0.0713	0.1020	0.1328	0.1615	0.1901	0.2178	0.2443	0.2698
3	0.0437	0.0530	0.0759	0.0990	0.1207	0.1424	0.1637	0.1843	0.2044
4	0.0265	0.0321	0.0460	0.0602	0.0736	0.0871	0.1005	0.1136	0.1265
5	0.0176	0.0213	0.0306	0.0401	0.0490	0.0581	0.0672	0.0761	0.0849
6	0.0125	0.0151	0.0217	0.0284	0.0348	0.0413	0.0478	0.0542	0.0606
7	0.0093	0.0113	0.0162	0.0212	0.0260	0.0308	0.0357	0.0405	0.0453
8	0.0072	0.0087	0.0125	0.0164	0.0201	0.0238	0.0276	0.0313	0.0350
9	0.0057	0.0069	0.0099	0.0130	0.0160	0.0190	0.0219	0.0249	0.0279
10	0.0046	0.0056	0.0081	0.0106	0.0130	0.0154	0.0179	0.0203	0.0227
12	0.0032	0.0039	0.0056	0.0074	0.0091	0.0108	0.0125	0.0142	0.0159
14	0.0024	0.0029	0.0042	0.0055	0.0067	0.0080	0.0092	0.0105	0.0117
16	0.0018	0.0022	0.0032	0.0042	0.0051	0.0061	0.0071	0.0080	0.0090
20	0.0012	0.0014	0.0020	0.0027	0.0033	0.0039	0.0045	0.0052	0.0058
24	0.0008	0.0010	0.0014	0.0019	0.0023	0.0027	0.0032	0.0036	0.0040
28	0.0006	0.0007	0.0010	0.0014	0.0017	0.0020	0.0023	0.0026	0.0030
32	0.0005	0.0006	0.0008	0.0011	0.0013	0.0015	0.0018	0.0020	0.0023
Depth of Cover *ft*	**Pipe Size—*in.***								
	20	**24**	**30**	**36**	**42**	**48**	**54**	**60**	**64**
	Surface Load Factor—*C*								
2.5	0.2941	0.3390	0.3962	0.4437	0.4813	0.5115	0.5366	0.5488	0.5592
3	0.2237	0.2602	0.3085	0.3507	0.3857	0.4153	0.4412	0.4543	0.4657
4	0.1391	0.1635	0.1972	0.2284	0.2559	0.2808	0.3040	0.3164	0.3277
5	0.0936	0.1106	0.1347	0.1576	0.1786	0.1982	0.2173	0.2278	0.2377
6	0.0669	0.0793	0.0970	0.1143	0.1304	0.1458	0.1612	0.1698	0.1781
7	0.0500	0.0594	0.0730	0.0863	0.0988	0.1111	0.1235	0.1306	0.1374
8	0.0387	0.0461	0.0567	0.0672	0.0773	0.0871	0.0973	0.1031	0.1088
9	0.0309	0.0367	0.0453	0.0538	0.0620	0.0700	0.0784	0.0833	0.0880
10	0.0251	0.0299	0.0370	0.0440	0.0507	0.0574	0.0644	0.0685	0.0725
12	0.0176	0.0210	0.0259	0.0309	0.0357	0.0405	0.0456	0.0486	0.0515
14	0.0130	0.0155	0.0192	0.0229	0.0265	0.0301	0.0339	0.0362	0.0384
16	0.0100	0.0119	0.0147	0.0176	0.0204	0.0232	0.0262	0.0279	0.0297
20	0.0064	0.0076	0.0095	0.0113	0.0131	0.0149	0.0169	0.0181	0.0192
24	0.0045	0.0053	0.0066	0.0079	0.0091	0.0104	0.0118	0.0126	0.0134
28	0.0033	0.0039	0.0049	0.0058	0.0067	0.0077	0.0087	0.0093	0.0099
32	0.0025	0.0030	0.0037	0.0044	0.0052	0.0059	0.0067	0.0071	0.0076

NOTE: To convert inches (in.) to millimeters (mm), multiply by 25.4; to convert feet (ft) to meters (m), multiply by 0.3048.

Table 7 Diameter-thickness ratios for laying condition Type 1*

Trench Load (P_v)—*psi*			Trench Load (P_v)—*psi*		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ or $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ or $\frac{D}{t_1}$ †
4.40	3.46	170	5.40	4.03	145
4.43	3.48	169	5.45	4.06	144
4.46	3.50	168	5.49	4.09	143
4.50	3.51	167	5.54	4.13	142
4.54	3.53	166	5.59	4.16	141
4.57	3.55	165	5.65	4.20	140
4.61	3.57	164	5.70	4.23	139
4.64	3.59	163	5.75	4.27	138
4.68	3.61	162	5.80	4.31	137
4.72	3.63	161	5.86	4.35	136
4.76	3.65	160	5.91	4.39	135
4.80	3.67	159	5.97	4.43	134
4.84	3.69	158	6.03	4.47	133
4.88	3.71	157	6.09	4.52	132
4.92	3.74	156	6.15	4.56	131
4.96	3.76	155	6.21	4.61	130
5.00	3.78	154	6.27	4.66	129
5.04	3.81	153	6.33	4.71	128
5.08	3.83	152	6.40	4.76	127
5.13	3.86	151	6.46	4.82	126
5.17	3.89	150	6.53	4.87	125
5.21	3.91	149	6.60	4.93	124
5.26	3.94	148	6.67	4.99	123
5.30	3.97	147	6.74	5.05	122
5.35	4.00	146	6.82	5.11	121
6.89	5.18	120	9.56	7.89	95
6.97	5.25	119	9.71	8.07	94
7.05	5.32	118	9.87	8.25	93
7.13	5.39	117	10.03	8.44	92
7.21	5.46	116	10.20	8.64	91
7.29	5.54	115	10.37	8.85	90
7.38	5.62	114	10.55	9.06	89
7.47	5.71	113	10.74	9.29	88
7.56	5.79	112	10.93	9.53	87
7.65	5.88	111	11.13	9.78	86

(continued)

Table 7 Diameter-thickness ratios for laying condition Type 1* *(Continued)*

Trench Load (P_v)—*psi*			Trench Load (P_v)—*psi*		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †
7.75	5.97	110	11.34	10.04	85
7.85	6.07	109	11.55	10.31	84
7.95	6.17	108	11.78	10.60	83
8.05	6.27	107	12.01	10.90	82
8.16	6.38	106	12.25	11.22	81
8.27	6.49	105	12.50	11.56	80
8.38	6.61	104	12.76	11.91	79
8.49	6.73	103	13.03	12.28	78
8.61	6.86	102	13.31	12.67	77
8.74	6.99	101	13.60	13.08	76
8.86	7.12	100	13.91	13.51	75
8.99	7.26	99	14.23	13.97	74
9.13	7.41	98	14.56	14.45	73
9.27	7.57	97	14.91	14.96	72
9.41	7.73	96	15.27	15.50	71
15.65	16.07	70	28.94	40.32	50
16.05	16.68	69	30.07	42.73	49
16.46	17.32	68	31.28	45.35	48
16.89	18.00	67	32.57	48.20	47
17.35	18.73	66	33.95	51.31	46
17.83	19.50	65	35.42	54.72	45
18.33	20.32	64	37.00	58.44	44
18.85	21.19	63	38.69	62.53	43
19.40	22.12	62	40.50	67.03	42
19.98	23.12	61	42.46	71.99	41
20.59	24.18	60	44.56	77.47	40
21.23	25.32	59	46.84	83.54	39
21.91	26.54	58	49.30	90.28	38
22.63	27.85	57	51.96	97.80	37
23.38	29.26	56	54.86	106.20	36
24.18	30.77	55	58.02	115.62	35
25.02	32.39	54	61.46	126.21	34
25.92	34.15	53	65.23	138.18	33
26.86	36.05	52	69.36	151.73	32
27.87	38.10	51	73.92	167.15	31

* E' = 150 psi; K_b = 0.235; K_x = 0.108.

