

ANSI/AWWA C101—67 (R1977)

Reaffirmed without revision 1977

AMERICAN NATIONAL STANDARD
for
THICKNESS DESIGN OF CAST-IRON PIPE

With Tables of Pipe Thicknesses

In Four Parts

- Sec. 1-1—Thickness Tables for Standard Conditions**
- Sec. 1-2—General Procedure for Thickness Determination**
- Sec. 1-3—Design Theory—Determination of Net Thickness,
Earth Load, and Truck Superload**
- Sec. 1-4—Thickness Determination for Pipe on Piers or Piling
Aboveground or Underground**

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Foreword

This foreword is provided for information only and is not a part of ANSI/AWWA C101.

History of Standard

On Sep. 10, 1902, NEWWA adopted a "Standard Specification for Cast-Iron Pipe and Special Castings," covering bell-and-spigot pit-cast pipe and fittings of ten thickness classes. The thickness classes were based on allowable internal pressures varying by increments of 50 ft of head.

On May 12, 1908, AWWA adopted a "Standard Specification for Cast-Iron Pipe and Special Castings," covering bell-and-spigot pit-cast pipe and fittings of eight classes, A through H, with allowable working pressures varying by increments of 100 ft of head from 100 to 800 ft. Dimensions and weights were given for pipe and fittings.

In 1926, ASA Sectional Committee (now ANSI Standards Committee) A21 on Cast-Iron Pipe and Fittings was organized under the sponsorship of AGA, ASTM, AWWA, and NEWWA. The present scope of Committee A21 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.

Sectional Committee A21 sponsored many tests of pipe and fittings; these included subsection of pipe to combined earth load and internal pressures (which form the basis of pipe-thickness design), corrosion tests, measurement of hydraulic friction loss in fittings, and tests of bursting strengths of pipe and fittings. After exhaustive study of the test results and other research, the committee in 1939 issued A21.1, "American Standard Practice Manual for the Computation of Strength and Thickness of Cast-Iron Pipe." The manual included nomograms and thickness tables for pit-cast pipe with 11/31 * iron strength. As stated in the preface to that manual, however, the design method was applicable to pipe of any iron strength.

Discussions and interpretations^{1, 2} of the method of design of cast-iron pipe were published in 1939 and presented to AWWA and AGA. As a result of these publications and because of the general acceptance of A21.1, a substantial volume of cast-iron pipe was designed by the new method and furnished to manufacturers' standards between 1939 and 1953. A standard (A21.2) for pit-cast pipe with 11/31 iron strength also was issued in 1939. Work on standards for centrifugally cast pipe with 18/40 iron strength was started after the design was completed in 1939, but, owing to the intervention of World War II and other causes, they were not formally issued until 1953.

* The first figure designates the bursting tensile strength in units of 1,000 psi and the second figure designates the ring modulus of rupture in units of 1,000 psi.

In 1957, a revision of A21.1 was issued. In that revision, designated ASA A21.1-1957 (AWWA H1-57) the major change was the addition of a method for computing earth loads on pipe laid under embankments and of nomograms and thickness tables for centrifugally cast pipe with 18/40 iron strength.

In 1958, Sectional Committee A21 was reorganized. Subcommittees were established to study each group of standards in accordance with the review and revision policy of ASA (now ANSI). The scope of Subcommittee 1—Pipe is:

To include the periodic review of all current A21 standards for pipe, the preparation of revisions or new standards when needed, as well as other matters pertaining to pipe standards.

As a result of the work of Subcommittee No. 1 on this assignment, revisions of the cast-iron pipe standards A21.6 (AWWA C106), A21.7, A21.8 (AWWA C108), and A21.9 were issued in 1962 and again in 1970. Revision of A21.1-1957 (AWWA H1-57) was delayed in order for the subcommittee to carry out a new assignment from the sectional committee to develop a design standard and pipe standards for ductile-iron pipe. Subsequently, the subcommittee completed its study and a revision of A21.1 was issued in 1967.

In 1971 and again in 1976, Subcommittee No. 1 reviewed the 1967 edition and submitted a recommendation to Committee A21 that the standard be reaffirmed without change. Therefore, this reaffirmed edition is unchanged from the 1967 edition, except for the updating of this foreword. For convenience, the major features listed in the foreword of the 1967 edition are repeated here.

Major Features of 1967 Revision

Although ANSI A21.1-1967 (AWWA H1-67) contained no changes in the basic design method, a number of revisions were incorporated to simplify the design procedure and to reflect changes in technology. Major features of the 1967 revision are discussed.

1. *Format.* This revision is divided into four major sections: Sec. 1-1 gives thickness tables for standard conditions; Sec. 1-2 gives the general procedure for thickness determination; Sec. 1-3 gives design theory and provides methods for determining pipe thicknesses, earth loads, and truck superloads for both standard and special conditions; and Sec. 1-4 gives the design procedure for a special installation condition, pipe on piers aboveground or underground.

2. *Iron strength.* Thickness tables, nomograms, and other data for pit-cast pipe (11/31 iron strength) were deleted, as this type of pipe is seldom furnished today.

Centrifugally cast pipe covered under ANSI Standards A21.6 (AWWA C106), A21.7, A21.8 (AWWA C108), and A21.9 are specified to have an iron strength of not less than 18/40. Advances in production technology have enabled the manufacturers to furnish pipe with greater strength, and pipe with 21/45 iron strength has been available for many years. Thus, for the con-

venience of users, tables and figures in the standard cover pipe with iron strengths of both 18/40 and 21/45.

3. *Laying conditions.* Laying conditions C, D, and E (also called "field conditions" in the 1957 revision) were deleted. Conditions C and D were for pipe laid on blocks, a method sometimes used in the 1920s and 1930s. This method has been recognized as undesirable and is seldom used today. Condition E was for pipe laid with special bedding but without tamping the backfill. It was felt that this combination would rarely be used today; when special bedding is used, the backfill is almost always tamped, giving laying condition F, which was retained in this revision.

4. *Earth loads.* Formulas and procedures were added (Sec. 1-3) for determining earth loads for standard and special conditions. Earth loads shown in Table 1-8 are the same as those given in the 1957 revision, except that loads for 20 and 24 ft of cover were added.

5. *Allowance for truck superloads.* Formulas and procedures were added (Sec. 1-3) for determining truck superloads for standard and special conditions. These procedures may be used to compute truck superloads for unpaved roads, flexible pavement, or rigid pavement; one truck or two passing trucks; and any wheel load and impact factor, including AASHTO truck loadings. Truck superloads for standard conditions are shown in Table 1-8 and are the same as given in the 1957 revision, except that loads for 20 and 24 ft of cover were added.

6. *Allowance for surge pressure.* The allowances for surge pressure (water hammer), shown in Table 1-10, are unchanged from those given in the 1957 revision.

7. *Allowance for corrosion.* A standard allowance for soil corrosion of 0.08 in., based on judgment and experience of early engineers, was used in the 1939 manual and continued in the 1957 revision. The allowance of 0.08 in. was also retained in this edition. It is very conservative for many soils, and has proved to be adequate in most. In areas suspected or known to be highly corrosive, however, the designer should take special precautions. Where unusually corrosive soil conditions are anticipated, a soil survey is recommended.

8. *Pipe on piers.* A new section (Sec. 1-4) was added to provide procedures for computing thicknesses of pipe installed on piers or piling, a condition sometimes encountered in laying pipe in unstable soil, across streams or swamps, either aboveground or underground, and in installing pipe on bridges and other aboveground structures.

Standard Thicknesses of Pit-Cast Pipe

As stated in the foregoing, thickness tables for pit-cast pipe were deleted in the 1967 edition. During the review of this standard in 1971, it was determined that some standards and codes refer to the table of standard thickness classes for pit-cast pipe shown as Table 10 in the 1957 edition of A21.1. For reference, the contents of that table are reproduced on the next page:

*Standard Thickness Classes for Pit-Cast Pipe**

Pipe Size in.	Pipe-Wall Thickness (in.) for Standard Thickness Class No.:													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
3	0.37	0.40	0.43	0.46	0.50	0.54	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99
4	0.40	0.43	0.46	0.50	0.54	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99	1.07
6	0.43	0.46	0.50	0.54	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99	1.07	1.16
8	0.46	0.50	0.54	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99	1.07	1.16	1.25
10	0.50	0.54	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99	1.07	1.16	1.25	1.35
12	0.54	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99	1.07	1.16	1.25	1.35	1.46
14	0.54	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99	1.07	1.16	1.25	1.35	1.46
16	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99	1.07	1.16	1.25	1.35	1.46	1.58
18	0.63	0.68	0.73	0.79	0.85	0.92	0.99	1.07	1.16	1.25	1.35	1.46	1.58	1.71
20	0.66	0.71	0.77	0.83	0.90	0.97	1.05	1.13	1.22	1.32	1.43	1.54	1.66	1.79
24	0.74	0.80	0.86	0.93	1.00	1.08	1.17	1.26	1.36	1.47	1.59	1.72	1.86	2.01
30	0.87	0.94	1.02	1.10	1.19	1.29	1.39	1.50	1.62	1.75	1.89	2.04	2.20	2.38
36	0.97	1.05	1.13	1.22	1.32	1.43	1.54	1.66	1.79	1.93	2.08	2.25	2.43	2.62
42	1.07	1.16	1.25	1.35	1.46	1.58	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94
48	1.18	1.27	1.37	1.48	1.60	1.73	1.87	2.02	2.18	2.35	2.54	2.74	2.96	3.20
54	1.30	1.40	1.51	1.63	1.76	1.90	2.05	2.21	2.39	2.58	2.79	3.01	3.25	3.51
60	1.39	1.50	1.62	1.75	1.89	2.04	2.20	2.38	2.57	2.78	3.00	3.24	3.50	3.78

* Each class is made 8 per cent heavier than the preceding class, starting with the thinnest, i.e., minimum thickness, as the base class.

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American National Standard for
Thickness Design of Cast-Iron Pipe

Sec. 1-1—Thickness Tables for Standard Conditions

Sec. 1-1.1—General

Tables 1-1, 1-2, and 1-3, as applicable, permit the direct determination of the required thickness of cast-iron pipe limited to the following conditions:

- a. Vertical-sided trench of width at top of pipe not greater than the nominal pipe diameter plus 2 ft
- b. Unit weight of soil 120 lb/cu ft
- c. $K_{\mu} = 0.1924$, $K_{\mu}' = 0.130$ (see Sec. 1-3.2 for definition)
- d. Truck superload based on two passing trucks with adjacent wheels 3 ft apart, 9,000 lb wheel load, unpaved road or flexible pavement, 1.50 impact factor
- e. Surge allowances as shown in Table 1-10
- f. Iron strengths of 18/40 and 21/45 *
- g. The three most common laying conditions:

A—Pipe laid on flat-bottom trench, backfill not tamped

B—Pipe laid on flat-bottom trench, backfill tamped

* The first figure designates the bursting tensile strength (S) in units of 1,000 psi and the second figure designates the ring modulus of rupture (R) in units of 1,000 psi.

F—Pipe bedded in gravel or sand, backfill tamped

h. Allowances for casting tolerance as shown in Table 1-6

i. A corrosion allowance of 0.08 in.

Sec. 1-1.2—Trench Load and Internal Pressure

The required thickness of cast-iron pressure pipe is determined from a consideration of trench load and internal pressure in combination. Trench load is considered to consist of the earth load on the pipe plus any superload resulting from traffic over the trench. Internal pressure is considered to consist of the design working pressure plus an additional allowance for surge pressure. Two different combinations of trench load and internal pressure are considered in the design:

Case 1. Trench load (earth load but no truck superload) in combination with internal pressure (working pressure plus surge pressure) and with 2.5 factor of safety applied to both trench load and internal pressure

Case 2. Trench load (earth load plus truck superload) in combination with internal pressure (working pressure but no surge pressure) and with

a 2.5 factor of safety applied to both trench load and internal pressure.

Sec. 1-1.3—Traffic Superload and Surge Pressure

In designing water pipe it is customary to assume that neither traffic superload nor surge pressure will occur in important magnitude simultaneously. Thus, calculations for the required thickness of water pipe are made for both conditions independently, and the greater of the two thicknesses thus determined is chosen as the net thickness.

In designing gas pipe the procedure is the same, except that surge pressure is not a factor and only Case 2 is considered.

Sec. 1-1.4—Corrosion Allowance and Casting Tolerance

To the net thickness determined as explained above, a corrosion allowance and a casting tolerance are added to obtain the calculated thickness shown in Tables 1-1, 1-2, and 1-3. The standard thickness class and/or the nominal thickness for this class shown in Tables 1-1, 1-2, and 1-3 are used for specifying and ordering pipe.

For other than standard conditions the formulas, tables, and diagrams in Sec. 1-2 may be used. The design theory on which Tables 1-1, 1-2, and 1-3 are based is presented in Sec. 1-3. Procedures for determining the net thickness of pipe on piers or piling above- or belowground are presented in Sec. 1-4.

TABLE 1-1
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Three-Inch Water Pipe									
A	2½	Calculated Thickness Use {Thickness Class Thickness	.21* 22 .32	.21* 22 .32	.22* 22 .32	.22* 22 .32	.22* 22 .32	.22* 22 .32	.23* 22 .32
	3½	Calculated Thickness Use {Thickness Class Thickness	.21* 22 .32	.21* 22 .32	.22* 22 .32	.22* 22 .32	.22* 22 .32	.22* 22 .32	.23* 22 .32
	5	Calculated Thickness Use {Thickness Class Thickness	.21* 22 .32	.21* 22 .32	.22* 22 .32	.22* 22 .32	.23 22 .32	.23 22 .32	.24 22 .32
	8	Calculated Thickness Use {Thickness Class Thickness	.22* 22 .32	.23* 22 .32	.23* 22 .32	.24 22 .32	.24 22 .32	.24 22 .32	.25 22 .32
	12	Calculated Thickness Use {Thickness Class Thickness	.24* 22 .32	.25* 22 .32	.25* 22 .32	.26 22 .32	.26 22 .32	.27 22 .32	.28 22 .32
	16	Calculated Thickness Use {Thickness Class Thickness	.27 22 .32	.27 22 .32	.28 22 .32	.28 22 .32	.28 22 .32	.29 22 .32	.29 22 .32
B	2½	Calculated Thickness Use {Thickness Class Thickness	.21* 22 .32	.21* 22 .32	.22* 22 .32	.22* 22 .32	.22* 22 .32	.22* 22 .32	.23* 22 .32
	3½	Calculated Thickness Use {Thickness Class Thickness	.21* 22 .32	.21* 22 .32	.22* 22 .32	.22* 22 .32	.22* 22 .32	.22* 22 .32	.23* 22 .32
	5	Calculated Thickness Use {Thickness Class Thickness	.21* 22 .32	.21* 22 .32	.22* 22 .32	.22* 22 .32	.23 22 .32	.23 22 .32	.24 22 .32
	8	Calculated Thickness Use {Thickness Class Thickness	.22* 22 .32	.22* 22 .32	.23* 22 .32	.23* 22 .32	.24 22 .32	.24 22 .32	.24 22 .32
	12	Calculated Thickness Use {Thickness Class Thickness	.24* 22 .32	.24* 22 .32	.25 22 .32	.25 22 .32	.26 22 .32	.26 22 .32	.27 22 .32
	16	Calculated Thickness Use {Thickness Class Thickness	.26 22 .32	.26 22 .32	.27 22 .32	.27 22 .32	.28 22 .32	.28 22 .32	.29 22 .32
F	2½	Calculated Thickness Use {Thickness Class Thickness	.21* 22 .32	.21* 22 .32	.21* 22 .32	.21* 22 .32	.22* 22 .32	.22* 22 .32	.23 22 .32
	3½	Calculated Thickness Use {Thickness Class Thickness	.21* 22 .32	.21* 22 .32	.21* 22 .32	.21* 22 .32	.22* 22 .32	.22* 22 .32	.23 22 .32
	5	Calculated Thickness Use {Thickness Class Thickness	.21* 22 .32	.21* 22 .32	.21* 22 .32	.22* 22 .32	.22* 22 .32	.22* 22 .32	.23 22 .32
	8	Calculated Thickness Use {Thickness Class Thickness	.21 22 .32	.21 22 .32	.22 22 .32	.22 22 .32	.23 22 .32	.23 22 .32	.24 22 .32
	12	Calculated Thickness Use {Thickness Class Thickness	.23 22 .32	.23 22 .32	.23 22 .32	.24 22 .32	.24 22 .32	.24 22 .32	.25 22 .32
	16	Calculated Thickness Use {Thickness Class Thickness	.24 22 .32	.24 22 .32	.25 22 .32	.25 22 .32	.26 22 .32	.26 22 .32	.27 22 .32

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Four-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.23* 22 .35	.23* 22 .35	.24* 22 .35	.24* 22 .35	.24* 22 .35	.25* 22 .35	.27 22 .35
	3½	Calculated Thickness Use { Thickness Class Thickness	.23* 22 .35	.23* 22 .35	.23* 22 .35	.24 22 .35	.24 22 .35	.25 22 .35	.27 22 .35
	5	Calculated Thickness Use { Thickness Class Thickness	.23* 22 .35	.24* 22 .35	.24* 22 .35	.25 22 .35	.26 22 .35	.27 22 .35	.28 22 .35
	8	Calculated Thickness Use { Thickness Class Thickness	.25* 22 .35	.26 22 .35	.27 22 .35	.28 22 .35	.28 22 .35	.29 22 .35	.30 22 .35
	12	Calculated Thickness Use { Thickness Class Thickness	.29 22 .35	.29 22 .35	.30 22 .35	.30 22 .35	.31 22 .35	.31 22 .35	.32 22 .35
	16	Calculated Thickness Use { Thickness Class Thickness	.31 22 .35	.31 22 .35	.32 22 .35	.32 22 .35	.33 22 .35	.33 22 .35	.34 22 .35
B	2½	Calculated Thickness Use { Thickness Class Thickness	.23* 22 .35	.23* 22 .35	.23* 22 .35	.23* 22 .35	.24* 22 .35	.25 22 .35	.27 22 .35
	3½	Calculated Thickness Use { Thickness Class Thickness	.23* 22 .35	.23* 22 .35	.23* 22 .35	.24 22 .35	.25 22 .35	.26 22 .35	.27 22 .35
	5	Calculated Thickness Use { Thickness Class Thickness	.23 22 .35	.24 22 .35	.24 22 .35	.25 22 .35	.26 22 .35	.27 22 .35	.28 22 .35
	8	Calculated Thickness Use { Thickness Class Thickness	.25 22 .35	.26 22 .35	.27 22 .35	.27 22 .35	.28 22 .35	.29 22 .35	.29 22 .35
	12	Calculated Thickness Use { Thickness Class Thickness	.28 22 .35	.28 22 .35	.29 22 .35	.30 22 .35	.30 22 .35	.31 22 .35	.32 22 .35
	16	Calculated Thickness Use { Thickness Class Thickness	.30 22 .35	.31 22 .35	.31 22 .35	.32 22 .35	.32 22 .35	.33 22 .35	.33 22 .35
F	2½	Calculated Thickness Use { Thickness Class Thickness	.23* 22 .35	.23* 22 .35	.23* 22 .35	.24* 22 .35	.24 22 .35	.25 22 .35	.26 22 .35
	3½	Calculated Thickness Use { Thickness Class Thickness	.23* 22 .35	.23* 22 .35	.23 22 .35	.24 22 .35	.24 22 .35	.25 22 .35	.26 22 .35
	5	Calculated Thickness Use { Thickness Class Thickness	.23 22 .35	.23 22 .35	.23 22 .35	.24 22 .35	.24 22 .35	.25 22 .35	.26 22 .35
	8	Calculated Thickness Use { Thickness Class Thickness	.24 22 .35	.24 22 .35	.25 22 .35	.25 22 .35	.25 22 .35	.26 22 .35	.27 22 .35
	12	Calculated Thickness Use { Thickness Class Thickness	.25 22 .35	.26 22 .35	.27 22 .35	.28 22 .35	.28 22 .35	.29 22 .35	.30 22 .35
	16	Calculated Thickness Use { Thickness Class Thickness	.28 22 .35	.28 22 .35	.29 22 .35	.29 22 .35	.30 22 .35	.30 22 .35	.31 22 .35

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condition	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Six-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.26* 22 .38	.29* 22 .38	.30* 22 .38	.31* 22 .38	.32* 22 .38	.33* 22 .38	.34 22 .38
	3½	Calculated Thickness Use { Thickness Class Thickness	.28* 22 .38	.28* 22 .38	.29* 22 .38	.30* 22 .38	.31* 22 .38	.32* 22 .38	.34 22 .38
	5	Calculated Thickness Use { Thickness Class Thickness	.29* 22 .38	.29* 22 .38	.30* 22 .38	.31* 22 .38	.33 22 .38	.34 22 .38	.35 22 .38
	8	Calculated Thickness Use { Thickness Class Thickness	.32 22 .38	.33 22 .38	.34 22 .38	.35 22 .38	.36 22 .38	.37 22 .38	.38 22 .38
	12	Calculated Thickness Use { Thickness Class Thickness	.36 22 .38	.37 22 .38	.38 22 .38	.38 22 .38	.39 22 .38	.40 23 .41	.41 23 .41
	16	Calculated Thickness Use { Thickness Class Thickness	.39 22 .38	.40 23 .41	.41 23 .41	.42 23 .41	.42 23 .41	.43 24 .44	.44 24 .44
B	2½	Calculated Thickness Use { Thickness Class Thickness	.28* 22 .38	.28* 22 .38	.29* 22 .38	.30* 22 .38	.31* 22 .38	.32* 22 .38	.33* 22 .38
	3½	Calculated Thickness Use { Thickness Class Thickness	.27* 22 .38	.28* 22 .38	.28* 22 .38	.29* 22 .38	.30* 22 .38	.32 22 .38	.34 22 .38
	5	Calculated Thickness Use { Thickness Class Thickness	.28* 22 .38	.29 22 .38	.30 22 .38	.31 22 .38	.32 22 .38	.33 22 .38	.34 22 .38
	8	Calculated Thickness Use { Thickness Class Thickness	.31 22 .38	.32 22 .38	.33 22 .38	.34 22 .38	.35 22 .38	.36 22 .38	.37 22 .38
	12	Calculated Thickness Use { Thickness Class Thickness	.35 22 .38	.35 22 .38	.36 22 .38	.37 22 .38	.38 22 .38	.39 22 .38	.40 23 .41
	16	Calculated Thickness Use { Thickness Class Thickness	.38 22 .38	.38 22 .38	.39 22 .38	.40 23 .41	.41 23 .41	.42 23 .41	.43 24 .44
F	2½	Calculated Thickness Use { Thickness Class Thickness	.26* 22 .38	.27* 22 .38	.28 22 .38	.29 22 .38	.30 22 .38	.32 22 .38	.34 22 .38
	3½	Calculated Thickness Use { Thickness Class Thickness	.27 22 .38	.27 22 .38	.28 22 .38	.29 22 .38	.30 22 .38	.32 22 .38	.34 22 .38
	5	Calculated Thickness Use { Thickness Class Thickness	.28 22 .38	.28 22 .38	.29 22 .38	.29 22 .38	.30 22 .38	.32 22 .38	.35 22 .38
	8	Calculated Thickness Use { Thickness Class Thickness	.29 22 .38	.30 22 .38	.31 22 .38	.32 22 .38	.33 22 .38	.34 22 .38	.35 22 .38
	12	Calculated Thickness Use { Thickness Class Thickness	.32 22 .38	.33 22 .38	.34 22 .38	.35 22 .38	.36 22 .38	.37 22 .38	.38 22 .38
	16	Calculated Thickness Use { Thickness Class Thickness	.35 22 .38	.35 22 .38	.36 22 .38	.37 22 .38	.38 22 .38	.39 22 .38	.40 23 .41

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Eight-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.34* 22 .41	.35* 22 .41	.36* 22 .41	.37* 22 .41	.38* 22 .41	.36* 22 .41	.46* 22 .41
	3½	Calculated Thickness Use { Thickness Class Thickness	.33* 22 .41	.34* 22 .41	.34* 22 .41	.35* 22 .41	.36* 22 .41	.39 22 .41	.41 22 .41
	5	Calculated Thickness Use { Thickness Class Thickness	.34* 22 .41	.35* 22 .41	.36* 22 .41	.37* 22 .41	.39 22 .41	.41 22 .41	.43 23 .44
	8	Calculated Thickness Use { Thickness Class Thickness	.38 22 .41	.39 22 .41	.40 22 .41	.41 22 .41	.43 23 .44	.44 23 .44	.46 24 .48
	12	Calculated Thickness Use { Thickness Class Thickness	.43 23 .44	.44 23 .44	.45 23 .44	.46 24 .48	.47 24 .48	.49 24 .48	.50 25 .52
	16	Calculated Thickness Use { Thickness Class Thickness	.46 24 .48	.47 24 .48	.48 24 .48	.49 24 .48	.51 25 .52	.52 25 .52	.53 25 .52
B	2½	Calculated Thickness Use { Thickness Class Thickness	.32* 22 .41	.33* 22 .41	.34* 22 .41	.35* 22 .41	.36* 22 .41	.38* 22 .41	.39* 22 .41
	3½	Calculated Thickness Use { Thickness Class Thickness	.32* 22 .41	.33* 22 .41	.33* 22 .41	.34* 22 .41	.36* 22 .41	.38 22 .41	.40 22 .41
	5	Calculated Thickness Use { Thickness Class Thickness	.33* 22 .41	.34* 22 .41	.35 22 .41	.36 22 .41	.38 22 .41	.40 22 .41	.42 22 .41
	8	Calculated Thickness Use { Thickness Class Thickness	.36 22 .41	.37 22 .41	.38 22 .41	.40 22 .41	.41 22 .41	.43 23 .44	.45 23 .44
	12	Calculated Thickness Use { Thickness Class Thickness	.41 22 .41	.42 22 .41	.43 23 .44	.44 23 .44	.46 24 .48	.47 24 .48	.48 24 .48
	16	Calculated Thickness Use { Thickness Class Thickness	.44 23 .44	.45 23 .44	.46 24 .48	.47 24 .48	.48 24 .48	.50 25 .52	.51 25 .52
F	2½	Calculated Thickness Use { Thickness Class Thickness	.30* 22 .41	.31* 22 .41	.32* 22 .41	.33* 22 .41	.35 22 .41	.37 22 .41	.39 22 .41
	3½	Calculated Thickness Use { Thickness Class Thickness	.29* 22 .41	.30* 22 .41	.31 22 .41	.33 22 .41	.35 22 .41	.37 22 .41	.39 22 .41
	5	Calculated Thickness Use { Thickness Class Thickness	.30* 22 .41	.31* 22 .41	.32 22 .41	.34 22 .41	.36 22 .41	.38 22 .41	.40 22 .41
	8	Calculated Thickness Use { Thickness Class Thickness	.34 22 .41	.35 22 .41	.36 22 .41	.37 22 .41	.39 22 .41	.41 22 .41	.43 23 .44
	12	Calculated Thickness Use { Thickness Class Thickness	.38 22 .41	.39 22 .41	.40 22 .41	.41 22 .41	.43 23 .44	.44 23 .44	.46 24 .48
	16	Calculated Thickness Use { Thickness Class Thickness	.40 22 .41	.41 22 .41	.42 22 .41	.43 23 .44	.45 23 .44	.46 24 .48	.48 24 .48

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover <i>ft</i>	Thickness Specifications	Internal Pressure— <i>psi</i>						
			50	100	150	200	250	300	350
			Barrel Thicknesses— <i>in.</i>						
Ten-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.40* 22 .44	.41* 22 .44	.42* 22 .44	.43* 22 .44	.45* 22 .44	.46* 23 .48	.48* 23 .48
	3½	Calculated Thickness Use { Thickness Class Thickness	.39* 22 .44	.40* 22 .44	.41* 22 .44	.42* 22 .44	.44* 22 .44	.46 23 .48	.49 23 .48
	5	Calculated Thickness Use { Thickness Class Thickness	.40* 22 .44	.41* 22 .44	.42* 22 .44	.44 22 .44	.46 23 .48	.48 23 .48	.51 24 .52
	8	Calculated Thickness Use { Thickness Class Thickness	.44 22 .44	.46 23 .48	.47 23 .48	.49 23 .48	.51 24 .52	.53 24 .52	.55 25 .56
	12	Calculated Thickness Use { Thickness Class Thickness	.51 24 .52	.52 24 .52	.53 24 .52	.55 25 .56	.56 25 .56	.58 26 .60	.60 26 .60
	16	Calculated Thickness Use { Thickness Class Thickness	.53 24 .52	.54 25 .56	.56 25 .56	.57 25 .56	.59 26 .60	.60 26 .60	.62 26 .60
B	2½	Calculated Thickness Use { Thickness Class Thickness	.38* 22 .44	.39* 22 .44	.40* 22 .44	.41* 22 .44	.43* 22 .44	.45* 22 .44	.47* 23 .48
	3½	Calculated Thickness Use { Thickness Class Thickness	.37* 22 .44	.38* 22 .44	.39* 22 .44	.40* 22 .44	.42* 22 .44	.44 22 .44	.48 23 .48
	5	Calculated Thickness Use { Thickness Class Thickness	.38* 22 .44	.39* 22 .44	.40* 22 .44	.42 22 .44	.45 22 .44	.47 23 .48	.50 24 .52
	8	Calculated Thickness Use { Thickness Class Thickness	.41* 22 .44	.44 22 .44	.45 22 .44	.47 23 .48	.49 23 .48	.51 24 .52	.53 24 .52
	12	Calculated Thickness Use { Thickness Class Thickness	.48 23 .48	.49 23 .48	.51 24 .52	.52 24 .52	.54 25 .56	.56 25 .56	.58 26 .60
	16	Calculated Thickness Use { Thickness Class Thickness	.50 24 .52	.52 24 .52	.53 24 .52	.54 25 .56	.56 25 .56	.58 26 .60	.60 26 .60
F	2½	Calculated Thickness Use { Thickness Class Thickness	.35* 22 .44	.36* 22 .44	.37* 22 .44	.38* 22 .44	.41 22 .44	.44 22 .44	.47 23 .48
	3½	Calculated Thickness Use { Thickness Class Thickness	.34* 22 .44	.35* 22 .44	.36* 22 .44	.38 22 .44	.41 22 .44	.44 22 .44	.47 23 .48
	5	Calculated Thickness Use { Thickness Class Thickness	.35* 22 .44	.36* 22 .44	.38 22 .44	.40 22 .44	.42 22 .44	.46 23 .48	.48 23 .48
	8	Calculated Thickness Use { Thickness Class Thickness	.39 22 .44	.41 22 .44	.42 22 .44	.44 22 .44	.46 23 .48	.48 23 .48	.51 24 .52
	12	Calculated Thickness Use { Thickness Class Thickness	.44 22 .44	.45 22 .44	.46 23 .48	.48 23 .48	.50 24 .52	.52 24 .52	.54 25 .56
	16	Calculated Thickness Use { Thickness Class Thickness	.46 23 .48	.47 23 .48	.49 23 .48	.51 24 .52	.52 24 .52	.54 25 .56	.56 25 .56

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Twelve-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.45* 22 .48	.46* 22 .48	.47* 22 .48	.49* 22 .48	.51* 23 .52	.53* 23 .52	.55* 24 .56
	3½	Calculated Thickness Use { Thickness Class Thickness	.43* 22 .48	.45* 22 .48	.46* 22 .48	.48* 22 .48	.50* 23 .52	.51 23 .52	.55 24 .56
	5	Calculated Thickness Use { Thickness Class Thickness	.45* 22 .48	.46* 22 .48	.47* 22 .48	.49 22 .48	.52 23 .52	.54 24 .56	.57 24 .56
	8	Calculated Thickness Use { Thickness Class Thickness	.50 23 .52	.52 23 .52	.53 23 .52	.55 24 .56	.57 24 .56	.60 25 .60	.62 25 .60
	12	Calculated Thickness Use { Thickness Class Thickness	.56 24 .56	.57 24 .56	.59 25 .60	.60 25 .60	.62 25 .60	.64 26 .65	.67 26 .65
	16	Calculated Thickness Use { Thickness Class Thickness	.59 25 .60	.60 25 .60	.61 25 .60	.63 26 .65	.65 26 .65	.67 26 .65	.69 27 .70
B	2½	Calculated Thickness Use { Thickness Class Thickness	.42* 22 .48	.44* 22 .48	.45* 22 .48	.46* 22 .48	.48* 22 .48	.50* 23 .52	.53* 23 .52
	3½	Calculated Thickness Use { Thickness Class Thickness	.41* 22 .48	.42* 22 .48	.44* 22 .48	.45* 22 .48	.47* 22 .48	.51 23 .52	.55 24 .56
	5	Calculated Thickness Use { Thickness Class Thickness	.42* 22 .48	.43* 22 .48	.45* 22 .48	.47 22 .48	.50 23 .52	.53 23 .52	.56 24 .56
	8	Calculated Thickness Use { Thickness Class Thickness	.48 22 .48	.49 22 .48	.51 23 .52	.53 23 .52	.55 24 .56	.57 24 .56	.60 25 .60
	12	Calculated Thickness Use { Thickness Class Thickness	.53 23 .52	.54 24 .56	.56 24 .56	.57 24 .56	.59 25 .60	.61 25 .60	.64 26 .65
	16	Calculated Thickness Use { Thickness Class Thickness	.55 24 .56	.57 24 .56	.58 25 .60	.60 25 .60	.62 25 .60	.64 26 .65	.66 26 .65
F	2½	Calculated Thickness Use { Thickness Class Thickness	.39* 22 .48	.40* 22 .48	.41* 22 .48	.43* 22 .48	.45* 22 .48	.49 22 .48	.53 23 .52
	3½	Calculated Thickness Use { Thickness Class Thickness	.38* 22 .48	.39* 22 .48	.40* 22 .48	.42* 22 .48	.45 22 .48	.50 23 .52	.53 23 .52
	5	Calculated Thickness Use { Thickness Class Thickness	.39* 22 .48	.40* 22 .48	.41* 22 .48	.43* 22 .48	.46 22 .48	.50 23 .52	.54 24 .56
	8	Calculated Thickness Use { Thickness Class Thickness	.44 22 .48	.45 22 .48	.47 22 .48	.49 22 .48	.52 23 .52	.55 24 .56	.58 25 .60
	12	Calculated Thickness Use { Thickness Class Thickness	.48 22 .48	.49 22 .48	.51 23 .52	.53 23 .52	.55 24 .56	.58 25 .60	.61 25 .60
	16	Calculated Thickness Use { Thickness Class Thickness	.50 23 .52	.52 23 .52	.53 23 .52	.55 24 .56	.57 24 .56	.59 25 .60	.62 25 .60

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condition	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses— <i>in.</i>						
Fourteen-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.51* 22 .51	.52* 22 .51	.54* 23 .55	.55* 23 .55	.58* 24 .59	.60* 24 .59	.62* 25 .64
	3½	Calculated Thickness Use { Thickness Class Thickness	.50* 22 .51	.51* 22 .51	.53* 23 .55	.54* 23 .55	.57* 24 .59	.60 24 .59	.64 25 .64
	5	Calculated Thickness Use { Thickness Class Thickness	.51* 22 .51	.53* 23 .55	.54* 23 .55	.56* 23 .55	.59 24 .59	.62 25 .64	.66 25 .64
	8	Calculated Thickness Use { Thickness Class Thickness	.58 24 .59	.60 24 .59	.62 25 .64	.64 25 .64	.66 25 .64	.69 26 .69	.72 27 .75
	12	Calculated Thickness Use { Thickness Class Thickness	.63 25 .64	.65 25 .64	.67 26 .69	.69 26 .69	.71 26 .69	.74 27 .75	.76 27 .75
	16	Calculated Thickness Use { Thickness Class Thickness	.67 26 .69	.68 26 .69	.70 26 .69	.72 27 .75	.74 27 .75	.76 27 .75	.79 28 .81
B	2½	Calculated Thickness Use { Thickness Class Thickness	.47* 21 .48	.49* 21 .48	.51* 22 .51	.52* 22 .51	.54* 23 .55	.57* 24 .59	.62 25 .64
	3½	Calculated Thickness Use { Thickness Class Thickness	.46* 21 .48	.47* 21 .48	.49* 22 .51	.51* 22 .51	.54 23 .55	.57 24 .59	.63 25 .64
	5	Calculated Thickness Use { Thickness Class Thickness	.48* 21 .48	.49* 22 .51	.52 22 .51	.54 23 .55	.57 24 .59	.61 24 .59	.65 25 .64
	8	Calculated Thickness Use { Thickness Class Thickness	.54 23 .55	.56 23 .55	.58 24 .59	.61 24 .59	.63 25 .64	.66 25 .64	.69 26 .69
	12	Calculated Thickness Use { Thickness Class Thickness	.59 24 .59	.61 24 .59	.63 25 .64	.65 25 .64	.68 26 .69	.70 26 .69	.73 27 .75
	16	Calculated Thickness Use { Thickness Class Thickness	.62 25 .64	.64 25 .64	.66 25 .64	.68 26 .69	.70 26 .69	.73 27 .75	.75 27 .75
F	2½	Calculated Thickness Use { Thickness Class Thickness	.44* 21 .48	.45* 21 .48	.47* 21 .48	.49* 21 .48	.52 22 .51	.57 24 .59	.61 24 .59
	3½	Calculated Thickness Use { Thickness Class Thickness	.44* 21 .48	.45* 21 .48	.47 21 .48	.50 22 .51	.53 23 .55	.57 24 .59	.62 25 .64
	5	Calculated Thickness Use { Thickness Class Thickness	.45 21 .48	.47 21 .48	.49 21 .48	.52 22 .51	.55 23 .55	.59 24 .59	.64 25 .64
	8	Calculated Thickness Use { Thickness Class Thickness	.50 22 .51	.52 22 .51	.54 23 .55	.57 24 .59	.60 24 .59	.64 25 .64	.66 25 .64
	12	Calculated Thickness Use { Thickness Class Thickness	.54 23 .55	.56 23 .55	.58 24 .59	.61 24 .59	.63 25 .64	.66 25 .64	.69 26 .69
	16	Calculated Thickness Use { Thickness Class Thickness	.57 24 .59	.58 24 .59	.60 24 .59	.63 25 .64	.65 25 .64	.68 26 .69	.71 26 .69

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Sixteen-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.54* 22 .54	.56* 23 .58	.58* 23 .58	.60* 23 .58	.62* 24 .63	.65* 24 .63	.68* 25 .68
	3½	Calculated Thickness Use { Thickness Class Thickness	.54* 22 .54	.55* 22 .54	.57* 23 .58	.59* 23 .58	.61 24 .63	.65 24 .63	.70 25 .68
	5	Calculated Thickness Use { Thickness Class Thickness	.56* 23 .58	.57* 23 .58	.59* 23 .58	.61* 24 .63	.64 24 .63	.68 25 .68	.72 26 .73
	8	Calculated Thickness Use { Thickness Class Thickness	.62 24 .63	.64 24 .63	.66 25 .68	.69 25 .68	.72 26 .73	.75 26 .73	.78 27 .79
	12	Calculated Thickness Use { Thickness Class Thickness	.68 25 .68	.70 25 .68	.72 26 .73	.74 26 .73	.77 27 .79	.80 27 .79	.83 28 .85
	16	Calculated Thickness Use { Thickness Class Thickness	.72 26 .73	.74 26 .73	.76 27 .79	.78 27 .79	.81 27 .79	.83 28 .85	.86 28 .85
B	2½	Calculated Thickness Use { Thickness Class Thickness	.50* 21 .50	.52* 22 .54	.54* 22 .54	.56* 23 .58	.56* 23 .58	.62* 24 .63	.65* 25 .68
	3½	Calculated Thickness Use { Thickness Class Thickness	.50* 21 .50	.52* 22 .54	.53* 22 .54	.56* 23 .58	.59 23 .58	.63 24 .63	.68 25 .68
	5	Calculated Thickness Use { Thickness Class Thickness	.52* 22 .54	.53* 22 .54	.55* 22 .54	.58 23 .58	.62 24 .63	.66 25 .68	.70 25 .68
	8	Calculated Thickness Use { Thickness Class Thickness	.58 23 .58	.60 23 .58	.62 24 .63	.65 24 .63	.68 25 .68	.71 26 .73	.75 26 .73
	12	Calculated Thickness Use { Thickness Class Thickness	.63 24 .63	.65 24 .63	.68 25 .68	.70 25 .68	.73 26 .73	.76 27 .79	.79 27 .79
	16	Calculated Thickness Use { Thickness Class Thickness	.67 25 .68	.69 25 .68	.71 26 .73	.73 26 .73	.76 27 .79	.79 27 .79	.82 28 .85
F	2½	Calculated Thickness Use { Thickness Class Thickness	.47* 21 .50	.48* 21 .50	.50* 21 .50	.52* 22 .54	.56 23 .58	.61 24 .63	.67 25 .68
	3½	Calculated Thickness Use { Thickness Class Thickness	.46* 21 .50	.47* 21 .50	.50 21 .50	.53 22 .54	.57 23 .58	.62 24 .63	.67 25 .68
	5	Calculated Thickness Use { Thickness Class Thickness	.48* 21 .50	.50 21 .50	.52 22 .54	.56 23 .58	.59 24 .58	.64 24 .63	.68 25 .68
	8	Calculated Thickness Use { Thickness Class Thickness	.53 22 .54	.55 22 .54	.58 23 .58	.61 24 .63	.64 24 .63	.68 25 .68	.72 26 .73
	12	Calculated Thickness Use { Thickness Class Thickness	.57 23 .58	.59 23 .58	.62 24 .63	.65 24 .63	.68 25 .68	.71 26 .73	.75 26 .73
	16	Calculated Thickness Use { Thickness Class Thickness	.61 24 .63	.63 24 .63	.65 24 .63	.68 25 .68	.71 26 .73	.74 26 .73	.77 27 .79

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure— <i>psi</i>						
			50	100	150	200	250	300	350
			Barrel Thicknesses— <i>in.</i>						
Eighteen-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.56* 22 .58	.60* 22 .58	.62* 23 .63	.65* 23 .63	.67* 24 .68	.76* 24 .68	.74* 25 .73
	3½	Calculated Thickness Use { Thickness Class Thickness	.56* 22 .58	.55* 22 .58	.62* 23 .63	.64* 23 .63	.67* 24 .68	.70 24 .68	.76 26 .79
	5	Calculated Thickness Use { Thickness Class Thickness	.60* 22 .58	.62* 23 .63	.64* 23 .63	.67 24 .68	.70 24 .68	.75 25 .73	.79 26 .79
	8	Calculated Thickness Use { Thickness Class Thickness	.67 24 .68	.69 24 .68	.72 25 .73	.74 25 .73	.77 26 .79	.81 26 .79	.85 27 .85
	12	Calculated Thickness Use { Thickness Class Thickness	.73 25 .73	.75 25 .73	.78 26 .79	.80 26 .79	.83 27 .85	.86 27 .85	.90 28 .92
	16	Calculated Thickness Use { Thickness Class Thickness	.77 26 .79	.80 26 .79	.82 27 .85	.85 27 .85	.88 27 .85	.91 28 .92	.95 28 .92
B	2½	Calculated Thickness Use { Thickness Class Thickness	.54* 21 .54	.56* 22 .58	.58* 22 .58	.60* 22 .58	.63* 23 .63	.67 24 .68	.73 25 .73
	3½	Calculated Thickness Use { Thickness Class Thickness	.53* 21 .54	.55* 21 .54	.57* 22 .58	.60 22 .58	.64 23 .63	.69 24 .68	.75 25 .73
	5	Calculated Thickness Use { Thickness Class Thickness	.55* 21 .54	.58* 22 .58	.60 22 .58	.63 23 .63	.67 24 .68	.72 25 .73	.77 26 .79
	8	Calculated Thickness Use { Thickness Class Thickness	.62 23 .63	.64 23 .63	.67 24 .68	.70 24 .68	.74 25 .73	.77 26 .79	.82 27 .85
	12	Calculated Thickness Use { Thickness Class Thickness	.68 24 .68	.70 24 .68	.73 25 .73	.75 25 .73	.78 26 .79	.82 27 .85	.86 27 .85
	16	Calculated Thickness Use { Thickness Class Thickness	.72 25 .73	.74 25 .73	.76 26 .79	.79 26 .79	.82 27 .85	.85 27 .85	.89 28 .92
F	2½	Calculated Thickness Use { Thickness Class Thickness	.50* 21 .54	.51* 21 .54	.53* 21 .54	.56* 22 .58	.61 23 .63	.67 24 .68	.73 25 .73
	3½	Calculated Thickness Use { Thickness Class Thickness	.49* 21 .54	.51 21 .54	.53 21 .54	.57 22 .58	.62 23 .63	.67 24 .68	.73 25 .73
	5	Calculated Thickness Use { Thickness Class Thickness	.51* 21 .54	.53 21 .54	.57 22 .58	.60 22 .58	.65 23 .63	.70 24 .68	.75 25 .73
	8	Calculated Thickness Use { Thickness Class Thickness	.57 22 .58	.59 22 .58	.62 23 .63	.65 23 .63	.69 24 .68	.74 25 .73	.78 26 .79
	12	Calculated Thickness Use { Thickness Class Thickness	.61 23 .63	.64 23 .63	.67 24 .68	.70 24 .68	.73 25 .73	.77 26 .79	.81 26 .79
	16	Calculated Thickness Use { Thickness Class Thickness	.65 23 .63	.67 24 .68	.69 24 .68	.72 25 .73	.76 26 .79	.80 26 .79	.84 27 .85

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover <i>ft</i>	Thickness Specifications	Internal Pressure— <i>psi</i>						
			50	100	150	200	250	300	350
			Barrel Thicknesses— <i>in.</i>						
Twenty-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.62* 22 .62	.65* 23 .67	.67* 23 .67	.70* 24 .72	.73* 24 .72	.76* 25 .78	.80* 25 .78
	3½	Calculated Thickness Use { Thickness Class Thickness	.62* 22 .62	.64* 22 .62	.66* 23 .67	.69* 23 .67	.72* 24 .72	.76* 25 .78	.80 26 .84
	5	Calculated Thickness Use { Thickness Class Thickness	.65* 23 .67	.67* 23 .67	.69* 23 .67	.72* 24 .72	.75* 25 .78	.80 25 .78	.85 26 .84
	8	Calculated Thickness Use { Thickness Class Thickness	.71 24 .72	.73 24 .72	.76 25 .78	.79 25 .78	.83 26 .84	.87 26 .84	.91 27 .91
	12	Calculated Thickness Use { Thickness Class Thickness	.78 25 .78	.80 25 .78	.83 26 .84	.86 26 .84	.89 27 .91	.93 27 .91	.97 28 .98
	16	Calculated Thickness Use { Thickness Class Thickness	.83 26 .84	.86 26 .84	.88 27 .91	.91 27 .91	.94 27 .91	.97 28 .98	1.01 28 .98
B	2½	Calculated Thickness Use { Thickness Class Thickness	.57* 21 .57	.59* 21 .57	.62* 22 .62	.65* 23 .67	.68* 23 .67	.72 24 .72	.78 25 .78
	3½	Calculated Thickness Use { Thickness Class Thickness	.57* 21 .57	.58* 21 .57	.62* 22 .62	.64* 22 .62	.68 23 .67	.74 24 .72	.80 25 .78
	5	Calculated Thickness Use { Thickness Class Thickness	.59* 21 .57	.61* 22 .62	.64* 22 .62	.67 23 .67	.72 24 .72	.77 25 .78	.82 26 .84
	8	Calculated Thickness Use { Thickness Class Thickness	.65 23 .67	.68 23 .67	.71 24 .72	.74 24 .72	.78 25 .78	.82 26 .84	.87 26 .84
	12	Calculated Thickness Use { Thickness Class Thickness	.71 24 .72	.74 24 .72	.77 25 .78	.80 25 .78	.84 26 .84	.87 26 .84	.92 27 .91
	16	Calculated Thickness Use { Thickness Class Thickness	.76 25 .78	.78 25 .78	.81 26 .84	.84 26 .84	.87 26 .84	.91 27 .91	.95 28 .98
F	2½	Calculated Thickness Use { Thickness Class Thickness	.51* 21 .57	.53* 21 .57	.57* 21 .57	.60* 22 .62	.64 22 .62	.70 24 .72	.77 25 .78
	3½	Calculated Thickness Use { Thickness Class Thickness	.52 21 .57	.54 21 .57	.57 21 .57	.61 22 .62	.66 23 .67	.72 24 .72	.78 25 .78
	5	Calculated Thickness Use { Thickness Class Thickness	.53 21 .57	.56 21 .57	.60 22 .62	.64 22 .62	.69 23 .67	.74 24 .72	.80 25 .78
	8	Calculated Thickness Use { Thickness Class Thickness	.60 22 .62	.62 22 .62	.65 23 .67	.69 23 .67	.73 24 .72	.78 25 .78	.83 26 .84
	12	Calculated Thickness Use { Thickness Class Thickness	.65 23 .67	.68 23 .67	.71 24 .72	.74 24 .72	.78 25 .78	.82 26 .84	.87 26 .84
	16	Calculated Thickness Use { Thickness Class Thickness	.69 23 .67	.71 24 .72	.74 24 .72	.77 25 .78	.81 26 .84	.85 26 .84	.90 27 .91