† When the calculated P_v is between two tabulated values, the smaller $\frac{D}{t}$ *or* $\frac{D}{t_1}$ should be used.

NOTE: To convert pounds per square inch (psi) to kilopascals (kPa), multiply by 6.895.

Table 8 Diameter-thickness ratios for laying condition Type 2*

Trench Load (P_v)—*psi*			Trench Load (P_v)—*psi*		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †
6.29	6.18	170	7.74	6.76	145
6.34	6.19	169	7.80	6.79	144
6.39	6.21	168	7.87	6.83	143
6.44	6.23	167	7.94	6.86	142
6.50	6.25	166	8.01	6.89	141
6.55	6.26	165	8.08	6.93	140
6.60	6.28	164	8.15	6.97	139
6.66	6.30	163	8.22	7.01	138
6.71	6.32	162	8.29	7.05	137
6.77	6.34	161	8.37	7.09	136
6.82	6.37	160	8.44	7.13	135
6.88	6.39	159	8.52	7.17	134
6.94	6.41	158	8.59	7.22	133
6.99	6.43	157	8.67	7.26	132
7.05	6.46	156	8.75	7.31	131
7.11	6.48	155	8.83	7.36	130
7.17	6.50	154	8.91	7.41	129
7.23	6.53	153	8.99	7.46	128
7.29	6.56	152	9.07	7.51	127
7.35	6.58	151	9.16	7.57	126
7.42	6.61	150	9.25	7.63	125
7.48	6.64	149	9.33	7.69	124
7.54	6.67	148	9.42	7.75	123
7.61	6.70	147	9.51	7.81	122
7.67	6.73	146	9.60	7.87	121
9.70	7.94	120	12.79	10.73	95
9.79	8.01	119	12.96	10.91	94
9.89	8.08	118	13.13	11.10	93
9.99	8.16	117	13.31	11.29	92
10.09	8.23	116	13.49	11.50	91
10.19	8.31	115	13.68	11.71	90
10.29	8.40	114	13.88	11.94	89
10.40	8.48	113	14.08	12.17	88
10.51	8.57	112	14.30	12.42	87
10.62	8.66	111	14.51	12.67	86
10.73	8.76	110	14.74	12.94	85

(continued)

Table 8 Diameter-thickness ratios for laying condition Type 2* *(Continued)*

Trench Load (P_v)—*psi*			Trench Load (P_v)—*psi*		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †
10.84	8.86	109	14.97	13.22	84
10.96	8.96	108	15.21	13.52	83
11.08	9.07	107	15.46	13.83	82
11.21	9.18	106	15.72	14.16	81
11.33	9.29	105	15.99	14.50	80
11.46	9.41	104	16.28	14.86	79
11.59	9.54	103	16.57	15.24	78
11.73	9.67	102	16.87	15.64	77
11.87	9.80	101	17.19	16.06	76
12.01	9.94	100	17.52	16.51	75
12.16	10.09	99	17.86	16.98	74
12.31	10.24	98	18.22	17.48	73
12.46	10.40	97	18.59	18.00	72
12.62	10.56	96	18.98	18.56	71
19.39	19.14	70	33.84	44.09	50
19.82	19.77	69	35.08	46.56	49
20.27	20.43	68	36.41	49.26	48
20.73	21.13	67	37.83	52.19	47
21.23	21.87	66	39.34	55.40	46
21.74	22.67	65	40.96	58.89	45
22.28	23.51	64	42.70	62.73	44
22.85	24.41	63	44.57	66.93	43
23.45	25.37	62	46.57	71.56	42
24.07	26.39	61	48.73	76.66	41
24.74	27.49	60	51.06	82.29	40
25.43	28.66	59	53.57	88.54	39
26.17	29.91	58	56.30	95.48	38
26.95	31.26	57	59.25	103.21	37
27.77	32.71	56	62.46	111.85	36
28.64	34.26	55	65.96	121.54	35
29.56	35.93	54	69.79	132.44	34
30.53	37.74	53	73.98	144.74	33
31.57	39.69	52	78.57	158.68	32
32.67	41.80	51	83.64	174.54	31

* E' = 300 psi; K_b = 0.210; K_x = 0.105.

† When the calculated P_v is between two tabulated values, the smaller $\frac{D}{t}$ *or* $\frac{D}{t_1}$ should be used.

NOTE: To convert pounds per square inch (psi) to kilopascals (kPa), multiply by 6.895.

Table 9 Diameter-thickness ratios for laying condition Type 3*

Trench Load (P_v)—*psi*			Trench Load (P_v)—*psi*		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †
3.25	7.26	310	4.45	7.38	260
3.29	7.27	308	4.51	7.38	258
3.33	7.27	306	4.57	7.39	256
3.37	7.27	304	4.63	7.39	254
3.41	7.28	302	4.69	7.40	252
3.45	7.28	300	4.76	7.41	250
3.49	7.28	298	4.82	7.42	248
3.54	7.29	296	4.89	7.42	246
3.58	7.29	294	4.96	7.43	244
3.63	7.30	292	5.03	7.44	242
3.67	7.30	290	5.10	7.45	240
3.72	7.30	288	5.17	7.46	238
3.76	7.31	286	5.24	7.47	236
3.81	7.31	284	5.31	7.48	234
3.86	7.32	282	5.39	7.48	232
3.91	7.32	280	5.47	7.49	230
3.96	7.33	278	5.54	7.51	228
4.01	7.33	276	5.62	7.52	226
4.06	7.34	274	5.70	7.53	224
4.11	7.34	272	5.79	7.54	222
4.17	7.35	270	5.87	7.55	220
4.22	7.35	268	5.96	7.56	218
4.28	7.36	266	6.04	7.58	216
4.33	7.36	264	6.13	7.59	214
4.39	7.37	262	6.22	7.60	212
6.32	7.62	210	8.89	8.16	165
6.41	7.63	208	8.96	8.18	164
6.51	7.65	206	9.03	8.20	163
6.60	7.66	204	9.10	8.22	162
6.70	7.68	202	9.17	8.24	161
6.80	7.70	200	9.25	8.27	160
6.91	7.72	198	9.32	8.29	159
7.01	7.74	196	9.39	8.31	158
7.12	7.76	194	9.47	8.33	157
7.22	7.78	192	9.54	8.36	156

(continued)

Table 9 Diameter-thickness ratios for laying condition Type 3* *(Continued)*

Trench Load (P_v)—*psi*			Trench Load (P_v)—*psi*		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ or $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ or $\frac{D}{t_1}$ †
7.33	7.80	190	9.62	8.38	155
7.45	7.82	188	9.69	8.41	154
7.56	7.84	186	9.77	8.43	153
7.68	7.87	184	9.85	8.46	152
7.80	7.89	182	9.92	8.49	151
7.92	7.92	180	10.00	8.52	150
8.04	7.95	178	10.08	8.54	149
8.16	7.98	176	10.16	8.57	148
8.29	8.01	174	10.24	8.60	147
8.42	8.04	172	10.33	8.64	146
8.55	8.07	170	10.41	8.67	145
8.62	8.09	169	10.49	8.70	144
8.69	8.11	168	10.58	8.73	143
8.75	8.13	167	10.66	8.77	142
8.82	8.14	166	10.75	8.81	141
10.83	8.84	140	13.34	10.25	115
10.92	8.88	139	13.46	10.34	114
11.01	8.92	138	13.58	10.42	113
11.10	8.96	137	13.71	10.51	112
11.19	9.00	136	13.83	10.61	111
11.28	9.04	135	13.96	10.71	110
11.37	9.09	134	14.09	10.81	109
11.46	9.13	133	14.22	10.91	108
11.56	9.18	132	14.36	11.02	107
11.65	9.23	131	14.50	11.13	106
11.75	9.28	130	14.64	11.25	105
11.84	9.33	129	14.78	11.37	104
11.94	9.38	128	14.93	11.50	103
12.04	9.44	127	15.08	11.63	102
12.14	9.49	126	15.23	11.77	101
12.25	9.55	125	15.39	11.91	100
12.35	9.61	124	15.55	12.06	99
12.45	9.67	123	15.71	12.21	98
12.56	9.74	122	15.88	12.37	97
12.67	9.80	121	16.06	12.54	96
12.78	9.87	120	16.23	12.72	95

(continued)

Table 9 Diameter-thickness ratios for laying condition Type 3* *(Continued)*

Trench Load (P_v)—psi			Trench Load (P_v)—psi		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ or $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ or $\frac{D}{t_1}$ †
12.89	9.94	119	16.42	12.90	94
13.00	10.02	118	16.61	13.09	93
13.11	10.09	117	16.80	13.29	92
13.23	10.17	116	17.00	13.50	91
17.21	13.72	90	29.08	29.80	60
17.42	13.95	89	29.83	30.99	59
17.64	14.18	88	30.63	32.27	58
17.86	14.43	87	31.47	33.64	57
18.10	14.70	86	32.36	35.12	56
18.34	14.97	85	33.31	36.70	55
18.59	15.26	84	34.30	38.41	54
18.85	15.56	83	35.37	40.25	53
19.12	15.88	82	36.49	42.24	52
19.40	16.21	81	37.69	44.39	51
19.68	16.56	80	38.97	46.72	50
19.99	16.93	79	40.33	49.25	49
20.30	17.31	78	41.78	51.99	48
20.62	17.72	77	43.33	54.98	47
20.96	18.15	76	44.98	58.25	46
21.31	18.61	75	46.76	61.81	45
21.68	19.09	74	48.66	65.72	44
22.07	19.59	73	50.71	70.01	43
22.47	20.13	72	52.91	74.72	42
22.88	20.69	71	55.28	79.92	41
23.32	21.29	70	57.84	85.67	40
23.78	21.93	69	60.61	92.04	39
24.26	22.60	68	63.61	99.11	38
24.76	23.32	67	66.86	106.99	37
25.29	24.08	66	70.40	115.80	36
25.85	24.88	65	74.27	125.67	35
26.43	25.74	64	78.49	136.78	34
27.04	26.66	63	83.11	149.32	33
27.68	27.64	62	88.19	163.54	32
28.36	28.68	61	93.79	174.71	31

* E' = 400 psi; K_b = 0.189; K_x = 0.103.

† When the calculated P_v is between two tabulated values, the smaller $\frac{D}{t}$ or $\frac{D}{t_1}$ should be used.

NOTE: To convert pounds per square inch (psi) to kilopascals (kPa), multiply by 6.895.

Table 10 Diameter-thickness ratios for laying condition Type 4*

Trench Load (P_v)—psi			Trench Load (P_v)—psi		
Bending-Stress Design	Deflection Check	$\frac{D}{t}$ or $\frac{D}{t_1}$ †	Bending-Stress Design	Deflection Check	$\frac{D}{t}$ or $\frac{D}{t_1}$ †
5.93	9.70	310	8.00	9.82	260
6.00	9.70	308	8.10	9.83	258
6.07	9.71	306	8.20	9.83	256
6.14	9.71	304	8.31	9.84	254
6.21	9.71	302	8.41	9.85	252
6.29	9.72	300	8.52	9.86	250
6.36	9.72	298	8.63	9.86	248
6.43	9.73	296	8.74	9.87	246
6.51	9.73	294	8.85	9.88	244
6.59	9.73	292	8.97	9.89	242
6.67	9.74	290	9.08	9.90	240
6.74	9.74	288	9.20	9.91	238
6.83	9.75	286	9.32	9.92	236
6.91	9.75	284	9.44	9.93	234
6.99	9.76	282	9.57	9.94	232
7.08	9.76	280	9.69	9.95	230
7.16	9.77	278	9.82	9.96	228
7.25	9.77	276	9.95	9.97	226
7.34	9.78	274	10.08	9.98	224
7.43	9.78	272	10.21	9.99	222
7.52	9.79	270	10.35	10.01	220
7.61	9.79	268	10.49	10.02	218
7.71	9.80	266	10.62	10.03	216
7.80	9.81	264	10.77	10.05	214
7.90	9.81	262	10.91	10.06	212
11.05	10.08	210	14.86	10.66	165
11.20	10.09	208	14.96	10.69	164
11.35	10.11	206	15.05	10.71	163
11.50	10.13	204	15.15	10.73	162
11.66	10.15	202	15.25	10.75	161
11.81	10.17	200	15.34	10.78	160
11.97	10.19	198	15.44	10.80	159
12.13	10.21	196	15.54	10.82	158
12.29	10.23	194	15.64	10.85	157
12.45	10.25	192	15.74	10.87	156
12.62	10.27	190	15.84	10.90	155
12.79	10.30	188	15.94	10.93	154

(continued)

Table 10 Diameter-thickness ratios for laying condition Type 4* *(Continued)*

Trench Load (P_v)—*psi*			Trench Load (P_v)—*psi*		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †
12.96	10.32	186	16.04	10.96	153
13.13	10.35	184	16.14	10.98	152
13.30	10.37	182	16.24	11.01	151
13.48	10.40	180	16.34	11.04	150
13.66	10.43	178	16.45	11.07	149
13.84	10.46	176	16.55	11.11	148
14.02	10.50	174	16.65	11.14	147
14.20	10.53	172	16.76	11.17	146
14.39	10.57	170	16.86	11.21	145
14.48	10.59	169	16.96	11.24	144
14.57	10.60	168	17.07	11.28	143
14.67	10.62	167	17.18	11.31	142
14.76	10.64	166	17.28	11.35	141
17.39	11.39	140	20.29	12.91	115
17.50	11.43	139	20.42	13.00	114
17.60	11.48	138	20.55	13.09	113
17.71	11.52	137	20.69	13.19	112
17.82	11.56	136	20.82	13.29	111
17.93	11.61	135	20.96	13.39	110
18.04	11.66	134	21.10	13.50	109
18.15	11.71	133	21.24	13.61	108
18.26	11.76	132	21.39	13.73	107
18.37	11.81	131	21.54	13.85	106
18.49	11.86	130	21.69	13.98	105
18.60	11.92	129	21.84	14.11	104
18.72	11.97	128	22.00	14.24	103
18.83	12.03	127	22.16	14.38	102
18.95	12.09	126	22.32	14.53	101
19.06	12.15	125	22.49	14.68	100
19.18	12.22	124	22.66	14.84	99
19.30	12.28	123	22.83	15.01	98
19. 42	12.35	122	23.01	15.18	97
19.54	12.42	121	23.20	15.36	96
19.66	12.50	120	23.38	15.55	95
19.78	12.57	119	23.58	15.75	94
19.91	12.65	118	23.78	15.95	93

(continued)

Table 10 Diameter-thickness ratios for laying condition Type 4* *(Continued)*

Trench Load (P_v)—*psi*			Trench Load (P_v)—*psi*		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ or $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ or $\frac{D}{t_1}$ †
20.04	12.73	117	23.99	16.17	92
20.16	12.82	116	24.20	16.39	91
24.42	16.62	90	37.63	33.88	60
24.64	16.87	89	38.50	35.16	59
24.88	17.12	88	39.42	36.53	58
25.12	17.39	87	40.39	38.00	57
25.37	17.67	86	41.42	39.58	56
25.63	17.97	85	42.51	41.28	55
25.90	18.28	84	43.67	43.12	54
26.18	18.60	83	44.91	45.09	53
26.47	18.94	82	46.22	47.22	52
26.77	19.30	81	47.62	49.53	51
27.09	19.67	80	49.11	52.03	50
27.42	20.07	79	50.70	54.74	49
27.76	20.48	78	52.41	57.69	48
28.11	20.92	77	54.23	60.90	47
28.49	21.38	76	56.18	64.40	46
28.87	21.87	75	58.27	68.23	45
29.28	22.38	74	60.52	72.42	44
29.70	22.93	73	62.93	77.02	43
30.15	23.50	72	65.54	82.08	42
30.62	24.11	71	68.35	87.66	41
31.11	24.75	70	71.39	93.82	40
31.62	25.43	69	74.67	100.65	39
32.16	26.16	68	78.24	108.24	38
32.72	26.92	67	82.11	116.70	37
33.32	27.74	66	86.33	126.15	36
33.95	28.60	65	90.93	136.74	35
34.61	29.53	64	95.97	148.66	34
35.30	30.51	63	101.49	162.12	33
36.04	31.56	62	107.56	177.37	32
36.81	32.68	61	114.25	194.72	31

* E' = 500 psi; K_b = 0.157; K_x = 0.096.