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Twenty-four-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.69* 22 .68	.72* 23 .73	.75* 23 .73	.78* 24 .79	.82* 25 .85	.86* 25 .85	.91* 26 .92
	3½	Calculated Thickness Use { Thickness Class Thickness	.69* 22 .68	.71* 23 .73	.74* 23 .73	.78* 24 .79	.81* 24 .79	.86 25 .85	.93 26 .92
	5	Calculated Thickness Use { Thickness Class Thickness	.72* 23 .73	.75* 23 .73	.78* 24 .79	.81* 24 .79	.85* 25 .85	.91 26 .92	.96 27 .99
	8	Calculated Thickness Use { Thickness Class Thickness	.80 24 .79	.82 25 .85	.86 25 .85	.90 26 .92	.94 26 .92	.99 27 .99	1.04 28 1.07
	12	Calculated Thickness Use { Thickness Class Thickness	.88 25 .85	.91 26 .92	.94 26 .92	.98 27 .99	1.02 27 .99	1.06 28 1.07	1.10 28 1.07
	16	Calculated Thickness Use { Thickness Class Thickness	.94 26 .92	.97 27 .99	1.00 27 .99	1.03 28 1.07	1.07 28 1.07	1.11 28 1.07	1.15 29 1.16
B	2½	Calculated Thickness Use { Thickness Class Thickness	.63* 21 .63	.65* 21 .63	.68* 22 .68	.72* 23 .73	.76* 24 .79	.82 25 .85	.90 26 .92
	3½	Calculated Thickness Use { Thickness Class Thickness	.62* 21 .63	.65* 21 .63	.68* 22 .68	.71* 23 .73	.77 24 .79	.81 25 .85	.91 26 .92
	5	Calculated Thickness Use { Thickness Class Thickness	.65* 21 .63	.67* 22 .68	.71* 23 .73	.76 24 .79	.81 24 .79	.88 25 .85	.94 26 .92
	8	Calculated Thickness Use { Thickness Class Thickness	.72 23 .73	.75 23 .73	.79 24 .79	.83 25 .85	.88 25 .85	.94 26 .92	.99 27 .99
	12	Calculated Thickness Use { Thickness Class Thickness	.79 24 .79	.82 25 .85	.86 25 .85	.90 26 .92	.94 26 .92	.99 27 .99	1.04 28 1.07
	16	Calculated Thickness Use { Thickness Class Thickness	.85 25 .85	.88 25 .85	.91 26 .92	.95 26 .92	.99 27 .99	1.03 28 1.07	1.08 28 1.07
F	2½	Calculated Thickness Use { Thickness Class Thickness	.56* 21 .63	.58* 21 .63	.63* 21 .63	.67* 22 .68	.73 23 .73	.81 24 .79	.89 26 .92
	3½	Calculated Thickness Use { Thickness Class Thickness	.56* 21 .63	.59 21 .63	.63 21 .63	.69 22 .68	.75 23 .73	.82 25 .85	.90 26 .92
	5	Calculated Thickness Use { Thickness Class Thickness	.59 21 .63	.63 21 .63	.67 22 .68	.72 23 .73	.78 24 .79	.84 25 .85	.92 26 .92
	8	Calculated Thickness Use { Thickness Class Thickness	.66 22 .68	.69 22 .68	.73 23 .73	.77 24 .79	.83 25 .85	.89 26 .92	.95 26 .92
	12	Calculated Thickness Use { Thickness Class Thickness	.72 23 .73	.75 23 .73	.79 24 .79	.83 25 .85	.88 25 .85	.93 26 .92	.99 27 .99
	16	Calculated Thickness Use { Thickness Class Thickness	.77 24 .79	.80 24 .79	.83 25 .85	.87 25 .85	.91 26 .92	.96 27 .99	1.02 27 .99

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Thirty-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.83* 23 .85	.86* 23 .85	.90* 24 .92	.94* 24 .92	.98* 25 .99	1.04* 26 1.07	1.10 26 1.07
	3½	Calculated Thickness Use { Thickness Class Thickness	.82* 23 .85	.85* 23 .85	.89* 24 .92	.93* 24 .92	.98* 25 .99	1.04 26 1.07	1.12 27 1.16
	5	Calculated Thickness Use { Thickness Class Thickness	.86* 23 .85	.90* 24 .92	.93* 24 .92	.97* 25 .99	1.03 26 1.07	1.10 26 1.07	1.18 27 1.16
	8	Calculated Thickness Use { Thickness Class Thickness	.94* 24 .92	.98 25 .99	1.02 25 .99	1.07 26 1.07	1.12 27 1.16	1.19 27 1.16	1.25 28 1.25
	12	Calculated Thickness Use { Thickness Class Thickness	1.05 26 1.07	1.08 26 1.07	1.12 27 1.16	1.17 27 1.16	1.22 28 1.25	1.28 28 1.25	1.33 29 1.35
	16	Calculated Thickness Use { Thickness Class Thickness	1.13 27 1.16	1.17 27 1.16	1.20 27 1.16	1.25 28 1.25	1.29 28 1.25	1.35 29 1.35	1.40 29 1.35
B	2½	Calculated Thickness Use { Thickness Class Thickness	.74* 21 .73	.77* 22 .79	.81* 22 .79	.85* 23 .85	.90* 24 .92	.99 25 .99	1.09 26 1.07
	3½	Calculated Thickness Use { Thickness Class Thickness	.73* 21 .73	.76* 22 .79	.80* 22 .79	.85* 23 .85	.92 24 .92	1.01 25 .99	1.10 26 1.07
	5	Calculated Thickness Use { Thickness Class Thickness	.77* 22 .79	.80* 22 .79	.84* 23 .85	.90 24 .92	.97 25 .99	1.05 26 1.07	1.13 27 1.16
	8	Calculated Thickness Use { Thickness Class Thickness	.84 23 .85	.88 23 .85	.93 24 .92	.98 25 .99	1.05 26 1.07	1.11 26 1.07	1.18 27 1.16
	12	Calculated Thickness Use { Thickness Class Thickness	.93 24 .92	.97 25 .99	1.01 25 .99	1.06 26 1.07	1.12 27 1.16	1.18 27 1.16	1.25 28 1.25
	16	Calculated Thickness Use { Thickness Class Thickness	1.00 25 .99	1.04 26 1.07	1.08 26 1.07	1.13 27 1.16	1.18 27 1.16	1.24 28 1.25	1.30 29 1.35
F	2½	Calculated Thickness Use { Thickness Class Thickness	.66* 21 .73	.70* 21 .73	.74* 21 .73	.79* 22 .79	.88 23 .85	.98 25 .99	1.08 26 1.07
	3½	Calculated Thickness Use { Thickness Class Thickness	.66* 21 .73	.70* 21 .73	.74* 21 .73	.80 22 .79	.90 24 .92	1.00 25 .99	1.10 26 1.07
	5	Calculated Thickness Use { Thickness Class Thickness	.70* 21 .73	.73* 21 .73	.79 22 .79	.86 23 .85	.93 24 .92	1.01 25 .99	1.11 26 1.07
	8	Calculated Thickness Use { Thickness Class Thickness	.77 22 .79	.81 22 .79	.86 23 .85	.93 24 .92	1.00 25 .99	1.07 26 1.07	1.15 27 1.16
	12	Calculated Thickness Use { Thickness Class Thickness	.85 23 .85	.89 24 .92	.94 24 .92	.99 25 .99	1.05 26 1.07	1.12 27 1.16	1.20 27 1.16
	16	Calculated Thickness Use { Thickness Class Thickness	.91 24 .92	.95 24 .92	.99 25 .99	1.04 26 1.07	1.10 26 1.07	1.16 27 1.16	1.23 28 1.25

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condition	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Thirty-six-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	.94* 23 .94	.98* 24 1.02	1.02* 24 1.02	1.07* 25 1.10	1.13* 25 1.10	1.19* 26 1.19	1.27 27 1.29
	3½	Calculated Thickness Use { Thickness Class Thickness	.93* 23 .94	.97* 23 .94	1.02* 24 1.02	1.07* 25 1.10	1.12* 25 1.10	1.19 26 1.19	1.31 27 1.29
	5	Calculated Thickness Use { Thickness Class Thickness	.98* 24 1.02	1.02* 24 1.02	1.07* 25 1.10	1.12* 25 1.10	1.17* 26 1.19	1.26 27 1.29	1.35 28 1.39
	8	Calculated Thickness Use { Thickness Class Thickness	1.07* 25 1.10	1.11* 25 1.10	1.16 26 1.19	1.22 26 1.19	1.28 27 1.29	1.36 28 1.39	1.44 28 1.39
	12	Calculated Thickness Use { Thickness Class Thickness	1.19 26 1.19	1.24 27 1.29	1.28 27 1.29	1.34 28 1.39	1.40 28 1.39	1.47 29 1.50	1.54 29 1.50
	1	Calculated Thickness Use { Thickness Class Thickness	1.29 27 1.29	1.33 27 1.29	1.38 28 1.39	1.43 28 1.39	1.49 29 1.50	1.55 29 1.50	1.62 30 1.62
B	2½	Calculated Thickness Use { Thickness Class Thickness	.82* 21 .81	.86* 22 .87	.91* 23 .94	.97* 23 .94	1.03* 24 1.02	1.14 25 1.10	1.26 27 1.29
	3½	Calculated Thickness Use { Thickness Class Thickness	.81* 21 .81	.85* 22 .87	.90* 22 .87	.96* 23 .94	1.04 24 1.02	1.15 26 1.19	1.28 27 1.29
	5	Calculated Thickness Use { Thickness Class Thickness	.86* 22 .87	.90* 22 .87	.94* 23 .94	1.01 24 1.02	1.10 25 1.10	1.20 26 1.19	1.30 27 1.29
	8	Calculated Thickness Use { Thickness Class Thickness	.94 23 .94	.99 24 1.02	1.05 24 1.02	1.11 25 1.10	1.18 26 1.19	1.27 27 1.29	1.36 28 1.39
	12	Calculated Thickness Use { Thickness Class Thickness	1.05 24 1.02	1.09 25 1.10	1.14 25 1.10	1.20 26 1.19	1.27 27 1.29	1.34 28 1.39	1.43 28 1.39
	16	Calculated Thickness Use { Thickness Class Thickness	1.12 25 1.10	1.17 26 1.19	1.22 26 1.19	1.27 27 1.29	1.34 28 1.39	1.40 28 1.39	1.48 29 1.50
F	2½	Calculated Thickness Use { Thickness Class Thickness	.73* 21 .81	.79* 21 .81	.84* 22 .87	.89 22 .87	1.01 24 1.02	1.13 25 1.10	1.25 27 1.29
	3½	Calculated Thickness Use { Thickness Class Thickness	.73* 21 .81	.78* 21 .81	.83* 21 .81	.92 23 .94	1.03 24 1.02	1.14 25 1.10	1.26 27 1.29
	5	Calculated Thickness Use { Thickness Class Thickness	.78* 21 .81	.82* 21 .81	.89 22 .87	.97 23 .94	1.07 25 1.10	1.17 26 1.19	1.28 27 1.29
	8	Calculated Thickness Use { Thickness Class Thickness	.86 22 .87	.91 23 .94	.97 23 .94	1.04 24 1.02	1.13 25 1.10	1.22 26 1.19	1.33 27 1.29
	12	Calculated Thickness Use { Thickness Class Thickness	.95 23 .94	1.00 24 1.02	1.06 25 1.10	1.12 25 1.10	1.20 26 1.19	1.28 27 1.29	1.37 28 1.39
	16	Calculated Thickness Use { Thickness Class Thickness	1.02 24 1.02	1.07 25 1.10	1.12 25 1.10	1.18 26 1.19	1.25 27 1.29	1.33 27 1.29	1.42 28 1.39

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Forty-two-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	1.04* 23 1.05	1.08* 23 1.05	1.14* 24 1.13	1.20* 25 1.22	1.27* 26 1.32	1.34* 26 1.32	1.43 27 1.43
	3½	Calculated Thickness Use { Thickness Class Thickness	1.04* 23 1.05	1.08* 23 1.05	1.14* 24 1.13	1.20* 25 1.22	1.27* 26 1.32	1.33 26 1.32	1.46 27 1.43
	5	Calculated Thickness Use { Thickness Class Thickness	1.09* 24 1.13	1.14* 24 1.13	1.19* 25 1.22	1.25* 25 1.22	1.32* 26 1.32	1.43 27 1.43	1.52 28 1.54
	8	Calculated Thickness Use { Thickness Class Thickness	1.19* 25 1.22	1.24* 25 1.22	1.30 26 1.32	1.37 26 1.32	1.45 27 1.43	1.53 28 1.54	1.63 29 1.66
	12	Calculated Thickness Use { Thickness Class Thickness	1.33 26 1.32	1.38 27 1.43	1.44 27 1.43	1.50 28 1.54	1.58 28 1.54	1.65 29 1.66	1.74 30 1.79
	16	Calculated Thickness Use { Thickness Class Thickness	1.46 27 1.43	1.51 28 1.54	1.56 28 1.54	1.62 29 1.66	1.68 29 1.66	1.75 30 1.79	1.83 30 1.79
B	2½	Calculated Thickness Use { Thickness Class Thickness	.89* 21 .90	.94* 22 .97	1.00* 22 .97	1.07* 23 1.05	1.14 24 1.13	1.28 26 1.32	1.42 27 1.43
	3½	Calculated Thickness Use { Thickness Class Thickness	.89* 21 .90	.94* 22 .97	1.00* 22 .97	1.07* 23 1.05	1.17 24 1.13	1.30 26 1.32	1.43 27 1.43
	5	Calculated Thickness Use { Thickness Class Thickness	.94* 22 .97	.98* 22 .97	1.04* 23 1.05	1.13 24 1.13	1.23 25 1.22	1.34 26 1.32	1.47 27 1.43
	8	Calculated Thickness Use { Thickness Class Thickness	1.04 23 1.05	1.09 24 1.13	1.16 24 1.13	1.23 25 1.22	1.32 26 1.32	1.42 27 1.43	1.53 28 1.54
	12	Calculated Thickness Use { Thickness Class Thickness	1.15 24 1.13	1.21 25 1.22	1.27 26 1.32	1.33 26 1.32	1.42 27 1.43	1.51 28 1.54	1.60 29 1.66
	16	Calculated Thickness Use { Thickness Class Thickness	1.25 25 1.22	1.30 26 1.32	1.36 26 1.32	1.43 27 1.43	1.50 28 1.54	1.58 28 1.54	1.67 29 1.66
F	2½	Calculated Thickness Use { Thickness Class Thickness	.80* 21 .90	.86* 21 .90	.92* 21 .90	1.00 22 .97	1.15 24 1.13	1.28 26 1.32	1.42 27 1.43
	3½	Calculated Thickness Use { Thickness Class Thickness	.80* 21 .90	.86* 21 .90	.92* 21 .90	1.04 23 1.05	1.17 24 1.13	1.29 26 1.32	1.43 27 1.43
	5	Calculated Thickness Use { Thickness Class Thickness	.85* 21 .90	.90* 21 .90	.98 22 .97	1.08 23 1.05	1.19 25 1.22	1.32 26 1.32	1.45 27 1.43
	8	Calculated Thickness Use { Thickness Class Thickness	.94 22 .97	1.00 22 .97	1.08 23 1.05	1.16 24 1.13	1.26 25 1.22	1.36 26 1.32	1.49 28 1.54
	12	Calculated Thickness Use { Thickness Class Thickness	1.05 23 1.05	1.10 24 1.13	1.17 24 1.13	1.25 25 1.22	1.34 26 1.32	1.43 27 1.43	1.54 28 1.54
	16	Calculated Thickness Use { Thickness Class Thickness	1.13 24 1.13	1.18 25 1.22	1.24 25 1.22	1.32 26 1.32	1.40 27 1.43	1.49 28 1.54	1.59 28 1.54

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-1 (Continued)
Schedule of Barrel Thickness for Water Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thicknesses—in.						
Forty-eight-Inch Water Pipe									
A	2½	Calculated Thickness Use {Thickness Class Thickness	1.14* 23 1.14	1.19* 24 1.23	1.25* 24 1.23	1.32* 25 1.33	1.40* 26 1.44	1.49* 26 1.44	1.61 27 1.56
	3½	Calculated Thickness Use {Thickness Class Thickness	1.14* 23 1.14	1.20* 24 1.23	1.26* 24 1.23	1.33* 25 1.33	1.40* 26 1.44	1.50 27 1.56	1.66 28 1.68
	5	Calculated Thickness Use {Thickness Class Thickness	1.22* 24 1.23	1.27* 24 1.23	1.32* 25 1.33	1.39* 26 1.44	1.47 26 1.44	1.58 27 1.56	1.71 28 1.68
	8	Calculated Thickness Use {Thickness Class Thickness	1.33* 25 1.33	1.38* 25 1.33	1.44 26 1.44	1.53 27 1.56	1.61 27 1.56	1.71 28 1.68	1.83 29 1.81
	12	Calculated Thickness Use {Thickness Class Thickness	1.49 26 1.44	1.55 27 1.56	1.61 27 1.56	1.69 28 1.68	1.77 29 1.81	1.85 29 1.81	1.96 30 1.95
	16	Calculated Thickness Use {Thickness Class Thickness	1.63 28 1.68	1.68 28 1.68	1.74 28 1.68	1.81 29 1.81	1.89 30 1.95	1.98 30 1.95	2.08
B	2½	Calculated Thickness Use {Thickness Class Thickness	.97* 21 .98	1.03* 22 1.06	1.09* 22 1.06	1.17* 23 1.14	1.28 25 1.33	1.43 26 1.44	1.59 27 1.56
	3½	Calculated Thickness Use {Thickness Class Thickness	.98* 21 .98	1.03* 22 1.06	1.10* 23 1.14	1.17 23 1.14	1.31 25 1.33	1.45 26 1.44	1.61 27 1.56
	5	Calculated Thickness Use {Thickness Class Thickness	1.03* 22 1.06	1.09* 22 1.06	1.15* 23 1.14	1.25 24 1.23	1.37 25 1.33	1.50 27 1.56	1.65 28 1.68
	8	Calculated Thickness Use {Thickness Class Thickness	1.13 23 1.14	1.20 24 1.23	1.28 25 1.33	1.37 25 1.33	1.47 26 1.44	1.58 27 1.56	1.72 28 1.68
	12	Calculated Thickness Use {Thickness Class Thickness	1.28 25 1.33	1.34 25 1.33	1.41 26 1.44	1.49 26 1.44	1.58 27 1.56	1.69 28 1.68	1.80 29 1.81
	16	Calculated Thickness Use {Thickness Class Thickness	1.38 25 1.33	1.43 26 1.44	1.50 27 1.56	1.58 27 1.56	1.67 28 1.68	1.77 29 1.81	1.87 29 1.81
F	2½	Calculated Thickness Use {Thickness Class Thickness	.88* 21 .98	.93* 21 .98	1.00* 21 .98	1.12 23 1.14	1.27 24 1.23	1.43 26 1.44	1.59 27 1.56
	3½	Calculated Thickness Use {Thickness Class Thickness	.88* 21 .98	.94* 21 .98	1.01* 21 .98	1.14 23 1.14	1.29 25 1.33	1.44 26 1.44	1.60 27 1.56
	5	Calculated Thickness Use {Thickness Class Thickness	.93* 21 .98	.99* 21 .98	1.08 22 1.06	1.20 24 1.23	1.33 25 1.33	1.48 26 1.44	1.63 28 1.68
	8	Calculated Thickness Use {Thickness Class Thickness	1.03 22 1.06	1.10 23 1.14	1.19 24 1.23	1.28 25 1.33	1.40 26 1.44	1.52 27 1.56	1.67 28 1.68
	12	Calculated Thickness Use {Thickness Class Thickness	1.15 23 1.14	1.22 24 1.23	1.29 25 1.33	1.39 26 1.44	1.48 26 1.44	1.60 27 1.56	1.73 28 1.68
	16	Calculated Thickness Use {Thickness Class Thickness	1.25 24 1.23	1.31 25 1.33	1.38 25 1.33	1.46 26 1.44	1.56 27 1.56	1.67 28 1.68	1.78 29 1.81

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condition	Depth of Cover ft	Thickness Specifications	Internal Pressure— <i>psi</i>						
			50	100	150	200	250	300	350
			Barrel Thickness— <i>in.</i>						
Three-Inch Water Pipe									
A	2½	Calculated Thickness Use {Thickness Class Thickness	0.20* 22 0.32	0.20* 22 0.32	0.20* 22 0.32	0.20* 22 0.32	0.21* 22 0.32	0.21* 22 0.32	0.21 22 0.32
	3½	Calculated Thickness Use {Thickness Class Thickness	0.20* 22 0.32	0.20* 22 0.32	0.20* 22 0.32	0.21* 22 0.32	0.21* 22 0.32	0.22* 22 0.32	0.22 22 0.32
	5	Calculated Thickness Use {Thickness Class Thickness	0.21 22 0.32	0.21 22 0.32	0.21 22 0.32	0.22 22 0.32	0.22 22 0.32	0.23 22 0.32	0.23 22 0.32
	8	Calculated Thickness Use {Thickness Class Thickness	0.22 22 0.32	0.23 22 0.32	0.23 22 0.32	0.23 22 0.32	0.24 22 0.32	0.24 22 0.32	0.25 22 0.32
	12	Calculated Thickness Use {Thickness Class Thickness	0.24 22 0.32	0.25 22 0.32	0.25 22 0.32	0.25 22 0.32	0.26 22 0.32	0.26 22 0.32	0.26 22 0.32
	16	Calculated Thickness Use {Thickness Class Thickness	0.26 22 0.32	0.26 22 0.32	0.27 22 0.32	0.27 22 0.32	0.27 22 0.32	0.28 22 0.32	0.28 22 0.32
B	2½	Calculated Thickness Use {Thickness Class Thickness	0.19* 22 0.32	0.20* 22 0.32	0.20* 22 0.32	0.20* 22 0.32	0.21 22 0.32	0.22 22 0.32	0.22 22 0.32
	3½	Calculated Thickness Use {Thickness Class Thickness	0.19* 22 0.32	0.20* 22 0.32	0.20 22 0.32	0.21 22 0.32	0.21 22 0.32	0.22 22 0.32	0.22 22 0.32
	5	Calculated Thickness Use {Thickness Class Thickness	0.21 22 0.32	0.21 22 0.32	0.21 22 0.32	0.21 22 0.32	0.22 22 0.32	0.22 22 0.32	0.23 22 0.32
	8	Calculated Thickness Use {Thickness Class Thickness	0.22 22 0.32	0.22 22 0.32	0.22 22 0.32	0.23 22 0.32	0.23 22 0.32	0.24 22 0.32	0.24 22 0.32
	12	Calculated Thickness Use {Thickness Class Thickness	0.24 22 0.32	0.24 22 0.32	0.24 22 0.32	0.25 22 0.32	0.25 22 0.32	0.25 22 0.32	0.26 22 0.32
	16	Calculated Thickness Use {Thickness Class Thickness	0.25 22 0.32	0.26 22 0.32	0.26 22 0.32	0.26 22 0.32	0.27 22 0.32	0.27 22 0.32	0.27 22 0.32
F	2½	Calculated Thickness Use {Thickness Class Thickness	0.19* 22 0.32	0.19* 22 0.32	0.19 22 0.32	0.20 22 0.32	0.20 22 0.32	0.21 22 0.32	0.22 22 0.32
	3½	Calculated Thickness Use {Thickness Class Thickness	0.19* 22 0.32	0.19 22 0.32	0.19 22 0.32	0.20 22 0.32	0.20 22 0.32	0.21 22 0.32	0.22 22 0.32
	5	Calculated Thickness Use {Thickness Class Thickness	0.19 22 0.32	0.20 22 0.32	0.20 22 0.32	0.21 22 0.32	0.21 22 0.32	0.22 22 0.32	0.22 22 0.32
	8	Calculated Thickness Use {Thickness Class Thickness	0.21 22 0.32	0.21 22 0.32	0.21 22 0.32	0.22 22 0.32	0.22 22 0.32	0.23 22 0.32	0.23 22 0.32
	12	Calculated Thickness Use {Thickness Class Thickness	0.22 22 0.32	0.22 22 0.32	0.23 22 0.32	0.23 22 0.32	0.24 22 0.32	0.24 22 0.32	0.25 22 0.32
	16	Calculated Thickness Use {Thickness Class Thickness	0.24 22 0.32	0.24 22 0.32	0.24 22 0.32	0.25 22 0.32	0.25 22 0.32	0.25 22 0.32	0.26 22 0.32