† When the calculated P_v is between two tabulated values, the smaller $\frac{D}{t}$ or $\frac{D}{t_1}$ should be used.

Note: To convert pounds per square inch (psi) to kilopascals (kPa), multiply by 6.895

Table 11 Diameter-thickness ratios for laying condition Type 5*

Trench Load (P_v)—*psi*			Trench Load (P_v)—*psi*		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †
3.06	15.09	660	4.60	15.11	535
3.10	15.09	655	4.69	15.11	530
3.15	15.09	650	4.77	15.11	525
3.20	15.09	645	4.86	15.11	520
3.25	15.09	640	4.95	15.11	515
3.30	15.09	635	5.05	15.11	510
3.35	15.09	630	5.14	15.11	505
3.40	15.09	625	5.24	15.12	500
3.46	15.09	620	5.35	15.12	495
3.51	15.09	615	5.45	15.12	490
3.57	15.10	610	5.56	15.12	485
3.63	15.10	605	5.67	15.12	480
3.68	15.10	600	5.78	15.12	475
3.75	15.10	595	5.90	15.13	470
3.81	15.10	590	6.02	15.13	465
3.87	15.10	585	6.15	15.13	460
3.94	15.10	580	6.28	15.13	455
4.00	15.10	575	6.41	15.13	450
4.07	15.10	570	6.54	15.14	445
4.14	15.10	565	6.68	15.14	440
4.21	15.10	560	6.83	15.14	435
4.29	15.10	555	6.98	15.14	430
4.36	15.10	550	7.13	15.14	425
4.44	15.11	545	7.29	15.15	420
4.52	15.11	540	7.46	15.15	415
7.63	15.15	410	13.23	15.28	300
7.80	15.16	405	13.37	15.29	298
7.98	15.16	400	13.52	15.29	296
8.17	15.16	395	13.67	15.30	294
8.36	15.17	390	13.83	15.30	292
8.56	15.17	385	13.98	15.30	290
8.77	15.17	380	14.14	15.31	288
8.98	15.18	375	14.30	15.31	286
9.20	15.18	370	14.46	15.32	284
9.43	15.19	365	14.62	15.33	282
9.66	15.19	360	14.79	15.33	280

(continued)

Table 11 Diameter-thickness ratios for laying condition Type 5* *(Continued)*

Trench Load (P_v)—psi			Trench Load (P_v)—psi		
Bending-Stress Design	Deflection Check	$\frac{D}{t}$ or $\frac{D}{t_1}$ †	Bending-Stress Design	Deflection Check	$\frac{D}{t}$ or $\frac{D}{t_1}$ †
9.91	15.20	355	14.96	15.34	278
10.16	15.20	350	15.13	15.34	276
10.42	15.21	345	15.30	15.35	274
10.69	15.22	340	15.48	15.35	272
10.97	15.22	335	15.65	15.36	270
11.26	15.23	330	15.83	15.37	268
11.56	15.24	325	16.02	15.37	266
11.87	15.24	320	16.20	15.38	264
12.19	15.25	315	16.39	15.39	262
12.52	15.26	310	16.58	15.40	260
12.66	15.27	308	16.77	15.40	258
12.80	15.27	306	16.97	15.41	256
12.94	15.27	304	17.16	15.42	254
13.08	15.28	302	17.36	15.43	252
17.57	15.44	250	23.44	15.79	200
17.77	15.45	248	23.70	15.81	198
17.98	15.45	246	23.97	15.83	196
18.19	15.46	244	24.24	15.86	194
18.40	15.47	242	24.50	15.88	192
18.62	15.48	240	24.77	15.91	190
18.84	15.49	238	25.04	15.93	188
19.06	15.51	236	25.31	15.96	186
19.28	15.52	234	25.59	15.99	184
19.51	15.53	232	25.86	16.02	182
19.73	15.54	230	26.13	16.06	180
19.97	15.55	228	26.41	16.09	178
20.20	15.57	226	26.68	16.12	176
20.43	15.58	224	26.96	16.16	174
20.67	15.59	222	27.23	16.20	172
20.91	15.61	220	27.51	16.24	170
21.16	15.62	218	27.65	16.26	169
21.40	15.64	216	27.78	16.28	168
21.65	15.65	214	27.92	16.31	167
21.90	15.67	212	28.06	16.33	166
22.15	15.69	210	28.19	16.35	165
22.40	15.71	208	28.33	16.37	164

(continued)

Table 11 Diameter-thickness ratios for laying condition Type 5* *(Continued)*

Trench Load (P_v)—psi			Trench Load (P_v)—psi		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ or $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ or $\frac{D}{t_1}$ †
22.66	15.73	206	28.47	16.40	163
22.92	15.75	204	28.60	16.42	162
23.18	15.77	202	28.74	16.45	161
28.87	16.48	160	32.13	17.42	135
29.01	16.50	159	32.25	17.47	134
29.15	16.53	158	32.38	17.53	133
29.28	16.56	157	32.50	17.58	132
29.41	16.59	156	32.62	17.64	131
29.55	16.62	155	32.75	17.70	130
29.68	16.65	154	32.87	17.76	129
29.82	16.68	153	32.99	17.83	128
29.95	16.71	152	33.11	17.89	127
30.08	16.74	151	33.23	17.96	126
30.21	16.78	150	33.35	18.03	125
30.34	16.81	149	33.47	18.11	124
30.48	16.85	148	33.59	18.18	123
30.61	16.89	147	33.71	18.26	122
30.74	16.92	146	33.83	18.34	121
30.87	16.96	145	33.95	18.42	120
30.99	17.00	144	34.07	18.51	119
31.12	17.04	143	34.19	18.60	118
31.25	17.09	142	34.31	18.69	117
31.38	17.13	141	34.43	18.78	116
31.50	17.17	140	34.55	18.88	115
31.63	17.22	139	34.68	18.98	114
31.76	17.27	138	34.80	19.09	113
31.88	17.32	137	34.92	19.20	112
32.01	17.37	136	35.05	19.31	111
35.17	19.43	110	39.41	24.60	85
35.30	19.55	109	39.67	24.95	84
35.43	19.68	108	39.94	25.31	83
35.56	19.81	107	40.22	25.70	82
35.69	19.95	106	40.51	26.10	81
35.83	20.09	105	40.82	26.52	80
35.96	20.24	104	41.14	26.97	79
36.10	20.39	103	41.48	27.44	78

(continued)

Table 11 Diameter-thickness ratios for laying condition Type 5* *(Continued)*

Trench Load (P_v)—*psi*			Trench Load (P_v)—*psi*		
Bending-Stress Design	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †	**Bending-Stress Design**	**Deflection Check**	$\frac{D}{t}$ *or* $\frac{D}{t_1}$ †
36.25	20.55	102	41.84	27.93	77
36.39	20.72	101	42.21	28.46	76
36.54	20.89	100	42.60	29.01	75
36.69	21.07	99	43.02	29.59	74
36.85	21.26	98	43.45	30.20	73
37.01	21.45	97	43.92	30.85	72
37.17	21.66	96	44.40	31.53	71
37.34	21.87	95	44.91	32.26	70
37.52	22.09	94	45.46	33.03	69
37.70	22.32	93	46.03	33.85	68
37.89	22.56	92	46.64	34.71	67
38.08	22.82	91	47.28	35.63	66
38.28	23.08	90	47.96	36.61	65
38.49	23.36	89	48.68	37.65	64
38.71	23.65	88	49.44	38.77	63
38.93	23.95	87	50.25	39.95	62
39.17	24.27	86	51.11	41.21	61
52.02	42.57	60	75.88	81.36	45
52.99	44.01	59	78.54	86.10	44
54.02	45.56	58	81.40	91.29	43
55.12	47.23	57	84.50	97.01	42
56.28	49.01	56	87.85	103.31	41
57.53	50.93	55	91.47	110.27	40
58.86	53.00	54	95.40	117.98	39
60.28	55.23	53	99.67	126.56	38
61.79	57.64	52	104.32	136.11	37
63.41	60.25	51	109.40	146.78	36
65.14	63.07	50	114.94	158.75	35
67.00	66.13	49	121.02	172.21	34
68.99	69.46	48	127.69	187.41	33
71.12	73.09	47	135.03	204.63	32
73.41	77.04	46	143.14	224.22	31

* E' = 700 psi; K_b = 0.128; K_x = 0.085.

† When the calculated P_v is between two tabulated values, the smaller $\frac{D}{t}$ *or* $\frac{D}{t_1}$ should be used.

NOTE: To convert pounds per square inch (psi) to kilopascals (kPa), multiply by 6.895.

Table 12 Thickness for trench load (earth load plus truck load)

		Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
Size *in.*	Depth of Cover* *ft*	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class
3	2.5	0.18	350	0.17	350	0.17	350	0.16	350	0.15	350
	3	0.18	350	0.17	350	0.16	350	0.15	350	0.15	350
	4	0.17	350	0.16	350	0.16	350	0.15	350	0.14	350
	5	0.17	350	0.16	350	0.16	350	0.15	350	0.14	350
	6	0.17	350	0.16	350	0.16	350	0.15	350	0.14	350
	7	0.17	350	0.16	350	0.16	350	0.15	350	0.14	350
	8	0.17	350	0.16	350	0.16	350	0.15	350	0.14	350
	9	0.17	350	0.16	350	0.16	350	0.15	350	0.15	350
	10	0.18	350	0.17	350	0.16	350	0.15	350	0.15	350
	12	0.18	350	0.17	350	0.16	350	0.15	350	0.15	350
	14	0.18	350	0.17	350	0.17	350	0.16	350	0.15	350
	16	0.19	350	0.18	350	0.17	350	0.16	350	0.15	350
	20	0.19	350	0.19	350	0.18	350	0.16	350	0.15	350
	24	0.20	350	0.19	350	0.19	350	0.17	350	0.15	350
	28	0.21	350	0.20	350	0.19	350	0.18	350	0.15	350
	32	0.21	350	0.20	350	0.20	350	0.18	350	0.16	350
4	2.5	0.19	350	0.18	350	0.17	350	0.16	350	0.15	350
	3	0.19	350	0.18	350	0.17	350	0.16	350	0.15	350
	4	0.18	350	0.17	350	0.16	350	0.15	350	0.15	350
	5	0.18	350	0.17	350	0.16	350	0.15	350	0.15	350
	6	0.18	350	0.17	350	0.16	350	0.15	350	0.15	350
	7	0.18	350	0.17	350	0.16	350	0.15	350	0.15	350
	8	0.18	350	0.17	350	0.16	350	0.15	350	0.15	350
	9	0.18	350	0.17	350	0.16	350	0.15	350	0.15	350
	10	0.18	350	0.17	350	0.16	350	0.16	350	0.15	350
	12	0.19	350	0.18	350	0.17	350	0.16	350	0.15	350
	14	0.19	350	0.18	350	0.17	350	0.16	350	0.15	350
	16	0.20	350	0.19	350	0.18	350	0.16	350	0.15	350
	20	0.21	350	0.20	350	0.19	350	0.17	350	0.15	350
	24	0.21	350	0.21	350	0.20	350	0.18	350	0.16	350
	28	0.22	350	0.21	350	0.20	350	0.19	350	0.16	350
	32	0.23	350	0.22	350	0.21	350	0.19	350	0.16	350
6	2.5	0.22	350	0.20	350	0.19	350	0.17	350	0.16	350
	3	0.21	350	0.19	350	0.18	350	0.17	350	0.15	350
	4	0.20	350	0.18	350	0.17	350	0.16	350	0.15	350
	5	0.19	350	0.18	350	0.17	350	0.16	350	0.15	350
	6	0.19	350	0.18	350	0.17	350	0.16	350	0.15	350
	7	0.20	350	0.18	350	0.17	350	0.16	350	0.15	350
	8	0.20	350	0.18	350	0.17	350	0.16	350	0.15	350
	9	0.20	350	0.19	350	0.18	350	0.16	350	0.15	350

(continued)

Table 12 Thickness for trench load (earth load plus truck load) *(Continued)*

		Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
Size *in.*	Depth of Cover* *ft*	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class
	10	0.21	350	0.19	350	0.18	350	0.16	350	0.15	350
	12	0.21	350	0.20	350	0.18	350	0.17	350	0.16	350
	14	0.22	350	0.20	350	0.19	350	0.17	350	0.16	350
	16	0.23	350	0.21	350	0.20	350	0.17	350	0.16	350
	20	0.24	350	0.22	350	0.21	350	0.18	350	0.16	350
	24	0.25	350	0.24	350	0.22	350	0.19	350	0.17	350
	28	—	—	0.25	350	0.23	350	0.21	350	0.17	350
	32	—	—	—	—	0.24	350	0.22	350	0.17	350
8	2.5	0.24	350	0.22	350	0.21	350	0.18	350	0.16	350
	3	0.23	350	0.21	350	0.19	350	0.17	350	0.16	350
	4	0.22	350	0.20	350	0.18	350	0.17	350	0.16	350
	5	0.21	350	0.19	350	0.18	350	0.17	350	0.16	350
	6	0.21	350	0.19	350	0.18	350	0.17	350	0.16	350
	7	0.21	350	0.20	350	0.18	350	0.17	350	0.16	350
	8	0.22	350	0.20	350	0.19	350	0.17	350	0.16	350
	9	0.22	350	0.20	350	0.19	350	0.17	350	0.16	350
	10	0.23	350	0.21	350	0.19	350	0.17	350	0.16	350
	12	0.24	350	0.22	350	0.20	350	0.18	350	0.16	350
	14	0.25	350	0.23	350	0.21	350	0.18	350	0.17	350
	16	0.25	350	0.24	350	0.22	350	0.19	350	0.17	350
	20	—	—	0.25	350	0.23	350	0.20	350	0.17	350
	24	—	—	—	—	0.25	350	0.21	350	0.17	350
	28	—	—	—	—	—	—	0.23	350	0.18	350
	32	—	—	—	—	—	—	0.25	350	0.19	350
10	2.5	—	—	0.25	350	0.23	350	0.20	350	0.18	350
	3	0.26	350	0.24	350	0.22	350	0.19	350	0.18	350
	4	0.25	350	0.22	350	0.21	350	0.19	350	0.17	350
	5	0.24	350	0.22	350	0.20	350	0.18	350	0.17	350
	6	0.24	350	0.22	350	0.20	350	0.18	350	0.17	350
	7	0.24	350	0.22	350	0.20	350	0.19	350	0.17	350
	8	0.25	350	0.22	350	0.21	350	0.19	350	0.17	350
	9	0.25	350	0.23	350	0.21	350	0.19	350	0.17	350
	10	0.26	350	0.23	350	0.21	350	0.19	350	0.17	350
	12	—	—	0.24	350	0.22	350	0.20	350	0.18	350
	14	—	—	0.26	350	0.23	350	0.20	350	0.18	350
	16	—	—	—	—	0.24	350	0.21	350	0.18	350
	20	—	—	—	—	—	—	0.22	350	0.19	350
	24	—	—	—	—	—	—	0.24	350	0.19	350
	28	—	—	—	—	—	—	0.26	350	0.20	350
	32	—	—	—	—	—	—	—	—	0.21	350