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Four-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	0.22* 22 0.35	0.23* 22 0.35	0.23* 22 0.35	0.24* 22 0.35	0.24* 22 0.35	0.25* 22 0.35	0.25* 22 0.35
	3½	Calculated Thickness Use { Thickness Class Thickness	0.22* 22 0.35	0.22* 22 0.35	0.23* 22 0.35	0.23* 22 0.35	0.24 22 0.35	0.25 22 0.35	0.26 22 0.35
	5	Calculated Thickness Use { Thickness Class Thickness	0.23* 22 0.35	0.23* 22 0.35	0.24* 22 0.35	0.24* 22 0.35	0.25 22 0.35	0.26 22 0.35	0.26 22 0.35
	8	Calculated Thickness Use { Thickness Class Thickness	0.25 22 0.35	0.26 22 0.35	0.26 22 0.35	0.27 22 0.35	0.27 22 0.35	0.28 22 0.35	0.28 22 0.35
	12	Calculated Thickness Use { Thickness Class Thickness	0.28 22 0.35	0.28 22 0.35	0.29 22 0.35	0.29 22 0.35	0.29 22 0.35	0.30 22 0.35	0.31 22 0.35
	16	Calculated Thickness Use { Thickness Class Thickness	0.30 22 0.35	0.30 22 0.35	0.31 22 0.35	0.31 22 0.35	0.32 22 0.35	0.32 22 0.35	0.33 22 0.35
B	2½	Calculated Thickness Use { Thickness Class Thickness	0.22* 22 0.35	0.22* 22 0.35	0.23* 22 0.35	0.23* 22 0.35	0.24* 22 0.35	0.24* 22 0.35	0.24 22 0.35
	3½	Calculated Thickness Use { Thickness Class Thickness	0.22* 22 0.35	0.22* 22 0.35	0.22* 22 0.35	0.23* 22 0.35	0.24 22 0.35	0.24 22 0.35	0.25 22 0.35
	5	Calculated Thickness Use { Thickness Class Thickness	0.22 22 0.35	0.23 22 0.35	0.23 22 0.35	0.24 22 0.35	0.25 22 0.35	0.25 22 0.35	0.26 22 0.35
	8	Calculated Thickness Use { Thickness Class Thickness	0.25 22 0.35	0.25 22 0.35	0.25 22 0.35	0.26 22 0.35	0.27 22 0.35	0.28 22 0.35	0.28 22 0.35
	12	Calculated Thickness Use { Thickness Class Thickness	0.27 22 0.35	0.27 22 0.35	0.28 22 0.35	0.28 22 0.35	0.29 22 0.35	0.29 22 0.35	0.30 22 0.35
	16	Calculated Thickness Use { Thickness Class Thickness	0.29 22 0.35	0.29 22 0.35	0.30 22 0.35	0.30 22 0.35	0.31 22 0.35	0.31 22 0.35	0.32 22 0.35
F	2½	Calculated Thickness Use { Thickness Class Thickness	0.21* 22 0.35	0.21* 22 0.35	0.21* 22 0.35	0.22* 22 0.35	0.23 22 0.35	0.24 22 0.35	0.25 22 0.35
	3½	Calculated Thickness Use { Thickness Class Thickness	0.20* 22 0.35	0.21 22 0.35	0.21 22 0.35	0.22 22 0.35	0.23 22 0.35	0.24 22 0.35	0.25 22 0.35
	5	Calculated Thickness Use { Thickness Class Thickness	0.21 22 0.35	0.22 22 0.35	0.22 22 0.35	0.23 22 0.35	0.24 22 0.35	0.25 22 0.35	0.25 22 0.35
	8	Calculated Thickness Use { Thickness Class Thickness	0.23 22 0.35	0.24 22 0.35	0.24 22 0.35	0.25 22 0.35	0.25 22 0.35	0.26 22 0.35	0.27 22 0.35
	12	Calculated Thickness Use { Thickness Class Thickness	0.25 22 0.35	0.26 22 0.35	0.26 22 0.35	0.27 22 0.35	0.27 22 0.35	0.28 22 0.35	0.28 22 0.35
	16	Calculated Thickness Use { Thickness Class Thickness	0.27 22 0.35	0.27 22 0.35	0.28 22 0.35	0.28 22 0.35	0.29 22 0.35	0.29 22 0.35	0.30 22 0.35

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condition	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Six-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	0.28* 21 0.35	0.28* 21 0.35	0.29* 21 0.35	0.30* 21 0.35	0.30* 21 0.35	0.31* 21 0.35	0.32* 21 0.35
	3½	Calculated Thickness Use { Thickness Class Thickness	0.27* 21 0.35	0.27* 21 0.35	0.28* 21 0.35	0.29* 21 0.35	0.29* 21 0.35	0.30* 21 0.35	0.32 21 0.35
	5	Calculated Thickness Use { Thickness Class Thickness	0.28* 21 0.35	0.28* 21 0.35	0.29 21 0.35	0.30 21 0.35	0.31 21 0.35	0.32 21 0.35	0.33 21 0.35
	8	Calculated Thickness Use { Thickness Class Thickness	0.31 21 0.35	0.31 21 0.35	0.32 21 0.35	0.33 21 0.35	0.34 21 0.35	0.35 21 0.35	0.36 21 0.35
	12	Calculated Thickness Use { Thickness Class Thickness	0.34 21 0.35	0.35 21 0.35	0.36 21 0.35	0.36 21 0.35	0.37 22 0.38	0.38 22 0.38	0.39 22 0.38
	16	Calculated Thickness Use { Thickness Class Thickness	0.38 22 0.38	0.38 22 0.38	0.39 22 0.38	0.39 22 0.38	0.40 23 0.41	0.41 23 0.41	0.42 23 0.41
B	2½	Calculated Thickness Use { Thickness Class Thickness	0.27* 21 0.35	0.27* 21 0.35	0.28* 21 0.35	0.29* 21 0.35	0.29* 21 0.35	0.30* 21 0.35	0.31* 21 0.35
	3½	Calculated Thickness Use { Thickness Class Thickness	0.26* 21 0.35	0.27* 21 0.35	0.27* 21 0.35	0.28* 21 0.35	0.29* 21 0.35	0.30 21 0.35	0.31 21 0.35
	5	Calculated Thickness Use { Thickness Class Thickness	0.27* 21 0.35	0.27* 21 0.35	0.28* 21 0.35	0.29 21 0.35	0.30 21 0.35	0.31 21 0.35	0.32 21 0.35
	8	Calculated Thickness Use { Thickness Class Thickness	0.30 21 0.35	0.30 21 0.35	0.31 21 0.35	0.32 21 0.35	0.33 21 0.35	0.34 21 0.35	0.35 21 0.35
	12	Calculated Thickness Use { Thickness Class Thickness	0.33 21 0.35	0.34 21 0.35	0.34 21 0.35	0.35 21 0.35	0.36 21 0.35	0.37 22 0.38	0.38 22 0.38
	16	Calculated Thickness Use { Thickness Class Thickness	0.36 21 0.35	0.37 22 0.38	0.37 22 0.38	0.38 22 0.38	0.39 22 0.38	0.39 22 0.38	0.40 23 0.41
F	2½	Calculated Thickness Use { Thickness Class Thickness	0.25* 21 0.35	0.26* 21 0.35	0.26* 21 0.35	0.27* 21 0.35	0.28* 21 0.35	0.29* 21 0.35	0.30 21 0.35
	3½	Calculated Thickness Use { Thickness Class Thickness	0.24* 21 0.35	0.25* 21 0.35	0.25 21 0.35	0.26 21 0.35	0.28 21 0.35	0.29 21 0.35	0.31 21 0.35
	5	Calculated Thickness Use { Thickness Class Thickness	0.25 21 0.35	0.26 21 0.35	0.27 21 0.35	0.28 21 0.35	0.29 21 0.35	0.30 21 0.35	0.31 21 0.35
	8	Calculated Thickness Use { Thickness Class Thickness	0.28 21 0.35	0.28 21 0.35	0.29 21 0.35	0.30 21 0.35	0.31 21 0.35	0.32 21 0.35	0.33 21 0.35
	12	Calculated Thickness Use { Thickness Class Thickness	0.31 21 0.35	0.31 21 0.35	0.32 21 0.35	0.33 21 0.35	0.34 21 0.35	0.34 21 0.35	0.35 21 0.35
	16	Calculated Thickness Use { Thickness Class Thickness	0.33 21 0.35	0.34 21 0.35	0.34 21 0.35	0.35 21 0.35	0.36 21 0.35	0.37 22 0.38	0.38 22 0.38

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Eight-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	0.33* 20 0.35	0.33* 20 0.35	0.34* 20 0.35	0.35* 20 0.35	0.36* 20 0.35	0.37* 21 0.38	0.38* 21 0.38
	3½	Calculated Thickness Use { Thickness Class Thickness	0.32* 20 0.35	0.32* 20 0.35	0.33* 20 0.35	0.34* 20 0.35	0.35* 20 0.35	0.36* 20 0.35	0.38 21 0.38
	5	Calculated Thickness Use { Thickness Class Thickness	0.32* 20 0.35	0.33* 20 0.35	0.34* 20 0.35	0.35 20 0.35	0.36 20 0.35	0.38 21 0.38	0.39 21 0.38
	8	Calculated Thickness Use { Thickness Class Thickness	0.36 20 0.35	0.37 21 0.38	0.38 21 0.38	0.39 21 0.38	0.40 22 0.41	0.41 22 0.41	0.43 23 0.44
	12	Calculated Thickness Use { Thickness Class Thickness	0.41 22 0.41	0.42 22 0.41	0.43 23 0.44	0.44 23 0.44	0.45 23 0.44	0.46 24 0.48	0.47 24 0.48
	16	Calculated Thickness Use { Thickness Class Thickness	0.44 23 0.44	0.45 23 0.44	0.46 24 0.48	0.47 24 0.48	0.47 24 0.48	0.48 24 0.48	0.50 25 0.52
B	2½	Calculated Thickness Use { Thickness Class Thickness	0.31* 20 0.35	0.32* 20 0.35	0.33* 20 0.35	0.34* 20 0.35	0.35* 20 0.35	0.36* 20 0.35	0.37* 21 0.38
	3½	Calculated Thickness Use { Thickness Class Thickness	0.30* 20 0.35	0.31* 20 0.35	0.32* 20 0.35	0.33* 20 0.35	0.34* 20 0.35	0.35 20 0.35	0.37 21 0.38
	5	Calculated Thickness Use { Thickness Class Thickness	0.31* 20 0.35	0.32* 20 0.35	0.33 20 0.35	0.34 20 0.35	0.35 20 0.35	0.37 21 0.38	0.38 21 0.38
	8	Calculated Thickness Use { Thickness Class Thickness	0.35 20 0.35	0.35 20 0.35	0.36 20 0.35	0.37 21 0.38	0.39 21 0.38	0.40 22 0.41	0.41 22 0.41
	12	Calculated Thickness Use { Thickness Class Thickness	0.39 21 0.38	0.40 22 0.41	0.41 22 0.41	0.42 22 0.41	0.43 23 0.44	0.44 23 0.44	0.45 23 0.44
	16	Calculated Thickness Use { Thickness Class Thickness	0.42 22 0.41	0.43 23 0.44	0.44 23 0.44	0.44 23 0.44	0.45 23 0.44	0.46 24 0.48	0.48 24 0.48
F	2½	Calculated Thickness Use { Thickness Class Thickness	0.29* 20 0.35	0.30* 20 0.35	0.30* 20 0.35	0.31* 20 0.35	0.32* 20 0.35	0.34 20 0.35	0.36 20 0.35
	3½	Calculated Thickness Use { Thickness Class Thickness	0.28* 20 0.35	0.29* 20 0.35	0.30* 20 0.35	0.31* 20 0.35	0.33 20 0.35	0.35 20 0.35	0.36 20 0.35
	5	Calculated Thickness Use { Thickness Class Thickness	0.29* 20 0.35	0.30 20 0.35	0.31 20 0.35	0.32 20 0.35	0.34 20 0.35	0.36 20 0.35	0.37 21 0.38
	8	Calculated Thickness Use { Thickness Class Thickness	0.32 20 0.35	0.33 20 0.35	0.34 20 0.35	0.35 20 0.35	0.36 20 0.35	0.38 21 0.38	0.39 21 0.38
	12	Calculated Thickness Use { Thickness Class Thickness	0.36 20 0.35	0.37 21 0.38	0.38 21 0.38	0.39 21 0.38	0.40 22 0.41	0.41 22 0.41	0.42 22 0.41
	16	Calculated Thickness Use { Thickness Class Thickness	0.38 21 0.38	0.39 21 0.38	0.40 22 0.41	0.41 22 0.41	0.42 22 0.41	0.43 23 0.44	0.44 23 0.44

*Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Ten-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	0.38* 20 0.38	0.39* 20 0.38	0.40* 21 0.41	0.41* 21 0.41	0.42* 21 0.41	0.44* 22 0.44	0.45* 22 0.44
	3½	Calculated Thickness Use { Thickness Class Thickness	0.37* 20 0.38	0.38* 20 0.38	0.39* 20 0.38	0.40* 21 0.41	0.41* 21 0.41	0.43* 22 0.44	0.44 22 0.44
	5	Calculated Thickness Use { Thickness Class Thickness	0.38* 20 0.38	0.39* 20 0.38	0.40* 21 0.41	0.41 21 0.41	0.43 22 0.44	0.44 22 0.44	0.46 23 0.48
	8	Calculated Thickness Use { Thickness Class Thickness	0.42 21 0.41	0.44 22 0.44	0.45 22 0.44	0.46 23 0.48	0.47 23 0.48	0.49 23 0.48	0.51 24 0.52
	12	Calculated Thickness Use { Thickness Class Thickness	0.48 23 0.48	0.49 23 0.48	0.50 24 0.52	0.51 24 0.52	0.53 24 0.52	0.54 25 0.56	0.56 25 0.56
	16	Calculated Thickness Use { Thickness Class Thickness	0.51 24 0.52	0.52 24 0.52	0.53 24 0.52	0.54 25 0.56	0.55 25 0.56	0.56 25 0.56	0.58 26 0.60
B	2½	Calculated Thickness Use { Thickness Class Thickness	0.36* 20 0.38	0.37* 20 0.38	0.38* 20 0.38	0.39* 20 0.38	0.41* 21 0.41	0.42* 21 0.41	0.44* 22 0.44
	3½	Calculated Thickness Use { Thickness Class Thickness	0.35* 20 0.38	0.36* 20 0.38	0.37* 20 0.38	0.39* 20 0.38	0.40* 21 0.41	0.41 21 0.41	0.44 22 0.44
	5	Calculated Thickness Use { Thickness Class Thickness	0.36* 20 0.38	0.37* 20 0.38	0.38* 20 0.38	0.40 21 0.41	0.41 21 0.41	0.43 22 0.44	0.46 23 0.48
	8	Calculated Thickness Use { Thickness Class Thickness	0.40 21 0.41	0.42 21 0.41	0.43 22 0.44	0.44 22 0.44	0.46 23 0.48	0.47 23 0.48	0.49 23 0.48
	12	Calculated Thickness Use { Thickness Class Thickness	0.46 23 0.48	0.47 23 0.48	0.48 23 0.48	0.49 23 0.48	0.50 24 0.52	0.52 24 0.52	0.53 24 0.52
	16	Calculated Thickness Use { Thickness Class Thickness	0.48 23 0.48	0.49 23 0.48	0.50 24 0.52	0.51 24 0.52	0.52 24 0.52	0.54 25 0.56	0.55 25 0.56
F	2½	Calculated Thickness Use { Thickness Class Thickness	0.33* 20 0.38	0.34* 20 0.38	0.35* 20 0.38	0.37* 20 0.38	0.38* 20 0.38	0.40 21 0.41	0.43 22 0.44
	3½	Calculated Thickness Use { Thickness Class Thickness	0.33* 20 0.38	0.33* 20 0.38	0.35* 20 0.38	0.36* 20 0.38	0.38 20 0.38	0.40 21 0.41	0.43 22 0.44
	5	Calculated Thickness Use { Thickness Class Thickness	0.33* 20 0.38	0.34 20 0.38	0.36 20 0.38	0.38 20 0.38	0.40 21 0.41	0.42 21 0.41	0.44 22 0.44
	8	Calculated Thickness Use { Thickness Class Thickness	0.37 20 0.38	0.38 20 0.38	0.40 21 0.41	0.41 21 0.41	0.43 22 0.44	0.45 22 0.44	0.47 23 0.48
	12	Calculated Thickness Use { Thickness Class Thickness	0.42 21 0.41	0.43 22 0.44	0.44 22 0.44	0.45 22 0.44	0.47 23 0.48	0.48 23 0.48	0.50 24 0.52
	16	Calculated Thickness Use { Thickness Class Thickness	0.44 22 0.44	0.45 22 0.44	0.46 23 0.48	0.47 23 0.48	0.48 23 0.48	0.50 24 0.52	0.52 24 0.52

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure— <i>psi</i>						
			50	100	150	200	250	300	350
			Barrel Thickness— <i>in.</i>						
Twelve-Inch Water Pipe									
A	2½	Calculated Thickness Use {Thickness Class Thickness	0.43* 21 0.44	0.44* 21 0.44	0.45* 21 0.44	0.47* 22 0.48	0.48* 22 0.48	0.49* 22 0.48	0.51* 23 0.52
	3½	Calculated Thickness Use {Thickness Class Thickness	0.42* 20 0.41	0.43* 21 0.44	0.44* 21 0.44	0.45* 21 0.44	0.47* 22 0.48	0.48* 22 0.48	0.50* 23 0.52
	5	Calculated Thickness Use {Thickness Class Thickness	0.43* 21 0.44	0.44* 21 0.44	0.45* 21 0.44	0.46* 22 0.48	0.48 22 0.48	0.50 23 0.52	0.52 23 0.52
	8	Calculated Thickness Use {Thickness Class Thickness	0.48 22 0.48	0.49 22 0.48	0.50 23 0.52	0.52 23 0.52	0.54 24 0.56	0.55 24 0.56	0.57 24 0.56
	12	Calculated Thickness Use {Thickness Class Thickness	0.53 23 0.52	0.54 24 0.56	0.56 24 0.56	0.57 24 0.56	0.58 25 0.60	0.60 25 0.60	0.62 25 0.60
	16	Calculated Thickness Use {Thickness Class Thickness	0.56 24 0.56	0.57 24 0.56	0.58 25 0.60	0.60 25 0.60	0.61 25 0.60	0.63 26 0.65	0.64 26 0.65
B	2½	Calculated Thickness Use {Thickness Class Thickness	0.41* 20 0.41	0.42* 20 0.41	0.43* 21 0.44	0.44* 21 0.44	0.46* 22 0.48	0.47* 22 0.48	0.49* 22 0.48
	3½	Calculated Thickness Use {Thickness Class Thickness	0.39* 20 0.41	0.40* 20 0.41	0.42* 20 0.41	0.43* 21 0.44	0.45* 21 0.44	0.46* 22 0.48	0.49 22 0.48
	5	Calculated Thickness Use {Thickness Class Thickness	0.40* 20 0.41	0.41* 20 0.41	0.42* 20 0.41	0.44* 21 0.44	0.46 22 0.48	0.48 22 0.48	0.51 23 0.52
	8	Calculated Thickness Use {Thickness Class Thickness	0.45 21 0.44	0.46 22 0.48	0.48 22 0.48	0.49 22 0.48	0.51 23 0.52	0.53 23 0.52	0.55 24 0.56
	12	Calculated Thickness Use {Thickness Class Thickness	0.50 23 0.52	0.51 23 0.52	0.52 23 0.52	0.54 24 0.56	0.56 24 0.56	0.57 24 0.56	0.59 25 0.60
	16	Calculated Thickness Use {Thickness Class Thickness	0.52 23 0.52	0.54 24 0.56	0.55 24 0.56	0.56 24 0.56	0.58 25 0.60	0.60 25 0.60	0.61 25 0.60
F	2½	Calculated Thickness Use {Thickness Class Thickness	0.37* 20 0.41	0.38* 20 0.41	0.39* 20 0.41	0.41* 20 0.41	0.42* 20 0.41	0.44* 21 0.44	0.48 22 0.48
	3½	Calculated Thickness Use {Thickness Class Thickness	0.36* 20 0.41	0.37* 20 0.41	0.38* 20 0.41	0.40* 20 0.41	0.42 20 0.41	0.45 21 0.44	0.48 22 0.48
	5	Calculated Thickness Use {Thickness Class Thickness	0.37* 20 0.41	0.38* 20 0.41	0.39* 20 0.41	0.42 20 0.41	0.44 21 0.44	0.47 22 0.48	0.49 22 0.48
	8	Calculated Thickness Use {Thickness Class Thickness	0.41 20 0.41	0.43 21 0.44	0.44 21 0.44	0.46 22 0.48	0.48 22 0.48	0.50 23 0.52	0.53 23 0.52
	12	Calculated Thickness Use {Thickness Class Thickness	0.45 21 0.44	0.47 22 0.48	0.48 22 0.48	0.50 23 0.52	0.52 23 0.52	0.54 24 0.56	0.56 24 0.56
	16	Calculated Thickness Use {Thickness Class Thickness	0.48 22 0.48	0.49 22 0.48	0.50 23 0.52	0.52 23 0.52	0.54 24 0.56	0.55 24 0.56	0.57 24 0.56

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure— <i>psi</i>						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Fourteen-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	0.48* 21 0.48	0.50* 22 0.51	0.51* 22 0.51	0.53* 23 0.55	0.54* 23 0.55	0.56* 23 0.55	0.58* 24 0.59
	3½	Calculated Thickness Use { Thickness Class Thickness	0.47* 21 0.48	0.49* 21 0.48	0.50* 22 0.51	0.52* 22 0.51	0.53* 23 0.55	0.55* 23 0.55	0.58 24 0.59
	5	Calculated Thickness Use { Thickness Class Thickness	0.49* 21 0.48	0.51* 22 0.51	0.52* 22 0.51	0.53* 23 0.55	0.55* 23 0.55	0.58 24 0.59	0.60 24 0.59
	8	Calculated Thickness Use { Thickness Class Thickness	0.55 23 0.55	0.56 23 0.55	0.58 24 0.59	0.60 24 0.59	0.62 25 0.64	0.64 25 0.64	0.66 25 0.64
	12	Calculated Thickness Use { Thickness Class Thickness	0.60 24 0.59	0.61 24 0.59	0.63 25 0.64	0.65 25 0.64	0.67 26 0.69	0.68 26 0.69	0.71 26 0.69
	16	Calculated Thickness Use { Thickness Class Thickness	0.63 25 0.64	0.65 25 0.64	0.66 25 0.64	0.68 26 0.69	0.69 26 0.69	0.71 26 0.69	0.73 27 0.75
B	2½	Calculated Thickness Use { Thickness Class Thickness	0.45* 21 0.48	0.47* 21 0.48	0.48* 21 0.48	0.50* 22 0.51	0.51* 22 0.51	0.53* 23 0.55	0.56* 23 0.55
	3½	Calculated Thickness Use { Thickness Class Thickness	0.44* 21 0.48	0.46* 21 0.48	0.47* 21 0.48	0.49* 21 0.48	0.51* 22 0.51	0.53 23 0.55	0.57 24 0.59
	5	Calculated Thickness Use { Thickness Class Thickness	0.46* 21 0.48	0.47* 21 0.48	0.49* 21 0.48	0.50 22 0.51	0.53 23 0.55	0.56 23 0.55	0.59 24 0.59
	8	Calculated Thickness Use { Thickness Class Thickness	0.52 22 0.51	0.53 23 0.55	0.55 23 0.55	0.57 24 0.59	0.59 24 0.59	0.61 24 0.59	0.64 25 0.64
	12	Calculated Thickness Use { Thickness Class Thickness	0.56 23 0.55	0.57 24 0.59	0.59 24 0.59	0.61 24 0.59	0.63 25 0.64	0.65 25 0.64	0.67 26 0.69
	16	Calculated Thickness Use { Thickness Class Thickness	0.59 24 0.59	0.60 24 0.59	0.62 25 0.64	0.64 25 0.64	0.65 25 0.64	0.67 26 0.69	0.70 26 0.69
F	2½	Calculated Thickness Use { Thickness Class Thickness	0.42* 21 0.48	0.43* 21 0.48	0.44* 21 0.48	0.46* 21 0.48	0.48* 21 0.48	0.51 22 0.51	0.55 23 0.55
	3½	Calculated Thickness Use { Thickness Class Thickness	0.41* 21 0.48	0.42* 21 0.48	0.44* 21 0.48	0.45* 21 0.48	0.48 21 0.48	0.52 22 0.51	0.56 23 0.55
	5	Calculated Thickness Use { Thickness Class Thickness	0.42* 21 0.48	0.43* 21 0.48	0.45 21 0.48	0.48 21 0.48	0.51 22 0.51	0.54 23 0.55	0.57 24 0.59
	8	Calculated Thickness Use { Thickness Class Thickness	0.47 21 0.48	0.49 21 0.48	0.51 22 0.51	0.53 23 0.55	0.55 23 0.55	0.58 24 0.59	0.61 24 0.59
	12	Calculated Thickness Use { Thickness Class Thickness	0.51 22 0.51	0.53 23 0.55	0.54 23 0.55	0.56 23 0.55	0.59 24 0.59	0.61 24 0.59	0.63 25 0.64
	16	Calculated Thickness Use { Thickness Class Thickness	0.54 23 0.55	0.55 23 0.55	0.57 24 0.59	0.59 24 0.59	0.61 24 0.59	0.63 25 0.64	0.65 25 0.64