(continued)

Table 12 Thickness for trench load (earth load plus truck load) *(Continued)*

		Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
Size *in.*	Depth of Cover* *ft*	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class
12	2.5	—	—	0.27	350	0.25	350	0.21	350	0.19	350
	3	0.28	350	0.25	350	0.23	350	0.20	350	0.18	350
	4	0.26	350	0.24	350	0.22	350	0.19	350	0.18	350
	5	0.26	350	0.23	350	0.21	350	0.19	350	0.18	350
	6	0.26	350	0.23	350	0.21	350	0.19	350	0.18	350
	7	0.26	350	0.23	350	0.21	350	0.19	350	0.18	350
	8	0.27	350	0.24	350	0.22	350	0.20	350	0.18	350
	9	0.27	350	0.24	350	0.22	350	0.20	350	0.18	350
	10	0.28	350	0.25	350	0.23	350	0.20	350	0.18	350
	12	—	—	0.26	350	0.24	350	0.21	350	0.18	350
	14	—	—	0.28	350	0.25	350	0.21	350	0.19	350
	16	—	—	—	—	0.26	350	0.22	350	0.19	350
	20	—	—	—	—	—	—	0.24	350	0.20	350
	24	—	—	—	—	—	—	0.26	350	0.20	350
	28	—	—	—	—	—	—	0.28	350	0.21	350
	32	—	—	—	—	—	—	—	—	0.23	350
14	2.5	‡	‡	0.29	300	0.26	250	0.23	250	0.20	250
	3			0.28	250	0.25	250	0.22	250	0.20	250
	4			0.26	250	0.24	250	0.21	250	0.19	250
	5			0.25	250	0.23	250	0.21	250	0.19	250
	6			0.25	250	0.23	250	0.21	250	0.19	250
	7			0.26	250	0.24	250	0.21	250	0.19	250
	8			0.26	250	0.24	250	0.21	250	0.19	250
	9			0.27	250	0.24	250	0.22	250	0.19	250
	10			0.28	250	0.25	250	0.22	250	0.20	250
	12			0.29	300	0.26	250	0.23	250	0.20	250
	14			0.31	350	0.28	250	0.23	250	0.20	250
	16			—	—	0.29	300	0.24	250	0.21	250
	20			—	—	—	—	0.26	250	0.21	250
	24			—	—	—	—	0.29	300	0.22	250
	28			—	—	—	—	—	—	0.25	250
	32			—	—	—	—	—	—	0.27	250
16	2.5	‡	‡	0.31	300	0.27	250	0.23	250	0.21	250
	3			0.29	250	0.26	250	0.23	250	0.20	250
	4			0.27	250	0.25	250	0.22	250	0.20	250
	5			0.27	250	0.24	250	0.22	250	0.20	250
	6			0.27	250	0.24	250	0.22	250	0.20	250
	7			0.27	250	0.25	250	0.22	250	0.20	250
	8			0.28	250	0.25	250	0.22	250	0.20	250
	9			0.28	250	0.26	250	0.22	250	0.20	250

(continued)

Table 12 Thickness for trench load (earth load plus truck load) *(Continued)*

		Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
Size *in.*	Depth of Cover* *ft*	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class
	10			0.29	250	0.26	250	0.23	250	0.20	250
	12			0.31	300	0.28	250	0.24	250	0.21	250
	14			0.33	350	0.29	250	0.24	250	0.21	250
	16			—	—	0.31	300	0.25	250	0.21	250
	20			—	—	0.34	350	0.28	250	0.22	250
	24			—	—	—	—	0.30	250	0.24	250
	28			—	—	—	—	0.34	350	0.27	250
	32			—	—	—	—	—	—	0.29	250
18	2.5	‡	‡	0.32	300	0.28	250	0.24	250	0.21	250
	3			0.30	250	0.27	250	0.23	250	0.21	250
	4			0.28	250	0.26	250	0.23	250	0.20	250
	5			0.28	250	0.25	250	0.22	250	0.20	250
	6			0.28	250	0.25	250	0.22	250	0.20	250
	7			0.28	250	0.26	250	0.23	250	0.20	250
	8			0.29	250	0.26	250	0.23	250	0.20	250
	9			0.30	250	0.27	250	0.23	250	0.21	250
	10			0.31	250	0.28	250	0.24	250	0.21	250
	12			0.33	300	0.29	250	0.24	250	0.21	250
	14			0.35	350	0.31	250	0.25	250	0.22	250
	16			—	—	0.33	300	0.26	250	0.22	250
	20			—	—	—	—	0.29	250	0.23	250
	24			—	—	—	—	0.32	300	0.26	250
	28			—	—	—	—	0.36	350	0.29	250
	32			—	—	—	—	—	—	0.32	300
20	2.5	‡	‡	0.33	250	0.29	250	0.25	250	0.21	250
	3			0.31	250	0.28	250	0.24	250	0.21	250
	4			0.30	250	0.27	250	0.23	250	0.21	250
	5			0.29	250	0.26	250	0.23	250	0.20	250
	6			0.29	250	0.26	250	0.23	250	0.20	250
	7			0.30	250	0.27	250	0.23	250	0.21	250
	8			0.30	250	0.27	250	0.24	250	0.21	250
	9			0.31	250	0.28	250	0.24	250	0.21	250
	10			0.32	250	0.29	250	0.24	250	0.21	250
	12			0.35	300	0.31	250	0.25	250	0.22	250
	14			0.37	350	0.33	250	0.26	250	0.22	250
	16			—	—	0.35	300	0.28	250	0.23	250
	20			—	—	—	—	0.32	250	0.24	250
	24			—	—	—	—	0.35	300	0.28	250
	28			—	—	—	—	0.38	350	0.32	250
	32			—	—	—	—	—	—	0.35	300

(continued)

Table 12 Thickness for trench load (earth load plus truck load) *(Continued)*

		Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
Size *in.*	Depth of Cover* *ft*	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class
24	2.5	‡	‡	0.36	250	0.32	200	0.26	200	0.22	200
	3			0.33	200	0.30	200	0.25	200	0.22	200
	4			0.32	200	0.29	200	0.25	200	0.21	200
	5			0.31	200	0.28	200	0.24	200	0.21	200
	6			0.31	200	0.28	200	0.24	200	0.21	200
	7			0.32	200	0.29	200	0.25	200	0.22	200
	8			0.33	200	0.30	200	0.25	200	0.22	200
	9			0.35	250	0.30	200	0.26	200	0.22	200
	10			0.36	250	0.31	200	0.26	200	0.22	200
	12			0.39	300	0.33	200	0.27	200	0.23	200
	14			0.41	350	0.36	250	0.29	200	0.24	200
	16			—	—	0.38	300	0.31	200	0.24	200
	20			—	—	—	—	0.36	250	0.26	200
	24			—	—	—	—	0.40	300	0.32	200
	28			—	—	—	—	0.43	350	0.37	250
	32			—	—	—	—	—	—	0.40	300
30	2.5	‡	‡	0.40	250	0.34	150	0.29	150	0.24	150
	3			0.37	200	0.33	150	0.28	150	0.23	150
	4			0.36	200	0.32	150	0.27	150	0.23	150
	5			0.35	200	0.31	150	0.26	150	0.23	150
	6			0.35	200	0.31	150	0.27	150	0.23	150
	7			0.36	200	0.32	150	0.27	150	0.23	150
	8			0.37	200	0.33	150	0.27	150	0.23	150
	9			0.39	250	0.34	150	0.28	150	0.24	150
	10			0.41	250	0.35	200	0.29	150	0.24	150
	12			0.44	300	0.38	200	0.30	150	0.25	150
	14			0.48	350	0.41	250	0.33	150	0.26	150
	16			—	—	0.44	300	0.37	200	0.26	150
	20			—	—	—	—	0.43	300	0.29	150
	24			—	—	—	—	0.48	350	0.38	200
	28			—	—	—	—	—	—	0.44	300
	32			—	—	—	—	—	—	0.48	350
36	2.5	‡	‡	0.43	250	0.37	150	0.31	150	0.25	150
	3			0.41	200	0.36	150	0.30	150	0.25	150
	4			0.39	200	0.34	150	0.29	150	0.24	150
	5			0.39	200	0.34	150	0.29	150	0.24	150
	6			0.39	200	0.34	150	0.29	150	0.24	150
	7			0.40	200	0.35	150	0.29	150	0.24	150
	8			0.42	200	0.36	150	0.30	150	0.25	150
	9			0.44	250	0.38	150	0.31	150	0.25	150

(continued)

Table 12 Thickness for trench load (earth load plus truck load) *(Continued)*

		Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
Size *in.*	Depth of Cover* *ft*	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class
	10			0.46	250	0.39	200	0.31	150	0.26	150
	12			0.50	300	0.42	200	0.33	150	0.27	150
	14			0.54	350	0.46	250	0.38	150	0.28	150
	16			—	—	0.50	300	0.43	250	0.29	150
	20			—	—	—	—	0.51	300	0.33	150
	24			—	—	—	—	0.56	350	0.44	250
	28			—	—	—	—	—	—	0.51	300
	32			—	—	—	—	—	—	0.56	350
42	2.5	‡	‡	0.47	200	0.40	150	0.32	150	0.27	150
	3			0.44	200	0.38	150	0.31	150	0.26	150
	4			0.42	200	0.37	150	0.30	150	0.25	150
	5			0.43	200	0.37	150	0.31	150	0.26	150
	6			0.43	200	0.37	150	0.31	150	0.26	150
	7			0.44	200	0.38	150	0.31	150	0.26	150
	8			0.46	200	0.40	150	0.32	150	0.26	150
	9			0.48	250	0.41	150	0.33	150	0.27	150
	10			0.50	250	0.43	200	0.34	150	0.27	150
	12			0.55	300	0.47	200	0.36	150	0.28	150
	14			0.60	350	0.52	250	0.43	200	0.30	150
	16			—	—	0.57	300	0.49	250	0.31	150
	20			—	—	—	—	0.57	300	0.38	150
	24			—	—	—	—	—	—	0.50	250
	28			—	—	—	—	—	—	0.58	350
	32			—	—	—	—	—	—	0.63	350
48	2.5	‡	‡	0.50	200	0.44	150	0.35	150	0.29	150
	3			0.48	200	0.42	150	0.34	150	0.28	150
	4			0.46	150	0.41	150	0.33	150	0.28	150
	5			0.47	200	0.41	150	0.34	150	0.28	150
	6			0.48	200	0.41	150	0.34	150	0.28	150
	7			0.49	200	0.43	150	0.35	150	0.28	150
	8			0.51	200	0.44	150	0.35	150	0.29	150
	9			0.54	250	0.46	150	0.37	150	0.29	150
	10			0.56	250	0.48	200	0.38	150	0.30	150
	12			0.62	300	0.54	250	0.40	150	0.31	150
	14			0.67	350	0.60	300	0.49	200	0.33	150
	16			—	—	0.65	350	0.56	250	0.34	150
	20			—	—	—	—	0.66	350	0.43	150
	24			—	—	—	—	—	—	0.57	250
	28			—	—	—	—	—	—	0.66	350
54	2.5	‡	‡	0.54	200	0.47	150	0.38	150	0.31	150
	3			0.53	200	0.46	150	0.37	150	0.30	150

(continued)

Table 12 Thickness for trench load (earth load plus truck load) *(Continued)*

		Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
Size *in.*	Depth of Cover* *ft*	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class
	4			0.51	150	0.44	150	0.36	150	0.30	150
	5			0.52	200	0.45	150	0.37	150	0.30	150
	6			0.53	200	0.46	150	0.37	150	0.30	150
	7			0.54	200	0.47	150	0.38	150	0.31	150
	8			0.57	200	0.49	150	0.39	150	0.32	150
	9			0.60	250	0.51	150	0.40	150	0.32	150
	10			0.63	250	0.53	200	0.41	150	0.33	150
	12			0.69	300	0.61	250	0.44	150	0.34	150
	14			0.75	350	0.68	300	0.55	200	0.36	150
	16			—	—	0.73	350	0.63	250	0.37	150
	20			—	—	—	—	0.74	350	0.48	150
	24			—	—	—	—	—	—	0.64	250
	28			—	—	—	—	—	—	0.74	350
60	2.5	‡	‡	0.56	200	0.48	150	0.39	150	0.32	150
	3			0.54	150	0.47	150	0.38	150	0.31	150
	4			0.53	150	0.46	150	0.38	150	0.31	150
	5			0.54	150	0.47	150	0.38	150	0.31	150
	6			0.55	200	0.48	150	0.39	150	0.31	150
	7			0.57	200	0.49	150	0.39	150	0.32	150
	8			0.59	200	0.51	150	0.40	150	0.33	150
	9			0.63	250	0.53	150	0.42	150	0.33	150
	10			0.67	250	0.55	200	0.43	150	0.34	150
	12			0.74	300	0.65	250	0.46	150	0.35	150
	14			0.79	350	0.72	300	0.58	200	0.37	150
	16			—	—	0.78	350	0.67	250	0.38	150
	20			—	—	—	—	0.79	350	0.51	150
	24			—	—	—	—	—	—	0.68	250
	28			—	—	—	—	—	—	0.79	350
64	2.5	‡	‡	0.58	200	0.50	150	0.40	150	0.32	150
	3			0.56	150	0.49	150	0.39	150	0.32	150
	4			0.55	150	0.48	150	0.39	150	0.32	150
	5			0.56	150	0.48	150	0.39	150	0.32	150
	6			0.57	200	0.49	150	0.40	150	0.32	150
	7			0.59	200	0.51	150	0.41	150	0.33	150
	8			0.62	200	0.53	150	0.42	150	0.33	150
	9			0.67	250	0.55	150	0.43	150	0.34	150
	10			0.70	250	0.58	200	0.45	150	0.35	150
	12			0.78	300	0.68	250	0.48	150	0.37	150
	14			0.84	350	0.76	300	0.61	200	0.38	150
	16			—	—	0.82	350	0.70	250	0.40	150
	20			—	—	—	—	0.83	350	0.54	150

(continued)

Table 12 Thickness for trench load (earth load plus truck load) *(Continued)*

		Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
Size *in.*	Depth of Cover* *ft*	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class	Total Calculated Thickness,† *in.*	Use Pressure Class
	24			—	—	—	—	—	—	0.72	250
	28			—	—	—	—	—	—	0.83	350

* Pipe may be available for depths of cover greater than those shown in the table.
† Total calculated thickness includes service allowance and casting allowance added to net thickness.
‡ For pipe 14 in. (350 mm) and larger, consideration should be given to laying conditions other than Type 1.
Note: To convert inches (in.) to millimeters (mm), multiply by 25.4; to convert feet (ft) to meters (m), multiply by 0.3048.