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Sixteen-Inch Water Pipe									
A	2½	Calculated Thickness Use {Thickness Class Thickness	0.52* 22 0.54	0.53* 22 0.54	0.55* 22 0.54	0.57* 23 0.58	0.59* 23 0.58	0.61* 24 0.63	0.63* 24 0.63
	3½	Calculated Thickness Use {Thickness Class Thickness	0.51* 21 0.50	0.53* 22 0.54	0.54* 22 0.54	0.56* 23 0.58	0.58* 23 0.58	0.60* 23 0.58	0.63* 24 0.63
	5	Calculated Thickness Use {Thickness Class Thickness	0.53* 22 0.54	0.55* 22 0.54	0.56* 23 0.58	0.58* 23 0.58	0.60* 23 0.58	0.63 24 0.63	0.66 25 0.68
	8	Calculated Thickness Use {Thickness Class Thickness	0.59 23 0.58	0.61 24 0.63	0.62 24 0.63	0.64 24 0.63	0.67 25 0.68	0.69 25 0.68	0.72 26 0.73
	12	Calculated Thickness Use {Thickness Class Thickness	0.64 24 0.63	0.66 25 0.68	0.68 25 0.68	0.70 25 0.68	0.72 26 0.73	0.74 26 0.73	0.77 27 0.79
	16	Calculated Thickness Use {Thickness Class Thickness	0.68 25 0.68	0.70 25 0.68	0.71 26 0.73	0.73 26 0.73	0.75 26 0.73	0.77 27 0.79	0.80 27 0.79
B	2½	Calculated Thickness Use {Thickness Class Thickness	0.48* 21 0.50	0.50* 21 0.50	0.51* 21 0.50	0.53* 22 0.54	0.55* 22 0.54	0.58* 23 0.58	0.60* 23 0.58
	3½	Calculated Thickness Use {Thickness Class Thickness	0.48* 21 0.50	0.49* 21 0.50	0.51* 21 0.50	0.53* 22 0.54	0.55* 22 0.54	0.57 23 0.58	0.61 24 0.63
	5	Calculated Thickness Use {Thickness Class Thickness	0.49* 21 0.50	0.51* 21 0.50	0.53* 22 0.54	0.54 22 0.54	0.57 23 0.58	0.60 23 0.58	0.64 24 0.63
	8	Calculated Thickness Use {Thickness Class Thickness	0.55 22 0.54	0.57 23 0.58	0.59 23 0.58	0.61 24 0.63	0.63 24 0.63	0.66 25 0.68	0.69 25 0.68
	12	Calculated Thickness Use {Thickness Class Thickness	0.60 23 0.58	0.62 24 0.63	0.63 24 0.63	0.65 24 0.63	0.68 25 0.68	0.70 25 0.68	0.73 26 0.73
	16	Calculated Thickness Use {Thickness Class Thickness	0.63 24 0.63	0.65 24 0.63	0.67 25 0.68	0.69 25 0.68	0.71 26 0.73	0.73 26 0.73	0.76 27 0.79
F	2½	Calculated Thickness Use {Thickness Class Thickness	0.44* 21 0.50	0.46* 21 0.50	0.47* 21 0.50	0.49* 21 0.50	0.52* 22 0.54	0.55 22 0.54	0.60 23 0.58
	3½	Calculated Thickness Use {Thickness Class Thickness	0.44* 21 0.50	0.45* 21 0.50	0.47* 21 0.50	0.49* 21 0.50	0.52 22 0.54	0.56 23 0.58	0.60 23 0.58
	5	Calculated Thickness Use {Thickness Class Thickness	0.45* 21 0.50	0.47* 21 0.50	0.49 21 0.50	0.52 22 0.54	0.55 22 0.54	0.58 23 0.58	0.62 24 0.63
	8	Calculated Thickness Use {Thickness Class Thickness	0.50 21 0.51	0.52 22 0.54	0.54 22 0.54	0.57 23 0.58	0.59 23 0.58	0.62 24 0.63	0.66 25 0.68
	12	Calculated Thickness Use {Thickness Class Thickness	0.55 22 0.54	0.56 23 0.58	0.58 23 0.58	0.61 24 0.63	0.63 24 0.63	0.66 25 0.68	0.69 25 0.68
	16	Calculated Thickness Use {Thickness Class Thickness	0.58 23 0.58	0.59 23 0.58	0.61 24 0.63	0.63 24 0.63	0.66 25 0.68	0.68 25 0.68	0.71 26 0.73

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Eighteen-Inch Water Pipe									
A	2½	Calculated Thickness Use {Thickness Class Thickness	0.56* 22 0.58	0.57* 22 0.58	0.59* 22 0.58	0.61* 23 0.63	0.63* 23 0.63	0.66* 24 0.68	0.68* 24 0.68
	3½	Calculated Thickness Use {Thickness Class Thickness	0.55* 21 0.54	0.57* 22 0.58	0.58* 22 0.58	0.60* 22 0.58	0.63* 23 0.63	0.65* 23 0.63	0.68 24 0.68
	5	Calculated Thickness Use {Thickness Class Thickness	0.57* 22 0.58	0.59* 22 0.58	0.61* 23 0.63	0.63* 23 0.63	0.65 23 0.63	0.68 24 0.68	0.72 25 0.73
	8	Calculated Thickness Use {Thickness Class Thickness	0.63* 23 0.63	0.65 23 0.63	0.67 24 0.68	0.69 24 0.68	0.72 25 0.73	0.75 25 0.73	0.78 26 0.79
	12	Calculated Thickness Use {Thickness Class Thickness	0.69 24 0.68	0.71 25 0.73	0.73 25 0.73	0.75 25 0.73	0.78 26 0.79	0.80 26 0.79	0.83 27 0.85
	16	Calculated Thickness Use {Thickness Class Thickness	0.73 25 0.73	0.75 25 0.73	0.77 26 0.79	0.79 26 0.79	0.82 27 0.85	0.84 27 0.85	0.87 27 0.85
B	2½	Calculated Thickness Use {Thickness Class Thickness	0.51* 21 0.54	0.53* 21 0.54	0.55* 21 0.54	0.57* 22 0.58	0.59* 22 0.58	0.62* 23 0.63	0.65 23 0.63
	3½	Calculated Thickness Use {Thickness Class Thickness	0.51* 21 0.54	0.53* 21 0.54	0.54* 21 0.54	0.56* 22 0.58	0.59* 22 0.58	0.62 23 0.63	0.67 24 0.68
	5	Calculated Thickness Use {Thickness Class Thickness	0.53* 21 0.54	0.54* 21 0.54	0.56* 22 0.58	0.59 22 0.58	0.62 23 0.63	0.66 24 0.68	0.70 24 0.68
	8	Calculated Thickness Use {Thickness Class Thickness	0.58 22 0.58	0.60 22 0.58	0.62 23 0.63	0.65 23 0.63	0.68 24 0.68	0.71 25 0.73	0.74 25 0.73
	12	Calculated Thickness Use {Thickness Class Thickness	0.64 23 0.63	0.66 24 0.68	0.68 24 0.68	0.70 24 0.68	0.73 25 0.73	0.76 26 0.79	0.79 26 0.79
	16	Calculated Thickness Use {Thickness Class Thickness	0.68 24 0.68	0.70 24 0.68	0.72 25 0.73	0.74 25 0.73	0.76 26 0.79	0.79 26 0.79	0.82 27 0.85
F	2½	Calculated Thickness Use {Thickness Class Thickness	0.47* 21 0.54	0.49* 21 0.54	0.50* 21 0.54	0.53* 21 0.54	0.55* 21 0.54	0.60 22 0.58	0.65 23 0.63
	3½	Calculated Thickness Use {Thickness Class Thickness	0.46* 21 0.54	0.48* 21 0.54	0.50* 21 0.54	0.52* 21 0.54	0.56 22 0.58	0.61 23 0.63	0.66 24 0.68
	5	Calculated Thickness Use {Thickness Class Thickness	0.48* 21 0.54	0.50* 21 0.54	0.52 21 0.54	0.56 22 0.58	0.59 22 0.58	0.63 23 0.63	0.68 24 0.68
	8	Calculated Thickness Use {Thickness Class Thickness	0.54 21 0.54	0.56 22 0.58	0.58 22 0.58	0.61 23 0.63	0.64 23 0.63	0.67 24 0.68	0.71 25 0.73
	12	Calculated Thickness Use {Thickness Class Thickness	0.58 22 0.58	0.60 22 0.58	0.63 23 0.63	0.65 23 0.63	0.68 24 0.68	0.71 25 0.73	0.74 25 0.73
	16	Calculated Thickness Use {Thickness Class Thickness	0.61 23 0.63	0.63 23 0.63	0.66 24 0.68	0.68 24 0.68	0.71 25 0.73	0.74 25 0.73	0.77 26 0.79

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condition	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Twenty-Inch Water Pipe									
A	2½	Calculated Thickness Use {Thickness Class Thickness	0.59* 21 0.57	0.61* 22 0.62	0.63* 22 0.62	0.65* 23 0.67	0.68* 23 0.67	0.71* 24 0.72	0.74* 24 0.72
	3½	Calculated Thickness Use {Thickness Class Thickness	0.59* 21 0.57	0.61* 22 0.62	0.63* 22 0.62	0.65* 23 0.67	0.68* 23 0.67	0.70* 24 0.72	0.73* 24 0.72
	5	Calculated Thickness Use {Thickness Class Thickness	0.62* 22 0.62	0.64* 22 0.62	0.65* 23 0.67	0.67* 23 0.67	0.70* 24 0.72	0.73 24 0.72	0.77 25 0.78
	8	Calculated Thickness Use {Thickness Class Thickness	0.67* 23 0.67	0.69 23 0.67	0.71 24 0.72	0.74 24 0.72	0.77 25 0.78	0.80 25 0.78	0.83 26 0.84
	12	Calculated Thickness Use {Thickness Class Thickness	0.74 24 0.72	0.76 25 0.78	0.78 25 0.78	0.80 25 0.78	0.83 26 0.84	0.86 26 0.84	0.89 27 0.91
	16	Calculated Thickness Use {Thickness Class Thickness	0.78 25 0.78	0.80 25 0.78	0.83 26 0.84	0.85 26 0.84	0.87 26 0.84	0.90 27 0.91	0.93 27 0.91
B	2½	Calculated Thickness Use {Thickness Class Thickness	0.55* 21 0.57	0.56* 21 0.57	0.58* 21 0.57	0.61* 22 0.62	0.63* 22 0.67	0.66* 23 0.67	0.70* 24 0.72
	3½	Calculated Thickness Use {Thickness Class Thickness	0.54* 21 0.57	0.56* 21 0.57	0.58* 21 0.57	0.60* 22 0.62	0.63* 22 0.62	0.66* 23 0.67	0.71* 24 0.72
	5	Calculated Thickness Use {Thickness Class Thickness	0.57* 21 0.57	0.58* 21 0.57	0.60* 22 0.62	0.63* 22 0.62	0.66 23 0.67	0.70 24 0.72	0.74 24 0.72
	8	Calculated Thickness Use {Thickness Class Thickness	0.62 22 0.62	0.64 22 0.62	0.66 23 0.67	0.69 23 0.67	0.72 24 0.72	0.76 24 0.78	0.79 25 0.78
	12	Calculated Thickness Use {Thickness Class Thickness	0.68 23 0.67	0.70 24 0.72	0.72 24 0.72	0.75 25 0.78	0.77 25 0.78	0.81 26 0.84	0.84 26 0.84
	16	Calculated Thickness Use {Thickness Class Thickness	0.72 24 0.72	0.74 24 0.72	0.76 25 0.78	0.78 25 0.78	0.81 25 0.84	0.84 26 0.84	0.87 26 0.84
F	2½	Calculated Thickness Use {Thickness Class Thickness	0.50* 21 0.57	0.52* 21 0.57	0.54* 21 0.57	0.56* 21 0.57	0.59* 21 0.57	0.64 22 0.62	0.69 23 0.67
	3½	Calculated Thickness Use {Thickness Class Thickness	0.49* 21 0.57	0.51* 21 0.57	0.53* 21 0.57	0.56* 21 0.57	0.60 22 0.62	0.65 23 0.67	0.70 24 0.72
	5	Calculated Thickness Use {Thickness Class Thickness	0.51* 21 0.57	0.53 21 0.57	0.55 21 0.57	0.59 21 0.57	0.63 22 0.62	0.67 23 0.67	0.72 24 0.72
	8	Calculated Thickness Use {Thickness Class Thickness	0.56 21 0.57	0.59 21 0.57	0.61 22 0.62	0.64 22 0.62	0.68 23 0.67	0.72 24 0.72	0.76 25 0.78
	12	Calculated Thickness Use {Thickness Class Thickness	0.61 22 0.62	0.64 22 0.62	0.66 23 0.67	0.69 23 0.67	0.72 24 0.72	0.75 25 0.78	0.79 25 0.78
	16	Calculated Thickness Use {Thickness Class Thickness	0.65 23 0.67	0.67 23 0.67	0.70 24 0.72	0.72 24 0.72	0.75 25 0.78	0.78 25 0.78	0.82 26 0.84

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Twenty-four-Inch Water Pipe									
A	2½	Calculated Thickness Use {Thickness Class Thickness	0.66* 22 0.68	0.68* 22 0.68	0.71* 23 0.73	0.73* 23 0.73	0.76* 24 0.79	0.80* 24 0.79	0.84* 25 0.85
	3½	Calculated Thickness Use {Thickness Class Thickness	0.66* 22 0.68	0.68* 22 0.68	0.70* 22 0.68	0.73* 23 0.73	0.76* 24 0.79	0.79* 24 0.79	0.83* 25 0.85
	5	Calculated Thickness Use {Thickness Class Thickness	0.69* 22 0.68	0.71* 23 0.73	0.74* 23 0.73	0.76* 24 0.79	0.79* 24 0.79	0.83 25 0.85	0.88 25 0.85
	8	Calculated Thickness Use {Thickness Class Thickness	0.75* 23 0.73	0.77 24 0.79	0.80 24 0.79	0.83 25 0.85	0.87 25 0.85	0.91 26 0.92	0.95 26 0.92
	12	Calculated Thickness Use {Thickness Class Thickness	0.83 25 0.85	0.85 25 0.85	0.88 25 0.85	0.91 26 0.92	0.94 26 0.92	0.98 27 0.99	1.01 27 0.99
	16	Calculated Thickness Use {Thickness Class Thickness	0.89 26 0.92	0.91 26 0.92	0.94 26 0.92	0.96 27 0.99	0.99 27 0.99	1.03 28 1.07	1.06 28 1.07
B	2½	Calculated Thickness Use {Thickness Class Thickness	0.60* 21 0.63	0.62* 21 0.63	0.65* 21 0.68	0.67* 22 0.68	0.71* 23 0.73	0.74* 23 0.73	0.80 24 0.79
	3½	Calculated Thickness Use {Thickness Class Thickness	0.59* 21 0.63	0.62* 21 0.63	0.64* 21 0.63	0.67* 22 0.68	0.70* 22 0.68	0.75 23 0.73	0.81 24 0.79
	5	Calculated Thickness Use {Thickness Class Thickness	0.62* 21 0.63	0.65* 21 0.63	0.67* 22 0.68	0.70 22 0.68	0.74 23 0.73	0.79 24 0.79	0.85 25 0.85
	8	Calculated Thickness Use {Thickness Class Thickness	0.68 22 0.68	0.71 23 0.73	0.74 23 0.73	0.77 24 0.79	0.81 24 0.79	0.85 25 0.85	0.90 26 0.92
	12	Calculated Thickness Use {Thickness Class Thickness	0.75 23 0.73	0.78 24 0.79	0.80 24 0.79	0.83 25 0.85	0.87 25 0.85	0.91 26 0.92	0.95 26 0.92
	16	Calculated Thickness Use {Thickness Class Thickness	0.80 24 0.79	0.82 25 0.85	0.85 25 0.85	0.88 25 0.85	0.91 26 0.92	0.95 26 0.92	0.99 27 0.99
F	2½	Calculated Thickness Use {Thickness Class Thickness	0.54* 21 0.63	0.57* 21 0.62	0.59* 21 0.63	0.62* 21 0.63	0.66* 22 0.68	0.72 23 0.73	0.79 24 0.79
	3½	Calculated Thickness Use {Thickness Class Thickness	0.54* 21 0.63	0.56* 21 0.63	0.59* 21 0.63	0.62* 21 0.63	0.67 22 0.68	0.73 23 0.72	0.80 24 0.79
	5	Calculated Thickness Use {Thickness Class Thickness	0.57* 21 0.63	0.59* 21 0.63	0.62 21 0.63	0.66 22 0.68	0.71 23 0.73	0.76 24 0.79	0.82 25 0.85
	8	Calculated Thickness Use {Thickness Class Thickness	0.62 21 0.63	0.65 21 0.63	0.68 22 0.68	0.72 23 0.73	0.76 24 0.79	0.81 24 0.79	0.86 25 0.85
	12	Calculated Thickness Use {Thickness Class Thickness	0.68 22 0.68	0.71 23 0.73	0.74 23 0.73	0.77 24 0.79	0.81 24 0.79	0.85 25 0.85	0.90 26 0.92
	16	Calculated Thickness Use {Thickness Class Thickness	0.72 23 0.73	0.75 23 0.73	0.78 24 0.79	0.81 24 0.79	0.85 25 0.85	0.89 25 0.92	0.93 26 0.92

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Thirty-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	0.79* 22 0.79	0.81* 22 0.79	0.84* 23 0.85	0.88* 23 0.85	0.92* 24 0.92	0.96* 25 0.99	1.01* 25 0.99
	3½	Calculated Thickness Use { Thickness Class Thickness	0.78* 22 0.79	0.81* 22 0.79	0.84* 23 0.85	0.87* 23 0.85	0.91* 24 0.92	0.95* 24 0.92	1.00 25 0.99
	5	Calculated Thickness Use { Thickness Class Thickness	0.82* 23 0.85	0.85* 23 0.85	0.88* 23 0.85	0.91* 24 0.92	0.94 24 0.92	1.00 25 0.99	1.06 26 1.01
	8	Calculated Thickness Use { Thickness Class Thickness	0.89* 24 0.92	0.92 24 0.92	0.95 24 0.92	0.99 25 0.99	1.04 26 1.07	1.09 26 1.07	1.14 27 1.16
	12	Calculated Thickness Use { Thickness Class Thickness	0.99 25 0.99	1.02 25 0.99	1.05 26 1.07	1.09 26 1.07	1.13 27 1.16	1.17 27 1.16	1.22 28 1.25
	16	Calculated Thickness Use { Thickness Class Thickness	1.06 26 1.07	1.09 26 1.07	1.12 27 1.16	1.16 27 1.16	1.20 27 1.16	1.24 28 1.25	1.29 25 1.29
B	2½	Calculated Thickness Use { Thickness Class Thickness	0.70* 20 0.68	0.73* 21 0.73	0.76* 22 0.79	0.80* 22 0.79	0.84* 23 0.85	0.89* 24 0.92	0.88 25 0.99
	3½	Calculated Thickness Use { Thickness Class Thickness	0.69* 20 0.68	0.72* 21 0.73	0.75* 21 0.73	0.79* 22 0.79	0.83* 23 0.85	0.90 24 0.92	0.98 25 0.99
	5	Calculated Thickness Use { Thickness Class Thickness	0.73* 21 0.73	0.76* 22 0.79	0.79* 22 0.79	0.83* 23 0.85	0.88 23 0.85	0.95 24 0.92	1.02 25 0.99
	8	Calculated Thickness Use { Thickness Class Thickness	0.79 22 0.79	0.83 23 0.85	0.86 23 0.85	0.91 24 0.92	0.96 25 0.99	1.01 25 0.99	1.07 26 1.07
	12	Calculated Thickness Use { Thickness Class Thickness	0.88 23 0.85	0.91 24 0.92	0.95 24 0.92	0.99 25 0.99	1.03 26 1.07	1.08 26 1.07	1.14 27 1.16
	16	Calculated Thickness Use { Thickness Class Thickness	0.94 24 0.92	0.97 25 0.99	1.01 25 0.99	1.05 26 1.07	1.09 26 1.07	1.13 27 1.16	1.18 27 1.16
F	2½	Calculated Thickness Use { Thickness class Thickness	0.64* 20 0.68	0.67* 20 0.68	0.70* 20 0.68	0.74* 21 0.73	0.79* 22 0.79	0.87 23 0.85	0.96 25 0.99
	3½	Calculated Thickness Use { Thickness Class Thickness	0.63* 20 0.68	0.66* 20 0.68	0.69* 20 0.68	0.73* 21 0.73	0.81 22 0.79	0.88 23 0.85	0.97 25 0.99
	5	Calculated Thickness Use { Thickness Class Thickness	0.66* 20 0.68	0.69* 20 0.68	0.73 21 0.73	0.78 22 0.79	0.85 23 0.85	0.92 24 0.92	0.99 25 0.99
	8	Calculated Thickness Use { Thickness Class Thickness	0.72 21 0.73	0.76 22 0.79	0.80 22 0.79	0.85 23 0.85	0.90 24 0.92	0.96 25 0.99	1.03 26 1.07
	12	Calculated Thickness Use { Thickness Class Thickness	0.80 22 0.79	0.84 23 0.85	0.87 23 0.85	0.91 24 0.92	0.96 25 0.99	1.02 25 0.99	1.08 26 1.07
	16	Calculated Thickness Use { Thickness Class Thickness	0.85 23 0.85	0.89 24 0.92	0.92 24 0.92	0.96 25 0.99	1.01 25 0.99	1.06 26 1.07	1.12 27 1.91

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condition	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Thirty-six-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	0.89* 22 0.87	0.92* 23 0.94	0.96* 23 0.94	1.00* 24 1.02	1.05* 24 1.02	1.10* 25 1.10	1.16* 26 1.19
	3½	Calculated Thickness Use { Thickness Class Thickness	0.88* 22 0.87	0.92* 23 0.94	0.95* 23 0.94	1.00* 24 1.02	1.04* 24 1.02	1.10* 25 1.10	1.15 26 1.19
	5	Calculated Thickness Use { Thickness Class Thickness	0.93* 23 0.94	0.96* 23 0.94	1.00* 24 1.02	1.04* 24 1.02	1.09* 25 1.10	1.14 25 1.10	1.22 26 1.19
	8	Calculated Thickness Use { Thickness Class Thickness	1.01* 24 1.02	1.04* 24 1.02	1.08 25 1.10	1.13 25 1.10	1.18 26 1.19	1.24 27 1.29	1.31 27 1.29
	12	Calculated Thickness Use { Thickness Class Thickness	1.13 25 1.10	1.16 26 1.19	1.20 26 1.19	1.25 27 1.29	1.30 27 1.29	1.35 28 1.39	1.41 28 1.39
	16	Calculated Thickness Use { Thickness Class Thickness	1.22 26 1.19	1.25 27 1.29	1.29 27 1.29	1.33 27 1.29	1.38 28 1.39	1.43 28 1.39	1.48 29 1.50
B	2½	Calculated Thickness Use { Thickness Class Thickness	0.78* 21 0.81	0.81* 21 0.81	0.85* 22 0.87	0.90* 22 0.87	0.95* 23 0.94	1.01* 24 1.02	1.12 25 1.10
	3½	Calculated Thickness Use { Thickness Class Thickness	0.77* 20 0.75	0.81* 21 0.81	0.85* 22 0.87	0.89* 22 0.87	0.95* 23 0.94	1.03 24 1.02	1.12 25 1.10
	5	Calculated Thickness Use { Thickness Class Thickness	0.81* 21 .81	0.85* 22 .87	0.89* 22 .87	0.93* 23 .94	1.00 24 1.02	1.08 25 1.10	1.16 26 1.19
	8	Calculated Thickness Use { Thickness Class Thickness	0.88 22 0.87	0.92 23 0.94	0.97 23 0.94	1.02 24 1.02	1.08 25 1.10	1.15 26 1.19	1.22 26 1.19
	12	Calculated Thickness Use { Thickness Class Thickness	0.99 24 1.02	1.02 24 1.02	1.07 25 1.10	1.12 25 1.10	1.17 26 1.19	1.23 26 1.19	1.30 27 1.29
	16	Calculated Thickness Use { Thickness Class Thickness	1.06 25 1.10	1.10 25 1.10	1.14 25 1.10	1.19 26 1.19	1.24 27 1.29	1.29 27 1.29	1.35 28 1.39
F	2½	Calculated Thickness Use { Thickness Class Thickness	0.71* 20 0.75	0.74* 20 0.75	0.78* 21 0.81	0.83* 21 0.81	0.90 22 0.87	1.00 24 1.02	1.10 25 1.10
	3½	Calculated Thickness Use { Thickness Class Thickness	0.70* 20 0.75	0.74* 20 0.75	0.78* 21 0.81	0.83 21 0.81	0.92 23 0.94	1.01 24 1.02	1.11 25 1.10
	5	Calculated Thickness Use { Thickness Class Thickness	0.74* 20 0.75	0.77* 20 0.75	0.82 21 0.81	0.88 22 0.87	0.96 23 0.94	1.05 24 1.02	1.14 25 1.10
	8	Calculated Thickness Use { Thickness Class Thickness	0.81 21 0.81	0.85 22 0.87	0.90 22 0.87	0.96 23 0.94	1.02 24 1.02	1.10 25 1.10	1.18 26 1.19
	12	Calculated Thickness Use { Thickness Class Thickness	0.90 22 0.87	0.94 23 0.94	0.98 24 1.02	1.04 24 1.02	1.09 25 1.10	1.16 26 1.19	1.23 26 1.19
	16	Calculated Thickness Use { Thickness Class Thickness	0.96 23 0.94	1.00 24 1.02	1.04 24 1.02	1.09 25 1.10	1.15 26 1.19	1.21 26 1.19	1.28 27 1.29