Table 13 Thickness for internal pressure

	Rated Water Working Pressure—*psi*									
	150		200		250		300		350	
Size *in.*	Total Calculated Thickness,* *in.*	Use Pressure Class	Total Calculated Thickness,* *in.*	Use Pressure Class	Total Calculated Thickness,* *in.*	Use Pressure Class	Total Calculated Thickness,* *in.*	Use Pressure Class	Total Calculated Thickness,* *in.*	Use Pressure Class
3	0.15	350	0.16	350	0.16	350	0.17	350	0.17	350
4	0.16	350	0.16	350	0.17	350	0.18	350	0.18	350
6	0.17	350	0.18	350	0.19	350	0.20	350	0.20	350
8	0.18	350	0.19	350	0.21	350	0.22	350	0.23	350
10	0.21	350	0.22	350	0.23	350	0.25	350	0.26	350
12	0.22	350	0.23	350	0.25	350	0.27	350	0.28	350
14	0.24	250	0.26	250	0.28	250	0.30	300	0.31	350
16	0.25	250	0.27	250	0.30	250	0.32	300	0.34	350
18	0.27	250	0.29	250	0.31	250	0.34	300	0.36	350
20	0.28	250	0.30	250	0.33	250	0.36	300	0.38	350
24	0.30	200	0.33	200	0.37	250	0.40	300	0.43	350
30	0.34	150	0.38	200	0.42	250	0.45	300	0.49	350
36	0.38	150	0.42	200	0.47	250	0.51	300	0.56	350
42	0.41	200	0.47	200	0.52	250	0.57	300	0.63	350
48	0.46	150	0.52	200	0.58	250	0.64	300	0.70	350
54	0.51	150	0.58	200	0.65	250	0.72	300	0.79	350
60	0.54	150	0.61	200	0.68	250	0.76	300	0.83	350
64	0.56	150	0.64	200	0.72	250	0.80	300	0.87	350

* Total calculated thickness includes service allowance and casting allowance added to net thickness.

Notes:

1. To convert inches (in.) to millimeters (mm), multiply by 25.4; to convert pounds per square inch (psi) to kilopascals (kPa), multiply by 6.895.
2. The thicknesses shown are adequate for the rated working pressure plus a surge allowance of 100 psi (689 kPa). Calculations are based on a minimum yield strength in tension of 42,000 psi (289,590 kPa) and a 2.0 safety factor times the sum of working pressure and 100 psi (689 kPa) surge allowance.

Table 14 Rated working pressure and maximum depth of cover

Size	Pressure Class*	Nominal Thickness	Laying Condition				
			Type 1 Trench	Type 2 Trench	Type 3 Trench	Type 4 Trench	Type 5 Trench
in.	*psi*	*in.*	Maximum Depth of Cover—*ft*†				
3	350	0.25	78	88	99	100‡	100‡
4	350	0.25	53	61	69	85	100‡
6	350	0.25	26	31	37	47	65
8	350	0.25	16	20	25	34	50
10	350	0.26	11§	15	19	28	45
12	350	0.28	10§	15	19	28	44
14	250	0.28	¶	11§	15	23	36
	300	0.30	¶	13	17	26	42
	350	0.31	¶	14	19	27	44
16	250	0.30	¶	11§	15	24	34
	300	0.32	¶	13	17	26	39
	350	0.34	¶	14	20	28	44
18	250	0.31	¶	10§	14	22	31
	300	0.34	¶	13	17	26	36
	350	0.36	¶	15	19	28	41
20	250	0.33	¶	10	14	22	30
	300	0.36	¶	13	17	26	35
	350	0.38	¶	15	19	28	38
24	200	0.33	¶	8§	12	17	25
	250	0.37	¶	11	15	20	29
	300	0.40	¶	13	17	24	32
	350	0.42	¶	15	19	28	37
30	150	0.34	¶	—	9	14	22
	200	0.38	¶	8§	12	16	24
	250	0.42	¶	11	15	19	27
	300	0.45	¶	12	16	21	29
	350	0.49	¶	15	19	25	33
36	150	0.38	¶	—	9	14	21
	200	0.42	¶	8§	12	15	23
	250	0.47	¶	10	14	18	25
	300	0.51	¶	12	16	20	28
	350	0.56	¶	15	19	24	32

(continued)

Table 14 Rated working pressure and maximum depth of cover *(Continued)*

Size	Pressure Class*	Nominal Thickness	Laying Condition				
			Type 1 Trench	Type 2 Trench	Type 3 Trench	Type 4 Trench	Type 5 Trench
in.	*psi*	*in.*	Maximum Depth of Cover—*ft*†				
42	150	0.41	¶	—	9	13	20
	200	0.47	¶	8	12	15	22
	250	0.52	¶	10	14	17	25
	300	0.57	¶	12	16	20	27
	350	0.63	¶	15	19	23	32
48	150	0.46	¶	—	9	13	20
	200	0.52	¶	8	11	15	22
	250	0.58	¶	10	13	17	24
	300	0.64	¶	12	15	19	27
	350	0.70	¶	15	18	22	30
54	150	0.51	¶	—	9	13	20
	200	0.58	¶	8	11	14	22
	250	0.65	¶	10	13	16	24
	300	0.72	¶	13	15	19	27
	350	0.79	¶	15	18	22	30
60	150	0.54	¶	5§	9	13	20
	200	0.61	¶	8	11	14	22
	250	0.68	¶	10	13	16	24
	300	0.76	¶	13	15	19	26
	350	0.83	¶	15	18	22	30
64	150	0.56	¶	5§	9	13	20
	200	0.64	¶	8	11	14	21
	250	0.72	¶	10	13	16	24
	300	0.80	¶	12	15	19	26
	350	0.87	¶	15	17	21	29

* Ductile-iron pipe is adequate for the rated working pressure indicated for each nominal size plus a surge allowance of 100 psi (689 kPa). Calculations are based on a 2.0 safety factor times the sum of working pressure and 100 psi (689 kPa) surge allowance. Ductile-iron pipe for working pressures higher than 350 psi (2,413 kPa) 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 (30.5 m).
§ Minimum allowable depth of cover is 3 ft (0.9 m).
¶ For pipe 14 in. (350 mm) and larger, consideration should be given to the use of laying conditions other than Type 1.
NOTE: To convert inches (in.) to millimeters (mm), multiply by 25.4; to convert feet (ft) to meters (m), multiply by 0.3048; and to convert pounds per square inch (psi) to kilopascals (kPa), multiply by 6.895.

Table 15 Special thickness classes of ductile-iron pipe*

Size *in.*	Outside Diameter	Thickness Class 50	51	52	53	54	55	56
		Thickness—*in.*						
3	3.96	—	0.25	0.28	0.31	0.34	0.37	0.40
4	4.80	—	0.26	0.29	0.32	0.35	0.38	0.41
6	6.90	0.25	0.28	0.31	0.34	0.37	0.4	0.43
8	9.05	0.27	0.3	0.33	0.36	0.39	0.42	0.45
10	11.10	0.29	0.32	0.35	0.38	0.41	0.44	0.47
12	13.20	0.31	0.34	0.37	0.40	0.43	0.46	0.49
14	15.30	0.33	0.36	0.39	0.42	0.45	0.48	0.51
16	17.40	0.34	0.37	0.40	0.43	0.46	0.49	0.52
18	19.50	0.35	0.38	0.41	0.44	0.47	0.50	0.53
20	21.60	0.36	0.39	0.42	0.45	0.48	0.51	0.54
24	25.80	0.38	0.41	0.44	0.47	0.50	0.53	0.56
30	32.00	0.39	0.43	0.47	0.51	0.55	0.59	0.63
36	38.30	0.43	0.48	0.53	0.58	0.63	0.68	0.73
42	44.50	0.47	0.53	0.59	0.65	0.71	0.77	0.83
48	50.80	0.51	0.58	0.65	0.72	0.79	0.86	0.93
54	57.56	0.57	0.65	0.73	0.81	0.89	0.97	1.05

* These special thickness classes were designated standard thickness classes in the 1986 edition of this standard.
NOTE: To convert inches (in.) to millimeters (mm), multiply by 25.4.

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