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Forty-two-Inch Water Pipe									
A	2½	Calculated Thickness Use {Thickness Class Thickness	0.99* 22 0.97	1.02* 23 1.05	1.07* 23 1.05	1.12* 24 1.13	1.17* 24 1.13	1.24* 25 1.22	1.31* 26 1.32
	3½	Calculated Thickness Use {Thickness Class Thickness	0.99* 22 0.97	1.02* 23 1.05	1.07* 23 1.05	1.12* 24 1.13	1.17* 24 1.13	1.24* 25 1.22	1.30 26 1.32
	5	Calculated Thickness Use {Thickness Class Thickness	1.04* 23 1.05	1.08* 23 1.05	1.12* 24 1.13	1.17* 24 1.13	1.22* 25 1.22	1.28* 26 1.32	1.37 26 1.32
	8	Calculated Thickness Use {Thickness Class Thickness	1.13* 24 1.13	1.17* 24 1.13	1.21 25 1.22	1.27 26 1.32	1.33 26 1.32	1.40 27 1.43	1.48 27 1.43
	12	Calculated Thickness Use {Thickness Class Thickness	1.26 25 1.22	1.30 26 1.32	1.35 26 1.32	1.40 27 1.43	1.46 27 1.43	1.52 28 1.54	1.59 28 1.54
	16	Calculated Thickness Use {Thickness Class Thickness	1.37 26 1.32	1.41 27 1.43	1.46 27 1.43	1.51 28 1.54	1.56 28 1.54	1.62 29 1.66	1.68 29 1.66
B	2½	Calculated Thickness Use {Thickness Class Thickness	0.85* 20 0.83	0.89* 21 0.90	0.94* 22 0.97	0.99* 22 0.97	1.05* 23 1.05	1.13 24 1.13	1.25 25 1.22
	3½	Calculated Thickness Use {Thickness Class Thickness	0.85* 20 0.83	0.89* 21 0.90	0.94* 22 0.97	0.99* 22 0.97	1.05 23 1.05	1.15 24 1.13	1.27 26 1.32
	5	Calculated Thickness Use {Thickness Class Thickness	0.89* 21 0.90	0.93* 21 0.90	0.98* 22 0.97	1.03* 23 1.05	1.11 24 1.13	1.21 25 1.22	1.31 26 1.32
	8	Calculated Thickness Use {Thickness Class Thickness	0.97 22 0.97	1.02 23 1.05	1.07 23 1.05	1.13 24 1.13	1.21 25 1.22	1.29 26 1.32	1.37 26 1.32
	12	Calculated Thickness Use {Thickness Class Thickness	1.09 24 1.13	1.13 24 1.13	1.18 25 1.22	1.24 25 1.22	1.30 26 1.32	1.38 27 1.43	1.45 27 1.43
	16	Calculated Thickness Use {Thickness Class Thickness	1.18 25 1.22	1.22 25 1.22	1.27 26 1.32	1.32 26 1.32	1.38 27 1.43	1.45 27 1.43	1.52 28 1.54
F	2½	Calculated Thickness Use {Thickness Class Thickness	0.77* 20 0.83	0.81* 20 0.83	0.86* 20 0.83	0.92* 21 0.90	1.00 22 0.97	1.12 24 1.13	1.24 25 1.22
	3½	Calculated Thickness Use {Thickness Class Thickness	0.77* 20 0.83	0.81* 20 0.83	0.86* 20 0.83	0.92* 21 0.90	1.02 23 1.05	1.14 24 1.13	1.25 25 1.22
	5	Calculated Thickness Use {Thickness Class Thickness	0.81* 20 0.83	0.85* 20 0.83	0.90 21 0.90	0.98 22 0.97	1.07 23 1.05	1.17 24 1.13	1.28 26 1.32
	8	Calculated Thickness Use {Thickness Class Thickness	0.89 21 0.90	0.94 22 0.97	0.99 22 0.97	1.06 23 1.05	1.14 24 1.13	1.23 25 1.22	1.33 26 1.32
	12	Calculated Thickness Use {Thickness Class Thickness	0.99 22 0.97	1.03 23 1.05	1.09 24 1.13	1.15 24 1.13	1.22 25 1.22	1.30 26 1.32	1.39 27 1.43
	16	Calculated Thickness Use {Thickness Class Thickness	1.07 23 1.05	1.11 24 1.13	1.16 24 1.13	1.21 25 1.22	1.28 26 1.32	1.36 26 1.32	1.44 27 1.43

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec. 1-2.1.

TABLE 1-2 (Continued)
Schedule of Barrel Thickness for Water Pipe of 21/45 Iron Strength

Laying Condition	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi						
			50	100	150	200	250	300	350
			Barrel Thickness—in.						
Forty-eight-Inch Water Pipe									
A	2½	Calculated Thickness Use { Thickness Class Thickness	1.08* 22 1.06	1.12* 23 1.14	1.17* 23 1.14	1.23* 24 1.23	1.29* 25 1.33	1.37* 25 1.33	1.45* 26 1.44
	3½	Calculated Thickness Use { Thickness Class Thickness	1.09* 22 1.06	1.13* 23 1.14	1.18* 23 1.14	1.24* 24 1.23	1.30* 25 1.33	1.37* 25 1.33	1.46 26 1.44
	5	Calculated Thickness Use { Thickness Class Thickness	1.15* 23 1.14	1.19* 24 1.23	1.24* 24 1.23	1.30* 25 1.33	1.36* 25 1.33	1.43 26 1.44	1.53 27 1.56
	8	Calculated Thickness Use { Thickness Class Thickness	1.25* 24 1.23	1.29* 25 1.33	1.34 25 1.33	1.41 26 1.44	1.48 26 1.44	1.56 27 1.56	1.65 28 1.68
	12	Calculated Thickness Use { Thickness Class Thickness	1.41 26 1.44	1.45 26 1.44	1.51 27 1.56	1.57 27 1.56	1.63 28 1.68	1.70 28 1.68	1.77 29 1.81
	16	Calculated Thickness Use { Thickness Class Thickness	1.53 27 1.56	1.58 27 1.56	1.63 28 1.68	1.68 28 1.68	1.75 29 1.81	1.81 29 1.81	1.89 30 1.95
B	2½	Calculated Thickness Use { Thickness Class Thickness	0.92* 20 0.91	0.97* 21 0.98	1.02* 22 1.06	1.08* 22 1.06	1.16* 23 1.14	1.26 24 1.23	1.40 26 1.44
	3½	Calculated Thickness Use { Thickness Class Thickness	0.93* 20 0.91	0.97* 21 0.98	1.03* 22 1.06	1.09* 22 1.06	1.17 23 1.14	1.29 25 1.33	1.42 26 1.44
	5	Calculated Thickness Use { Thickness Class Thickness	0.98* 21 0.98	1.02* 22 1.06	1.08* 22 1.06	1.14 23 1.14	1.23 24 1.23	1.34 25 1.33	1.46 26 1.44
	8	Calculated Thickness Use { Thickness Class Thickness	1.06 22 1.06	1.12 23 1.14	1.18 23 1.14	1.25 24 1.23	1.34 25 1.33	1.43 26 1.44	1.53 27 1.56
	12	Calculated Thickness Use { Thickness Class Thickness	1.20 24 1.23	1.25 24 1.23	1.31 25 1.33	1.37 25 1.33	1.45 26 1.44	1.53 27 1.56	1.62 28 1.68
	16	Calculated Thickness Use { Thickness Class Thickness	1.30 25 1.33	1.35 25 1.33	1.41 26 1.44	1.47 26 1.44	1.54 27 1.56	1.61 27 1.56	1.70 28 1.68
F	2½	Calculated Thickness Use { Thickness Class Thickness	0.83* 20 0.91	0.88* 20 0.91	0.94* 20 0.91	1.01* 21 0.98	1.12 23 1.14	1.25 24 1.23	1.39 26 1.44
	3½	Calculated Thickness Use { Thickness Class Thickness	0.84* 20 0.91	0.89* 20 0.91	0.94* 20 0.91	1.02 22 1.06	1.14 23 1.14	1.27 24 1.23	1.40 26 1.44
	5	Calculated Thickness Use { Thickness Class Thickness	0.88* 20 0.91	0.93* 20 0.91	0.99 21 0.98	1.08 22 1.06	1.19 24 1.23	1.30 25 1.33	1.43 26 1.44
	8	Calculated Thickness Use { Thickness Class Thickness	0.97 21 0.98	1.03 22 1.06	1.09 22 1.06	1.17 23 1.14	1.27 24 1.23	1.37 25 1.33	1.48 26 1.44
	12	Calculated Thickness Use { Thickness Class Thickness	1.09 22 1.06	1.14 23 1.14	1.20 24 1.23	1.27 24 1.23	1.35 25 1.33	1.45 26 1.44	1.55 27 1.56
	16	Calculated Thickness Use { Thickness Class Thickness	1.17 23 1.14	1.23 24 1.23	1.28 25 1.33	1.35 25 1.33	1.43 26 1.44	1.51 27 1.56	1.60 27 1.56

* Asterisk following total calculated thickness indicates that truck superload (Case 2) is the controlling factor. When total calculated thickness is not followed by asterisk, surge pressure (Case 1) is the controlling factor. See Sec 1-2.1.

TABLE 1-3
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi					
			10	50	100	150	200	250
			Barrel Thicknesses—in.					
Four-Inch Gas Pipe								
A	2½	Calculated Thickness Use {Thickness Class Thickness	.23 22 .35	.23 22 .35	.23 22 .35	.24 22 .35	.24 22 .35	.24 22 .35
	3½	Calculated Thickness Use {Thickness Class Thickness	.22 22 .35	.23 22 .35	.23 22 .35	.23 22 .35	.23 22 .35	.23 22 .35
	5	Calculated Thickness Use {Thickness Class Thickness	.23 22 .35	.23 22 .35	.24 22 .35	.24 22 .35	.24 22 .35	.25 22 .35
	8	Calculated Thickness Use {Thickness Class Thickness	.25 22 .35	.25 22 .35	.25 22 .35	.26 22 .35	.26 22 .35	.27 22 .35
	12	Calculated Thickness Use {Thickness Class Thickness	.27 22 .35	.28 22 .35	.28 22 .35	.29 22 .35	.29 22 .35	.29 22 .35
	16	Calculated Thickness Use {Thickness Class Thickness	.30 22 .35	.30 22 .35	.30 22 .35	.31 22 .35	.31 22 .35	.32 22 .35
B	2½	Calculated Thickness Use {Thickness Class Thickness	.23 22 .35	.23 22 .35	.23 22 .35	.23 22 .35	.23 22 .35	.24 22 .35
	3½	Calculated Thickness Use {Thickness Class Thickness	.22 22 .35	.23 22 .35	.23 22 .35	.23 22 .35	.24 22 .35	.24 22 .35
	5	Calculated Thickness Use {Thickness Class Thickness	.23 22 .35	.23 22 .35	.23 22 .35	.23 22 .35	.24 22 .35	.24 22 .35
	8	Calculated Thickness Use {Thickness Class Thickness	.24 22 .35	.24 22 .35	.24 22 .35	.25 22 .35	.25 22 .35	.26 22 .35
	12	Calculated Thickness Use {Thickness Class Thickness	.28 22 .35	.29 22 .35	.29 22 .35	.29 22 .35	.30 22 .35	.30 22 .35
	16	Calculated Thickness Use {Thickness Class Thickness	.29 22 .35	.29 22 .35	.29 22 .35	.30 22 .35	.30 22 .35	.31 22 .35
F	2½	Calculated Thickness Use {Thickness Class Thickness	.22 22 .35	.22 22 .35	.22 22 .35	.22 22 .35	.23 22 .35	.23 22 .35
	3½	Calculated Thickness Use {Thickness Class Thickness	.22 22 .35	.22 22 .35	.22 22 .35	.22 22 .35	.23 22 .35	.23 22 .35
	5	Calculated Thickness Use {Thickness Class Thickness	.22 22 .35	.22 22 .35	.22 22 .35	.22 22 .35	.23 22 .35	.23 22 .35
	8	Calculated Thickness Use {Thickness Class Thickness	.23 22 .35	.23 22 .35	.23 22 .35	.24 22 .35	.24 22 .35	.24 22 .35
	12	Calculated Thickness Use {Thickness Class Thickness	.24 22 .35	.24 22 .35	.25 22 .35	.25 22 .35	.26 22 .35	.27 22 .35
	16	Calculated Thickness Use {Thickness Class Thickness	.26 22 .35	.26 22 .35	.27 22 .35	.28 22 .35	.28 22 .35	.29 22 .35

TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi					
			10	50	100	150	200	250
			Barrel Thicknesses—in.					
Six-Inch Gas Pipe								
A	2½	Calculated Thickness Use {Thickness Class Thickness	.28 22 .38	.29 22 .38	.29 22 .38	.30 22 .38	.30 22 .38	.32 22 .38
	3½	Calculated Thickness Use {Thickness Class Thickness	.27 22 .38	.28 22 .38	.28 22 .38	.29 22 .38	.30 22 .38	.31 22 .38
	5	Calculated Thickness Use {Thickness Class Thickness	.28 22 .38	.29 22 .38	.29 22 .38	.30 22 .38	.31 22 .38	.32 22 .38
	8	Calculated Thickness Use {Thickness Class Thickness	.31 22 .38	.31 22 .38	.32 22 .38	.33 22 .38	.33 22 .38	.34 22 .38
	12	Calculated Thickness Use {Thickness Class Thickness	.34 22 .38	.35 22 .38	.35 22 .38	.36 22 .38	.37 22 .38	.38 22 .38
	16	Calculated Thickness Use {Thickness Class Thickness	.38 22 .38	.38 22 .38	.39 22 .38	.39 22 .38	.40 23 .41	.41 23 .41
B	2½	Calculated Thickness Use {Thickness Class Thickness	.27 22 .38	.28 22 .38	.28 22 .38	.29 22 .38	.30 22 .38	.31 22 .38
	3½	Calculated Thickness Use {Thickness Class Thickness	.27 22 .38	.27 22 .38	.28 22 .38	.28 22 .38	.29 22 .38	.30 22 .38
	5	Calculated Thickness Use {Thickness Class Thickness	.28 22 .38	.28 22 .38	.28 22 .38	.29 22 .38	.30 22 .38	.31 22 .38
	8	Calculated Thickness Use {Thickness Class Thickness	.29 22 .38	.30 22 .38	.31 22 .38	.31 22 .38	.32 22 .38	.33 22 .38
	12	Calculated Thickness Use {Thickness Class Thickness	.33 22 .38	.34 22 .38	.34 22 .38	.35 22 .38	.35 22 .38	.36 22 .38
	16	Calculated Thickness Use {Thickness Class Thickness	.36 22 .38	.36 22 .38	.37 22 .38	.38 22 .38	.38 22 .38	.39 22 .38
F	2½	Calculated Thickness Use {Thickness Class Thickness	.26 22 .38	.26 22 .38	.27 22 .38	.27 22 .38	.28 22 .38	.29 22 .38
	3½	Calculated Thickness Use {Thickness Class Thickness	.26 22 .38	.26 22 .38	.26 22 .38	.27 22 .38	.28 22 .38	.29 22 .38
	5	Calculated Thickness Use {Thickness Class Thickness	.26 22 .38	.27 22 .38	.27 22 .38	.28 22 .38	.28 22 .38	.29 22 .38
	8	Calculated Thickness Use {Thickness Class Thickness	.28 22 .38	.28 22 .38	.29 22 .38	.29 22 .38	.30 22 .38	.31 22 .38
	12	Calculated Thickness Use {Thickness Class Thickness	.30 22 .38	.31 22 .38	.31 22 .38	.32 22 .38	.33 22 .38	.34 22 .38
	16	Calculated Thickness Use {Thickness Class Thickness	.33 22 .38	.33 22 .38	.34 22 .38	.35 22 .38	.35 22 .38	.36 22 .38

TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi					
			10	50	100	150	200	250
			Barrel Thicknesses—in.					
Eight-Inch Gas Pipe								
A	2½	Calculated Thickness Use { Thickness Class Thickness	.33 22 .41	.34 22 .41	.35 22 .41	.36 22 .41	.37 22 .41	.38 22 .41
	3½	Calculated Thickness Use { Thickness Class Thickness	.32 22 .41	.33 22 .41	.34 22 .41	.34 22 .41	.35 22 .41	.36 22 .41
	5	Calculated Thickness Use { Thickness Class Thickness	.33 22 .41	.34 22 .41	.35 22 .41	.36 22 .41	.37 22 .41	.38 22 .41
	8	Calculated Thickness Use { Thickness Class Thickness	.36 22 .41	.37 22 .41	.37 22 .41	.38 22 .41	.39 22 .41	.40 22 .41
	12	Calculated Thickness Use { Thickness Class Thickness	.41 22 .41	.42 22 .41	.42 22 .41	.43 23 .44	.44 23 .44	.45 23 .44
	16	Calculated Thickness Use { Thickness Class Thickness	.44 23 .44	.45 23 .44	.45 23 .44	.46 24 .48	.47 24 .48	.48 24 .48
B	2½	Calculated Thickness Use { Thickness Class Thickness	.32 22 .41	.32 22 .41	.33 22 .41	.34 22 .41	.35 22 .41	.36 22 .41
	3½	Calculated Thickness Use { Thickness Class Thickness	.31 22 .41	.32 22 .41	.33 22 .41	.33 22 .41	.34 22 .41	.36 22 .41
	5	Calculated Thickness Use { Thickness Class Thickness	.32 22 .41	.33 22 .41	.34 22 .41	.34 22 .41	.35 22 .41	.37 22 .41
	8	Calculated Thickness Use { Thickness Class Thickness	.35 22 .41	.35 22 .41	.36 22 .41	.37 22 .41	.38 22 .41	.39 22 .41
	12	Calculated Thickness Use { Thickness Class Thickness	.39 22 .41	.39 22 .41	.40 22 .41	.41 22 .41	.42 22 .41	.43 23 .44
	16	Calculated Thickness Use { Thickness Class Thickness	.42 22 .41	.42 22 .41	.43 23 .44	.44 23 .44	.45 23 .44	.46 24 .48
F	2½	Calculated Thickness Use { Thickness Class Thickness	.29 22 .41	.30 22 .41	.31 22 .41	.32 22 .41	.33 22 .41	.34 22 .41
	3½	Calculated Thickness Use { Thickness Class Thickness	.29 22 .41	.29 22 .41	.30 22 .41	.30 22 .41	.31 22 .41	.33 22 .41
	5	Calculated Thickness Use { Thickness Class Thickness	.29 22 .41	.30 22 .41	.31 22 .41	.32 22 .41	.33 22 .41	.34 22 .41
	8	Calculated Thickness Use { Thickness Class Thickness	.32 22 .41	.33 22 .41	.33 22 .41	.34 22 .41	.35 22 .41	.36 22 .41
	12	Calculated Thickness Use { Thickness Class Thickness	.35 22 .41	.36 22 .41	.37 22 .41	.37 22 .41	.38 22 .41	.39 22 .41
	16	Calculated Thickness Use { Thickness Class Thickness	.38 22 .41	.38 22 .41	.39 22 .41	.40 22 .41	.41 22 .41	.42 22 .41

TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi					
			10	50	100	150	200	250
			Barrel Thicknesses—in.					
Ten-Inch Gas Pipe								
A	2½	Calculated Thickness Use {Thickness Class Thickness	.39 22 .44	.40 22 .44	.41 22 .44	.42 22 .44	.43 22 .44	.45 22 .44
	3½	Calculated Thickness Use {Thickness Class Thickness	.38 22 .44	.39 22 .44	.40 22 .44	.41 22 .44	.42 22 .44	.44 22 .44
	5	Calculated Thickness Use {Thickness Class Thickness	.39 22 .44	.40 22 .44	.41 22 .44	.42 22 .44	.43 22 .44	.44 22 .44
	8	Calculated Thickness Use {Thickness Class Thickness	.43 22 .44	.43 22 .44	.44 22 .44	.46 23 .48	.47 23 .48	.48 23 .48
	12	Calculated Thickness Use {Thickness Class Thickness	.48 23 .48	.49 23 .48	.49 23 .48	.50 24 .52	.51 24 .52	.52 24 .52
	16	Calculated Thickness Use {Thickness Class Thickness	.50 24 .52	.51 24 .52	.52 24 .52	.53 24 .52	.54 25 .56	.56 25 .56
B	2½	Calculated Thickness Use {Thickness Class Thickness	.37 22 .44	.38 22 .44	.39 22 .44	.40 22 .44	.41 22 .44	.43 22 .44
	3½	Calculated Thickness Use {Thickness Class Thickness	.36 22 .44	.37 22 .44	.38 22 .44	.39 22 .44	.40 22 .44	.42 22 .44
	5	Calculated Thickness Use {Thickness Class Thickness	.37 22 .44	.38 22 .44	.39 22 .44	.40 22 .44	.41 22 .44	.43 22 .44
	8	Calculated Thickness Use {Thickness Class Thickness	.40 22 .44	.41 22 .44	.42 22 .44	.43 22 .44	.44 22 .44	.46 23 .48
	12	Calculated Thickness Use {Thickness Class Thickness	.45 22 .44	.46 23 .48	.47 23 .48	.48 23 .48	.49 23 .48	.50 24 .52
	16	Calculated Thickness Use {Thickness Class Thickness	.47 23 .48	.48 23 .48	.49 23 .48	.50 24 .52	.51 24 .52	.53 24 .52
F	2½	Calculated Thickness Use {Thickness Class Thickness	.34 22 .44	.35 22 .44	.36 22 .44	.37 22 .44	.38 22 .44	.40 22 .44
	3½	Calculated Thickness Use {Thickness Class Thickness	.33 22 .44	.34 22 .44	.35 22 .44	.36 22 .44	.37 22 .44	.39 22 .44
	5	Calculated Thickness Use {Thickness Class Thickness	.34 22 .44	.35 22 .44	.36 22 .44	.37 22 .44	.38 22 .44	.40 22 .44
	8	Calculated Thickness Use {Thickness Class Thickness	.36 22 .44	.37 22 .44	.38 22 .44	.39 22 .44	.41 22 .44	.42 23 .44
	12	Calculated Thickness Use {Thickness Class Thickness	.41 22 .44	.42 22 .44	.43 22 .44	.44 22 .44	.45 22 .44	.46 23 .48
	16	Calculated Thickness Use {Thickness Class Thickness	.43 22 .44	.44 22 .44	.45 22 .44	.46 23 .48	.47 23 .48	.48 23 .48

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TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi					
			10	50	100	150	200	250
			Barrel Thicknesses—in.					
Twelve-Inch Gas Pipe								
A	2½	Calculated Thickness Use { Thickness Class Thickness	.44 22 .48	.45 22 .48	.46 22 .48	.47 22 .48	.49 22 .48	.51 23 .52
	3½	Calculated Thickness Use { Thickness Class Thickness	.43 22 .48	.43 22 .48	.45 22 .48	.46 22 .48	.48 22 .48	.50 23 .52
	5	Calculated Thickness Use { Thickness Class Thickness	.44 22 .48	.45 22 .48	.46 22 .48	.47 22 .48	.48 22 .48	.50 23 .52
	8	Calculated Thickness Use { Thickness Class Thickness	.48 22 .48	.49 22 .48	.50 23 .52	.52 23 .52	.53 23 .52	.55 24 .56
	12	Calculated Thickness Use { Thickness Class Thickness	.53 23 .52	.54 24 .56	.55 24 .56	.57 24 .56	.58 25 .60	.59 25 .60
	16	Calculated Thickness Use { Thickness Class Thickness	.56 24 .56	.56 24 .56	.58 25 .60	.59 25 .60	.60 25 .60	.62 25 .60
B	2½	Calculated Thickness Use { Thickness Class Thickness	.41 22 .48	.42 22 .48	.44 22 .48	.45 22 .48	.46 22 .48	.48 22 .48
	3½	Calculated Thickness Use { Thickness Class Thickness	.40 22 .48	.41 22 .48	.42 22 .48	.44 22 .48	.45 22 .48	.47 22 .48
	5	Calculated Thickness Use { Thickness Class Thickness	.41 22 .48	.42 22 .48	.43 22 .48	.45 22 .48	.46 22 .48	.48 22 .48
	8	Calculated Thickness Use { Thickness Class Thickness	.45 22 .48	.46 22 .48	.47 22 .48	.49 22 .48	.50 23 .52	.52 23 .52
	12	Calculated Thickness Use { Thickness Class Thickness	.50 23 .52	.51 23 .52	.52 23 .52	.53 23 .52	.55 24 .56	.56 24 .56
	16	Calculated Thickness Use { Thickness Class Thickness	.52 23 .52	.53 23 .52	.54 24 .56	.56 24 .56	.57 24 .56	.59 25 .60
F	2½	Calculated Thickness Use { Thickness Class Thickness	.38 22 .48	.39 22 .48	.40 22 .48	.41 22 .48	.43 22 .48	.45 22 .48
	3½	Calculated Thickness Use { Thickness Class Thickness	.37 22 .48	.38 22 .48	.39 22 .48	.40 22 .48	.42 22 .48	.44 22 .48
	5	Calculated Thickness Use { Thickness Class Thickness	.38 22 .48	.39 22 .48	.40 22 .48	.41 22 .48	.43 22 .48	.45 22 .48
	8	Calculated Thickness Use { Thickness Class Thickness	.41 22 .48	.42 22 .48	.43 22 .48	.45 22 .48	.46 22 .48	.48 22 .48
	12	Calculated Thickness Use { Thickness Class Thickness	.45 22 .48	.46 22 .48	.47 22 .48	.48 22 .48	.50 23 .52	.52 23 .52
	16	Calculated Thickness Use { Thickness Class Thickness	.47 22 .48	.48 22 .48	.49 22 .48	.50 23 .52	.52 23 .52	.53 23 .52

TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure— <i>psi</i>					
			10	50	100	150	200	250
			Barrel Thicknesses— <i>in.</i>					
Sixteen-Inch Gas Pipe								
A	2½	Calculated Thickness Use { Thickness Class Thickness	.53 22 .54	.54 22 .54	.56 23 .58	.58 23 .58	.60 23 .58	
	3½	Calculated Thickness Use { Thickness Class Thickness	.52 22 .54	.54 22 .54	.55 22 .54	.57 23 .58	.59 23 .58	
	5	Calculated Thickness Use { Thickness Class Thickness	.54 22 .54	.55 22 .54	.57 23 .58	.59 23 .58	.61 24 .63	
	8	Calculated Thickness Use { Thickness Class Thickness	.60 23 .58	.61 24 .63	.63 24 .63	.65 24 .63	.67 25 .68	
	12	Calculated Thickness Use { Thickness Class Thickness	.65 24 .63	.66 25 .68	.67 25 .68	.69 25 .68	.71 26 .73	
	16	Calculated Thickness Use { Thickness Class Thickness	.68 25 .68	.69 25 .68	.71 26 .73	.73 26 .73	.75 26 .73	
B	2½	Calculated Thickness Use { Thickness Class Thickness	.49 21 .50	.50 21 .50	.52 22 .54	.54 22 .54	.56 23 .58	
	3½	Calculated Thickness Use { Thickness Class Thickness	.49 21 .50	.50 21 .50	.52 22 .54	.53 22 .54	.56 23 .58	
	5	Calculated Thickness Use { Thickness Class Thickness	.51 21 .50	.51 21 .50	.53 22 .54	.55 22 .54	.57 23 .58	
	8	Calculated Thickness Use { Thickness Class Thickness	.55 22 .54	.56 23 .58	.58 23 .58	.60 23 .58	.62 24 .63	
	12	Calculated Thickness Use { Thickness Class Thickness	.60 23 .58	.61 24 .63	.62 24 .63	.64 24 .63	.66 25 .68	
	16	Calculated Thickness Use { Thickness Class Thickness	.63 24 .63	.64 24 .63	.66 25 .68	.67 25 .68	.69 25 .68	
F	2½	Calculated Thickness Use { Thickness Class Thickness	.46 21 .50	.47 21 .50	.48 21 .50	.50 21 .50	.52 22 .54	
	3½	Calculated Thickness Use { Thickness Class Thickness	.45 21 .50	.46 21 .50	.47 21 .50	.49 21 .50	.52 22 .54	
	5	Calculated Thickness Use { Thickness Class Thickness	.47 21 .50	.48 21 .50	.49 21 .50	.51 21 .50	.53 22 .54	
	8	Calculated Thickness Use { Thickness Class Thickness	.51 21 .50	.52 22 .54	.53 22 .54	.55 22 .54	.57 23 .58	
	12	Calculated Thickness Use { Thickness Class Thickness	.54 22 .54	.55 22 .54	.57 23 .58	.59 23 .58	.61 24 .63	
	16	Calculated Thickness Use { Thickness Class Thickness	.57 23 .58	.58 23 .58	.59 23 .58	.61 24 .63	.63 24 .63	

TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condition	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi					
			10	50	100	150	200	250
			Barrel Thicknesses—in.					
Twenty-Inch Gas Pipe								
A	2½	Calculated Thickness Use {Thickness Class Thickness	.61 22 .62	.62 22 .62	.65 23 .67	.67 23 .67	.70 24 .72	
	3½	Calculated Thickness Use {Thickness Class Thickness	.61 22 .62	.62 22 .62	.64 22 .62	.66 23 .67	.69 23 .67	
	5	Calculated Thickness Use {Thickness Class Thickness	.63 22 .62	.65 23 .67	.67 23 .67	.69 23 .67	.72 24 .72	
	8	Calculated Thickness Use {Thickness Class Thickness	.69 23 .67	.70 24 .72	.72 24 .72	.75 25 .78	.77 25 .78	
	12	Calculated Thickness Use {Thickness Class Thickness	.74 24 .72	.76 25 .78	.78 25 .78	.80 25 .78	.83 26 .84	
	16	Calculated Thickness Use {Thickness Class Thickness	.79 25 .78	.80 25 .78	.82 26 .84	.84 26 .84	.87 26 .84	
B	2½	Calculated Thickness Use {Thickness Class Thickness	.56 21 .57	.57 21 .57	.59 21 .57	.62 22 .62	.65 23 .67	
	3½	Calculated Thickness Use {Thickness Class Thickness	.55 21 .57	.57 21 .57	.59 21 .57	.62 22 .62	.64 22 .62	
	5	Calculated Thickness Use {Thickness Class Thickness	.58 21 .57	.59 21 .57	.61 22 .62	.64 22 .62	.67 23 .67	
	8	Calculated Thickness Use {Thickness Class Thickness	.63 22 .62	.64 22 .62	.66 23 .67	.69 23 .67	.71 24 .72	
	12	Calculated Thickness Use {Thickness Class Thickness	.68 23 .67	.69 23 .67	.71 24 .72	.73 24 .72	.76 25 .78	
	16	Calculated Thickness Use {Thickness Class Thickness	.71 24 .72	.73 24 .72	.75 25 .78	.77 25 .78	.80 25 .78	
F	2½	Calculated Thickness Use {Thickness Class Thickness	.50 21 .57	.51 21 .57	.53 21 .57	.57 21 .57	.60 22 .62	
	3½	Calculated Thickness Use {Thickness Class Thickness	.50 21 .57	.51 21 .57	.53 21 .57	.57 21 .57	.60 22 .62	
	5	Calculated Thickness Use {Thickness Class Thickness	.52 21 .57	.54 21 .57	.56 21 .57	.58 21 .57	.62 22 .62	
	8	Calculated Thickness Use {Thickness Class Thickness	.56 21 .57	.58 21 .57	.60 22 .62	.62 22 .62	.65 23 .67	
	12	Calculated Thickness Use {Thickness Class Thickness	.61 22 .62	.62 22 .62	.64 22 .62	.67 23 .67	.70 24 .72	
	16	Calculated Thickness Use {Thickness Class Thickness	.64 22 .62	.66 23 .67	.68 23 .67	.70 24 .72	.72 24 .72	

TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi					
			10	50	100	150	200	250
			Barrel Thicknesses—in.					
Twenty-four-Inch Gas Pipe								
A	2½	Calculated Thickness Use {Thickness Class Thickness	.67 22 .68	.69 22 .68	.72 23 .73	.75 23 .73	.78 24 .79	
	3½	Calculated Thickness Use {Thickness Class Thickness	.67 22 .68	.69 22 .68	.71 23 .73	.74 23 .73	.78 24 .79	
	5	Calculated Thickness Use {Thickness Class Thickness	.71 23 .73	.72 23 .73	.75 23 .73	.78 24 .79	.81 24 .79	
	8	Calculated Thickness Use {Thickness Class Thickness	.77 24 .79	.79 24 .79	.81 24 .79	.84 25 .85	.87 25 .85	
	12	Calculated Thickness Use {Thickness Class Thickness	.84 25 .85	.86 25 .85	.88 25 .85	.91 26 .92	.94 26 .92	
	16	Calculated Thickness Use {Thickness Class Thickness	.90 26 .92	.91 26 .92	.94 26 .92	.97 27 .99	1.00 27 .99	
B	2½	Calculated Thickness Use {Thickness Class Thickness	.61 21 .63	.63 21 .63	.65 21 .63	.68 22 .68	.72 23 .73	
	3½	Calculated Thickness Use {Thickness Class Thickness	.59 21 .63	.62 21 .63	.65 21 .63	.68 22 .68	.71 23 .73	
	5	Calculated Thickness Use {Thickness Class Thickness	.63 21 .63	.65 21 .63	.67 22 .68	.71 23 .73	.75 23 .73	
	8	Calculated Thickness Use {Thickness Class Thickness	.69 22 .68	.71 23 .73	.73 23 .73	.76 24 .79	.79 24 .79	
	12	Calculated Thickness Use {Thickness Class Thickness	.75 23 .73	.77 24 .79	.79 24 .79	.82 25 .85	.85 25 .85	
	16	Calculated Thickness Use {Thickness Class Thickness	.80 24 .79	.81 24 .79	.84 25 .85	.87 25 .85	.90 26 .92	
F	2½	Calculated Thickness Use {Thickness Class Thickness	.55 21 .63	.56 21 .63	.58 21 .63	.63 21 .63	.67 22 .68	
	3½	Calculated Thickness Use {Thickness Class Thickness	.54 21 .63	.56 21 .63	.58 21 .63	.62 21 .63	.66 22 .68	
	5	Calculated Thickness Use {Thickness Class Thickness	.57 21 .63	.58 21 .63	.62 21 .63	.65 21 .63	.68 22 .68	
	8	Calculated Thickness Use {Thickness Class Thickness	.62 21 .63	.64 21 .63	.67 22 .68	.70 22 .68	.73 23 .73	
	12	Calculated Thickness Use {Thickness Class Thickness	.67 22 .68	.69 22 .68	.72 23 .73	.75 23 .73	.78 24 .79	
	16	Calculated Thickness Use {Thickness Class Thickness	.71 23 .73	.73 23 .73	.76 24 .79	.79 24 .79	.82 25 .85	

TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi					
			10	50	100	150	200	250
			Barrel Thicknesses—in.					

Thirty-Inch Gas Pipe								
A	2½	Calculated Thickness Use {Thickness Class Thickness	.80 22 .79	.83 23 .85	.86 23 .85	.90 24 .92		
	3½	Calculated Thickness Use {Thickness Class Thickness	.79 22 .79	.82 23 .85	.85 23 .85	.89 24 .92		
	5	Calculated Thickness Use {Thickness Class Thickness	.84 23 .85	.86 23 .85	.90 24 .92	.93 24 .92		
	8	Calculated Thickness Use {Thickness Class Thickness	.92 24 .92	.94 24 .92	.97 25 .99	1.01 25 .99		
	12	Calculated Thickness Use {Thickness Class Thickness	1.01 25 .99	1.03 26 1.07	1.06 26 1.07	1.09 26 1.07		
	16	Calculated Thickness Use {Thickness Class Thickness	1.07 26 1.07	1.09 26 1.07	1.12 27 1.16	1.15 27 1.16		

B	2½	Calculated Thickness Use {Thickness Class Thickness	.69 21 .73	.74 21 .73	.77 22 .79	.81 22 .79		
	3½	Calculated Thickness Use {Thickness Class Thickness	.69 21 .73	.73 21 .73	.76 22 .79	.80 22 .79		
	5	Calculated Thickness Use {Thickness Class Thickness	.75 21 .73	.77 22 .79	.80 22 .79	.85 23 .85		
	8	Calculated Thickness Use {Thickness Class Thickness	.81 22 .79	.83 23 .85	.86 23 .85	.90 24 .92		
	12	Calculated Thickness Use {Thickness Class Thickness	.88 23 .85	.90 24 .92	.93 24 .92	.97 25 .99		
	16	Calculated Thickness Use {Thickness Class Thickness	.94 24 .92	.96 25 .99	.99 25 .99	1.03 26 1.07		

F	2½	Calculated Thickness Use {Thickness Class Thickness	.63 21 .73	.66 21 .73	.70 21 .73	.74 21 .73		
	3½	Calculated Thickness Use {Thickness Class Thickness	.63 21 .73	.66 21 .73	.70 21 .73	.74 21 .73		
	5	Calculated Thickness Use {Thickness Class Thickness	.68 21 .73	.70 21 .73	.73 21 .73	.77 22 .79		
	8	Calculated Thickness Use {Thickness Class Thickness	.73 21 .73	.75 21 .73	.79 22 .79	.83 23 .85		
	12	Calculated Thickness Use {Thickness Class Thickness	.79 22 .79	.81 22 .79	.85 23 .85	.88 23 .85		
	16	Calculated Thickness Use {Thickness Class Thickness	.84 23 .85	.86 23 .85	.90 24 .92	.93 24 .92		

TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure— <i>psi</i>					
			10	50	100	150	200	250
			Barrel Thicknesses— <i>in.</i>					
Thirty-six-Inch Gas Pipe								
A	2½	Calculated Thickness Use {Thickness Class Thickness	.91 23 .94	.94 23 .94	.98 24 1.02	1.02 24 1.02		
	3½	Calculated Thickness Use {Thickness Class Thickness	.90 22 .87	.93 23 .94	.97 23 .94	1.02 24 1.02		
	5	Calculated Thickness Use {Thickness Class Thickness	.95 23 .94	.98 24 1.02	1.02 24 1.02	1.07 25 1.10		
	8	Calculated Thickness Use {Thickness Class Thickness	1.04 24 1.02	1.07 25 1.10	1.11 25 1.10	1.15 26 1.19		
	12	Calculated Thickness Use {Thickness Class Thickness	1.15 26 1.19	1.17 26 1.19	1.21 26 1.19	1.25 27 1.29		
	16	Calculated Thickness Use {Thickness Class Thickness	1.23 26 1.19	1.26 27 1.29	1.29 27 1.29	1.33 27 1.29		
B	2½	Calculated Thickness Use {Thickness Class Thickness	.79 21 .81	.82 21 .81	.86 22 .87	.91 23 .94		
	3½	Calculated Thickness Use {Thickness Class Thickness	.79 21 .81	.81 21 .81	.85 22 .87	.90 22 .87		
	5	Calculated Thickness Use {Thickness Class Thickness	.83 21 .81	.86 22 .87	.90 22 .87	.94 23 .94		
	8	Calculated Thickness Use {Thickness Class Thickness	.90 22 .87	.93 23 .94	.96 23 .94	1.01 24 1.02		
	12	Calculated Thickness Use {Thickness Class Thickness	.99 24 1.02	1.01 24 1.02	1.05 24 1.02	1.10 25 1.10		
	16	Calculated Thickness Use {Thickness Class Thickness	1.06 25 1.10	1.08 25 1.10	1.13 25 1.10	1.17 26 1.19		
F	2½	Calculated Thickness Use {Thickness Class Thickness	.71 21 .81	.73 21 .81	.79 21 .81	.84 22 .87		
	3½	Calculated Thickness Use {Thickness Class Thickness	.71 21 .81	.73 21 .81	.78 21 .81	.83 21 .81		
	5	Calculated Thickness Use {Thickness Class Thickness	.75 21 .81	.78 21 .81	.82 21 .81	.87 22 .87		
	8	Calculated Thickness Use {Thickness Class Thickness	.81 21 .81	.84 22 .87	.88 22 .87	.93 23 .94		
	12	Calculated Thickness Use {Thickness Class Thickness	.89 22 .87	.91 23 .94	.95 23 94	1.00 24 1.02		
	16	Calculated Thickness Use {Thickness Class Thickness	.95 23 .94	.97 23 .94	1.01 24 1.02	1.06 25 1.10		

TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condition	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi					
			10	50	100	150	200	250
			Barrel Thicknesses—in.					
Forty-two-Inch Gas Pipe								
A	2½	Calculated Thickness Use {Thickness Class Thickness	1.01 23 1.05	1.04 23 1.05	1.08 23 1.05	1.14 24 1.13		
	3½	Calculated Thickness Use {Thickness Class Thickness	1.01 23 1.05	1.04 23 1.05	1.08 23 1.05	1.14 24 1.13		
	5	Calculated Thickness Use {Thickness Class Thickness	1.07 23 1.05	1.09 24 1.13	1.14 24 1.13	1.19 25 1.22		
	8	Calculated Thickness Use {Thickness Class Thickness	1.16 24 1.13	1.19 25 1.22	1.24 25 1.22	1.29 26 1.32		
	12	Calculated Thickness Use {Thickness Class Thickness	1.29 26 1.32	1.32 26 1.32	1.36 26 1.32	1.41 27 1.43		
	16	Calculated Thickness Use {Thickness Class Thickness	1.39 27 1.43	1.42 27 1.43	1.46 27 1.43	1.51 28 1.54		
B	2½	Calculated Thickness Use {Thickness Class Thickness	.86 21 .90	.89 21 .90	.94 22 .97	1.00 22 .97		
	3½	Calculated Thickness Use {Thickness Class Thickness	.86 21 .90	.89 21 .90	.94 22 .97	1.00 22 .97		
	5	Calculated Thickness Use {Thickness Class Thickness	.91 21 .90	.94 22 .97	.98 22 .97	1.04 23 1.05		
	8	Calculated Thickness Use {Thickness Class Thickness	.99 22 .97	1.02 23 1.05	1.07 23 1.05	1.12 24 1.13		
	12	Calculated Thickness Use {Thickness Class Thickness	1.10 24 1.13	1.13 24 1.13	1.17 24 1.13	1.22 25 1.22		
	16	Calculated Thickness Use {Thickness Class Thickness	1.18 25 1.22	1.21 25 1.22	1.25 25 1.22	1.30 26 1.32		
F	2½	Calculated Thickness Use {Thickness Class Thickness	.77 21 .90	.80 21 .90	.86 21 .90	.92 21 .90		
	3½	Calculated Thickness Use {Thickness Class Thickness	.77 21 .90	.80 21 .90	.86 21 .90	.92 21 .90		
	5	Calculated Thickness Use {Thickness Class Thickness	.82 21 .90	.85 21 .90	.90 21 .90	.96 22 .97		
	8	Calculated Thickness Use {Thickness Class Thickness	.89 21 .90	.92 21 .90	.97 22 .97	1.03 23 1.05		
	12	Calculated Thickness Use {Thickness Class Thickness	.98 22 .97	1.01 23 1.05	1.06 23 1.05	1.11 24 1.13		
	16	Calculated Thickness Use {Thickness Class Thickness	1.06 23 1.05	1.08 23 1.05	1.13 24 1.13	1.18 25 1.22		

TABLE 1-3 (Continued)
Schedule of Barrel Thickness for Gas Pipe of 18/40 Iron Strength

Laying Condi- tion	Depth of Cover ft	Thickness Specifications	Internal Pressure—psi					
			10	50	100	150	200	250
			Barrel Thicknesses—in.					
Forty-eight-Inch Gas Pipe								
A	2½	Calculated Thickness Use {Thickness Class Thickness	1.10 23 1.14	1.14 23 1.14	1.19 24 1.23	1.25 24 1.23		
	3½	Calculated Thickness Use {Thickness Class Thickness	1.11 23 1.14	1.14 23 1.14	1.20 24 1.23	1.26 24 1.23		
	5	Calculated Thickness Use {Thickness Class Thickness	1.18 23 1.14	1.22 24 1.23	1.27 24 1.23	1.32 25 1.33		
	8	Calculated Thickness Use {Thickness Class Thickness	1.29 25 1.33	1.33 25 1.33	1.38 25 1.33	1.43 26 1.44		
	12	Calculated Thickness Use {Thickness Class Thickness	1.43 26 1.44	1.47 26 1.44	1.52 27 1.56	1.57 27 1.56		
	16	Calculated Thickness Use {Thickness Class Thickness	1.55 27 1.56	1.58 27 1.56	1.63 28 1.68	1.69 28 1.68		
B	2½	Calculated Thickness Use {Thickness Class Thickness	.93 21 .98	.97 21 .98	1.03 22 1.06	1.09 22 1.06		
	3½	Calculated Thickness Use {Thickness Class Thickness	.94 21 .98	.98 21 .98	1.03 22 1.06	1.10 23 1.14		
	5	Calculated Thickness Use {Thickness Class Thickness	.99 21 .98	1.03 22 1.06	1.09 22 1.06	1.15 23 1.14		
		Calculated Thickness Use {Thickness Class Thickness	1.09 22 1.06	1.12 23 1.14	1.17 23 1.14	1.24 24 1.23		
	12	Calculated Thickness Use {Thickness Class Thickness	1.21 24 1.23	1.25 24 1.23	1.30 25 1.33	1.35 25 1.33		
	16	Calculated Thickness Use {Thickness Class Thickness	1.30 25 1.33	1.34 25 1.33	1.38 25 1.33	1.44 26 1.44		
F	2½	Calculated Thickness Use {Thickness Class Thickness	.84 21 .98	.88 21 .98	.93 21 .98	1.00 21 .98		
	3½	Calculated Thickness Use {Thickness Class Thickness	.84 21 .98	.88 21 .98	.94 21 .98	1.01 21 .98		
	5	Calculated Thickness Use {Thickness Class Thickness	.90 21 .98	.93 21 .98	.99 21 .98	1.06 22 1.06		
	8	Calculated Thickness Use {Thickness Class Thickness	.97 21 .98	1.01 21 .98	1.07 22 1.06	1.13 23 1.14		
	12	Calculated Thickness Use {Thickness Class Thickness	1.08 22 1.06	1.12 23 1.14	1.16 23 1.14	1.23 24 1.23		
	16	Calculated Thickness Use {Thickness Class Thickness	1.15 23 1.14	1.20 24 1.23	1.25 24 1.23	1.31 25 1.33		

Sec. 1-2—General Procedure for Thickness Determination

Sec. 1-2.1—Scope

This section gives the general method for determining the thicknesses of cast-iron pressure pipe. Thickness nomograms (Fig. 1-1 through 1-5) are included for two commonly used iron strengths (18/40 and 21/45); thicknesses for other iron strengths may be computed by the method presented in Sec. 1-3.1.

The required thickness of cast-iron pipe is determined by considering trench load and internal pressure in combination, and calculations of net thickness are made for two cases, namely:

Case 1. Trench load (earth load but no truck superload) in combination with internal pressure (working pressure plus surge pressure) and with a 2.5 factor of safety applied to both trench load and internal pressure

Case 2. Trench load (earth load plus truck superload) in combination with internal pressure (working pressure but no surge pressure) and with a 2.5 factor of safety applied to both trench load and internal pressure.

The larger thickness thus determined is chosen as the net thickness (only Case 2 is used for gas pipe). To the net thickness is added a corrosion allowance to obtain the minimum manufacturing thickness and a casting tolerance to obtain the total calculated thickness. Finally, the thickness for specifying and ordering is selected from a table of standard class thicknesses.

An example of this method is shown in Sec. 1-2.3.

Sec. 1-2.2—Procedure for Thickness Determination

This section gives the procedure for determining total calculated thick-

nesses and standard class thicknesses for pipe. This procedure was used in calculating the values shown in Sec. 1-1, Tables 1-1, 1-2 and 1-3.

1-2.2.1—Determination of Net Thickness

The net thickness for the more usual conditions may be readily determined using Tables 1-4 and 1-5 and the nomograms in Fig. 1-1 through 1-5. The bases for these tables and nomograms are described in Sec. 1-3. The three most commonly used methods of laying pipe, called "laying conditions," are defined below:

<i>Laying Condition</i>	<i>Description</i>
A	Pipe laid on flat-bottom trench, backfill not tamped
B	Pipe laid on flat-bottom trench, backfill tamped
F	Pipe bedded in gravel or sand, backfill tamped

After the pipe size, working pressure, iron strength, laying condition, and depth of cover have been established, the procedure for determining net thickness is as follows:

a. From Table 1-4, select for both Case 1 and Case 2 the value of w , which is the ring test load equivalent of trench load including a 2.5 safety factor (see Sec. 1-3.1 for definition of ring test load equivalent).

b. From Table 1-5, select for both Case 1 and Case 2 the value of p , which is the internal pressure including a 2.5 safety factor.

c. Thickness nomograms are provided in Fig. 1-1 through 1-5 for iron strengths of 18/40* and 21/45.* Se-

* The first figure designates the bursting tensile strength in 1,000 psi and the second figure designates the ring modulus of rupture in 1,000 psi.

lect the nomogram for the desired iron strength and range of loads and pressures. Locate the values of w and p for Case 1 on the vertical scales. Connect these values with a straightedge and read the required thickness for Case 1.

d. Repeat this procedure using the above values of w and p for Case 2 and read the required thickness for Case 2.

e. The larger thickness, as determined for Cases 1 and 2, is the net thickness for water pipe. (For gas pipe, only Case 2 is applicable.)

1-2.2.2—Addition of Allowances to Net Thickness

a. A corrosion allowance of 0.08 in. is added to the net thickness. The resulting thickness is the minimum manufacturing thickness. Where severe corrosion is anticipated, an analysis of the condition should be made.

b. A casting tolerance from Table 1-6 is added to the minimum manufacturing thickness and the resulting thickness is the total calculated thickness.

1-2.2.3—Selection of Standard Thickness

Refer to Table 1-7 and select the standard class thickness nearest to the total calculated thickness. When the calculated thickness is halfway between two standard thicknesses, the larger of these is selected. When the calculated thickness is less than the smallest standard thickness, the smallest standard thickness is selected.

Sec. 1-2.3—Example for Determining Thickness of 18-in. Water Pipe

Determine the thickness for 18-in. cast-iron pipe laid on flat-bottom trench with tamped backfill (laying condition B), under 5 ft of cover for a working pressure of 200 psi. Iron strength is 18/40.

1-2.3.1—Step 1—Determination of Net Thickness

a. From Table 1-4, the ring test load equivalents of trench load, including a safety factor of 2.5, are

For Case 1, $w = 2,786$ lb/lin ft

For Case 2, $w = 3,876$ lb/lin ft

b. From Table 1-5, the internal pressures, including a safety factor of 2.5, are

For Case 1, $p = 750$ psi

For Case 2, $p = 500$ psi

c. Using Fig. 1-1, locate $w = 2,786$ and $p = 750$ on the vertical scales. Connect these values with a straightedge and read the thickness for Case 1, which is 0.47 in.

d. Using Fig. 1-1, locate $w = 3,876$ and $p = 500$ and read the thickness for Case 2, which is 0.46 in.

e. The larger of these two thicknesses is the net thickness. The controlling one in this example is 0.47 in. (Case 1).

1-2.3.2—Step 2—Addition of Allowances to Net Thickness

The total calculated thickness, as shown in Table 1-1, is determined as follows:

Net thickness	0.47 in.
Corrosion allowance	0.08 in.
Minimum manufacturing thickness	0.55 in.
Casting tolerance (Table 1-6)	0.08 in.
<i>Total calculated thickness</i>	<i>0.63 in.</i>

1-2.3.3—Step 3—Selection of Standard Thickness

From Table 1-7, the total calculated thickness of 0.63 in. is exactly the same as Class 23. Therefore, Class 23 is the standard thickness class for the pipe in this example.

In ordering or specifying, the foregoing pipe is identified as 18-in. size, thickness Class 23, conforming to ANSI Standard A21.6 or A21.8 as applicable.

TABLE 1-4
*Ring Test Load Equivalents (w) of Trench Loads—lb/lin ft**

Laying Condition	Pipe Size in.	Depth of Cover—ft							
		2½	3½	5	8	12	16	20	24
Case 1—Ring Test Load Equivalent of Earth Load (Use With Surge Pressure)									
A	3	396	565	817	1,324	2,000	2,674	3,343	4,026
	4	491	704	1,024	1,663	2,515	3,367	4,222	5,074
	6	672	974	1,428	2,337	3,548	4,756	5,487	5,754
	8	826	1,211	1,791	2,948	4,491	5,635	6,120	6,446
	10	974	1,448	2,157	3,576	5,376	6,198	6,770	7,163
	12	1,111	1,674	2,520	4,239	5,839	6,774	7,433	7,902
	14	1,235	1,887	2,865	4,822	6,304	7,356	8,115	8,659
	16	1,341	2,085	3,196	5,176	6,776	7,954	8,804	9,433
	18	1,446	2,265	3,513	5,506	7,250	8,548	9,509	10,224
	20	1,552	2,433	3,815	5,839	7,728	9,150	10,224	11,033
	24	1,770	2,730	4,372	6,509	8,693	10,378	11,678	12,680
	30	2,093	3,167	5,087	7,520	10,161	12,256	13,915	15,237
	36	2,437	3,626	5,713	8,537	11,643	14,167	16,220	17,882
	42	2,761	4,083	6,341	9,556	13,078	16,104	18,554	20,560
	48	3,102	4,550	6,991	10,580	14,646	18,061	20,928	23,354
	54	3,437	5,022	7,650	11,609	16,161	20,039	23,346	26,161
	60	3,778	5,493	8,313	12,643	17,815	22,028	25,776	28,998
B	3	355	508	734	1,189	1,797	2,402	3,004	3,617
	4	438	628	913	1,483	2,242	3,002	3,764	4,523
	6	585	848	1,244	2,036	3,091	4,144	4,780	5,014
	8	709	1,039	1,537	2,530	3,855	4,836	5,252	5,531
	10	824	1,224	1,823	3,024	4,546	5,241	5,724	6,057
	12	926	1,395	2,100	3,533	4,866	5,645	6,194	6,586
	14	1,007	1,539	2,337	3,933	5,142	6,000	6,618	7,062
	16	1,079	1,677	2,570	4,163	5,449	6,397	7,080	7,586
	18	1,147	1,797	2,786	4,367	5,750	6,779	7,541	8,109
	20	1,214	1,903	2,985	4,568	6,046	7,158	7,998	8,631
	24	1,339	2,066	3,307	4,924	6,577	7,852	8,836	9,593
	30	1,524	2,305	3,703	5,473	7,396	8,921	10,128	11,090
	36	1,709	2,543	4,006	5,986	8,165	9,935	11,373	12,540
	42	1,879	2,778	4,315	6,503	8,899	10,959	12,626	14,015
	48	2,074	3,042	4,674	7,074	9,792	12,076	13,993	15,615
	54	2,259	3,300	5,027	7,629	10,620	13,169	15,342	17,191
	60	2,455	3,569	5,401	8,215	11,575	14,312	16,747	18,841
F	3	261	374	540	875	1,322	1,767	2,210	2,661
	4	323	463	673	1,093	1,653	2,213	2,774	3,334
	6	434	629	923	1,510	2,292	3,073	3,545	3,718
	8	528	774	1,144	1,883	2,869	3,600	3,910	4,118
	10	612	910	1,355	2,247	3,378	3,895	4,254	4,502
	12	691	1,041	1,566	2,635	3,630	4,211	4,620	4,912
	14	755	1,154	1,753	2,949	3,856	4,500	4,964	5,297
	16	812	1,262	1,934	3,133	4,101	4,815	5,329	5,709
	18	861	1,350	2,093	3,281	4,320	5,093	5,666	6,092
	20	915	1,435	2,250	3,444	4,558	5,396	6,029	6,506
	24	1,018	1,570	2,514	3,742	4,999	5,968	6,715	7,291
	30	1,157	1,751	2,812	4,157	5,618	6,776	7,693	8,424
	36	1,310	1,949	3,070	4,588	6,257	7,613	8,716	9,610
	42	1,443	2,134	3,315	4,996	6,837	8,418	9,699	10,766
	48	1,586	2,326	3,573	5,408	7,485	9,231	10,697	11,937
	54	1,726	2,522	3,842	5,830	8,116	10,063	11,724	13,138
	60	1,881	2,735	4,139	6,295	8,869	10,967	12,832	14,436

* A safety factor of 2.5 is included. These ring test load equivalents are based on the earth loads in Table 1-8.

TABLE 1-4 (Continued)
*Ring Test Load Equivalents (w) of Trench Loads—lb/lin ft**

Laying Condi- tion	Pipe Size in.	Depth of Cover—ft							
		2½	3½	5	8	12	16	20	24
Case 2—Ring Test Load Equivalent of Earth Load Plus Truck Superload (Use Without Surge Pressure)†									
A	3	748	741	935	1,411	2,059	2,704	3,363	4,041
	4	1,137	1,057	1,200	1,780	2,602	3,426	4,261	5,104
	6	1,904	1,678	1,839	2,541	3,696	4,843	5,543	5,798
	8	2,528	2,267	2,437	3,270	4,696	5,752	6,198	6,506
	10	3,087	2,798	2,978	3,987	5,611	6,346	6,867	7,239
	12	3,635	3,317	3,517	4,767	6,104	6,950	7,548	7,991
	14	3,880	3,641	4,039	5,409	6,598	7,561	8,250	8,763
	16	4,183	3,996	4,478	5,880	7,128	8,220	8,980	9,567
	18	4,489	4,361	4,887	6,298	7,661	8,841	9,702	10,374
	20	4,865	4,772	5,400	6,730	8,198	9,502	10,456	11,213
	24	5,383	5,250	6,043	7,513	9,250	10,761	11,930	12,876
	30	6,278	6,115	7,083	8,746	10,865	12,726	14,226	15,476
	36	7,180	7,054	8,083	9,911	12,465	14,724	16,587	18,167
	42	7,878	7,887	9,035	11,115	14,076	16,778	19,000	20,939
	48	8,596	8,728	10,035	12,350	15,761	18,824	21,432	23,743
	54	9,165	9,483	10,967	13,563	17,452	20,861	23,902	26,572
	60	9,789	10,237	11,904	14,783	19,193	22,909	26,393	29,437
B	3	672	666	840	1,268	1,850	2,430	3,021	3,631
	4	1,014	942	1,070	1,587	2,320	3,054	3,798	4,550
	6	1,659	1,462	1,602	2,214	3,220	4,220	4,830	5,051
	8	2,170	1,946	2,091	2,806	4,030	4,937	5,319	5,584
	10	2,610	2,366	2,518	3,371	4,744	5,366	5,807	6,121
	12	3,029	2,765	2,931	3,973	5,087	5,792	6,290	6,659
	14	3,165	2,970	3,294	4,411	5,381	6,166	6,729	7,147
	16	3,364	3,213	3,601	4,729	5,733	6,610	7,222	7,694
	18	3,560	3,459	3,876	4,995	6,076	7,012	7,695	8,228
	20	3,806	3,733	4,225	5,265	6,413	7,434	8,180	8,772
	24	4,072	3,972	4,572	5,684	6,998	8,141	9,026	9,742
	30	4,570	4,451	5,155	6,366	7,908	9,263	10,354	11,264
	36	5,035	4,947	5,668	6,950	8,741	10,325	11,631	12,739
	42	5,361	5,367	6,148	7,564	9,578	11,417	12,929	14,248
	48	5,747	5,836	6,709	8,257	10,538	12,586	14,330	15,875
	54	6,023	6,232	7,207	8,913	11,469	13,709	15,707	17,461
	60	6,360	6,651	7,734	9,604	12,470	14,884	17,148	19,126
F	3	494	490	618	932	1,361	1,787	2,223	2,671
	4	747	694	789	1,170	1,710	2,251	2,800	3,354
	6	1,230	1,084	1,188	1,642	2,388	3,129	3,581	3,746
	8	1,615	1,449	1,557	2,089	3,000	3,675	3,960	4,157
	10	1,940	1,758	1,872	2,505	3,526	3,988	4,316	4,549
	12	2,260	2,062	2,187	2,964	3,795	4,320	4,692	4,968
	14	2,374	2,227	2,471	3,309	4,036	4,625	5,046	5,360
	16	2,532	2,418	2,711	3,559	4,315	4,975	5,436	5,791
	18	2,675	2,598	2,912	3,752	4,565	5,268	5,781	6,181
	20	2,869	2,814	3,185	3,969	4,835	5,604	6,167	6,613
	24	3,095	3,019	3,475	4,320	5,319	6,188	6,860	7,404
	30	3,471	3,381	3,916	4,835	6,007	7,036	7,865	8,556
	36	3,859	3,791	4,343	5,326	6,698	7,912	8,914	9,763
	42	4,118	4,123	4,723	5,810	7,358	8,771	9,932	10,945
	48	4,393	4,461	5,129	6,312	8,055	9,621	10,954	12,136
	54	4,603	4,762	5,508	6,811	8,764	10,476	12,003	13,344
	60	4,874	5,097	5,927	7,360	9,556	11,405	13,140	14,655

*A safety factor of 2.5 is included. These ring test load equivalents are based on the earth loads and truck superloads in Table 1-8.

† Truck superload is based on two passing trucks with adjacent wheels 3 ft apart, having a 9,000-lb wheel load on unpaved road or flexible pavement and an impact factor of 1.50 (see Sec. 1-3.3).

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TABLE 1-5
Internal Pressures (p)*

Pipe Size in.	Rated Working Pressure—psi							
	10	50	100	150	200	250	300	350
Case 1—Internal Pressure With Surge Pressure Allowances†								
3	—	425	550	675	800	925	1,050	1,175
4	—	425	550	675	800	925	1,050	1,175
6	—	425	550	675	800	925	1,050	1,175
8	—	425	550	675	800	925	1,050	1,175
10	—	425	550	675	800	925	1,050	1,175
12	—	400	525	650	775	900	1,025	1,150
14	—	400	525	650	775	900	1,025	1,150
16	—	375	500	625	750	875	1,000	1,125
18	—	375	500	625	750	875	1,000	1,125
20	—	350	475	600	725	850	975	1,100
24	—	338	463	588	713	838	963	1,088
30	—	325	450	575	700	825	950	1,075
36	—	313	438	563	688	813	938	1,063
42	—	300	425	550	675	800	925	1,050
48	—	300	425	550	675	800	925	1,050
54	—	300	425	550	675	800	925	1,050
60	—	300	425	550	675	800	925	1,050
Case 2—Internal Pressure Without Surge Pressure Allowances								
3-60 all	25	125	250	375	500	625	750	875

* Safety factor of 2.5 included.

† For surge pressure allowances, see Table 1-10.

TABLE 1-6
Allowances For Casting Tolerance

Pipe Size in.	Casting Tolerance in.	Pipe Size in.	Casting Tolerance in.
3-8	0.05	14-24	0.08
10-12	0.06	30-48	0.10

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TABLE 1-7—Standard Thickness Classes of Cast-Iron Pipe
(See note on facing page)

Pipe Size in.	Thickness for Standard Thickness Class Number—in.										
	20	21	22	23	24	25	26	27	28	29	30
3			0.32*	0.35	0.38	0.41	0.44	0.48	0.52	0.56	0.60
4			0.35*	0.38	0.41	0.44	0.48	0.52	0.56	0.60	0.65
6		0.35*	0.38	0.41	0.44	0.48	0.52	0.56	0.60	0.65	0.70
8	0.35*	0.38	0.41	0.44	0.48	0.52	0.56	0.60	0.65	0.70	0.76
10	0.38*	0.41	0.44	0.48	0.52	0.56	0.60	0.65	0.70	0.76	0.82
12	0.41*	0.44	0.48	0.52	0.56	0.60	0.65	0.70	0.76	0.82	0.89
14	0.43	0.48*	0.51	0.55	0.59	0.64	0.69	0.75	0.81	0.87	0.94
16	0.46	0.50*	0.54	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99
18	0.50	0.54*	0.58	0.63	0.68	0.73	0.79	0.85	0.92	0.99	1.07
20	0.53	0.57*	0.62	0.67	0.72	0.78	0.84	0.91	0.98	1.06	1.14
24	0.58	0.63*	0.68	0.73	0.79	0.85	0.92	0.99	1.07	1.16	1.25
30	0.68*	0.73	0.79	0.85	0.92	0.99	1.07	1.16	1.25	1.35	1.46
36	0.75*	0.81	0.87	0.94	1.02	1.10	1.19	1.29	1.39	1.50	1.62
42	0.83*	0.90	0.97	1.05	1.13	1.22	1.32	1.43	1.54	1.66	1.79
48	0.91*	0.98	1.06	1.14	1.23	1.33	1.44	1.56	1.68	1.81	1.95

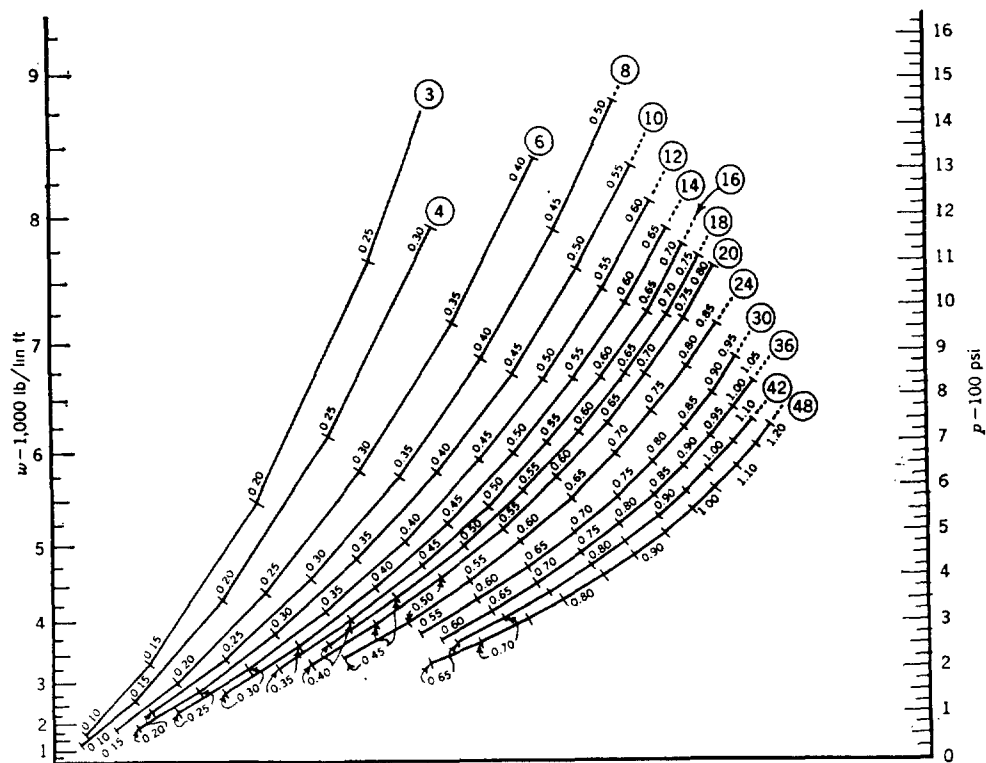


Fig. 1-1. Thickness Nomogram for Pipe of 18/40 Iron Strength, Low-Range Load

Thicknesses are net, and computations are made using nominal pipe diameter for inside diameter. S equals 18,000, R equals 40,000. The encircled values at the end of each curve are for pipe size, in inches.

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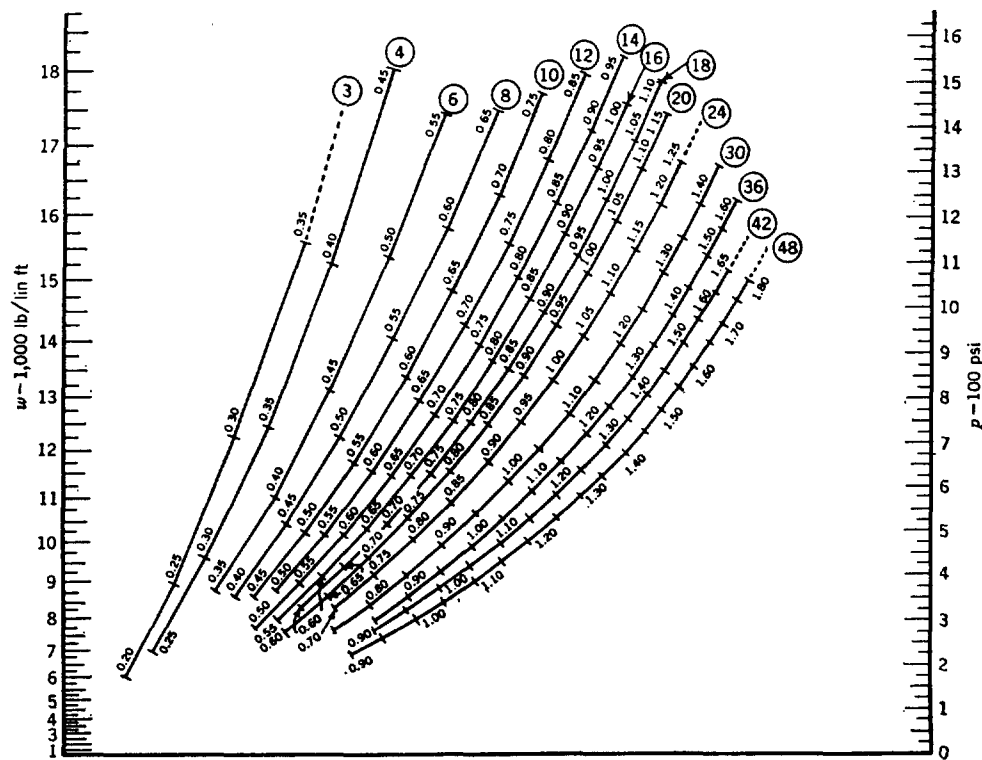


Fig. 1-2. Thickness Nomogram for Pipe of 18/40 Iron Strength, High-Range Load

Thicknesses are net, and computations are made using nominal pipe diameter for inside diameter. S equals 18,000, R equals 40,000. The encircled values at the end of each curve are for pipe size, in inches.

Explanatory Note to Table 1-7

Irrespective of calculated thickness, standard thicknesses are not made less than certain minimums, which are the smallest thickness classes shown in the table. They have been chosen by judgment based on experience with the shocks received by pipe in handling and transporting. ANSI Standards A21.6, A21.7, A21.8, and A21.9 are based on iron strength of 18/40. The recommended minimum nominal thicknesses for such pipe are shown in boldface type. Pipe of 21/45 iron strength for water service may have thicknesses less than those pipe of 18/40 iron strength. Pipe of such reduced thickness should be used only after consideration of possible adverse conditions of installation and environment. The recommended minimum nominal thicknesses for such pipe are shown with an asterisk. Pipe with 21/45 iron strength in Thickness Class 20 are sometimes used in sizes 14-24 in., when the calculated thicknesses permit and where provisions are made for special handling.

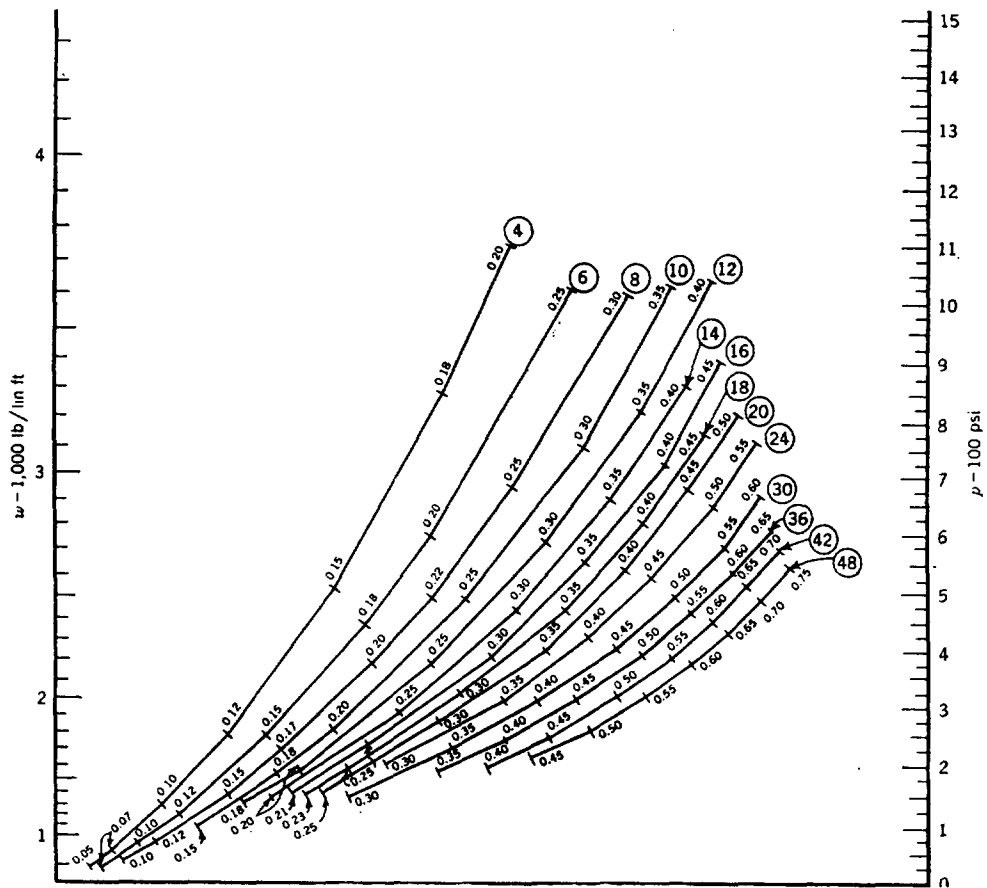


Fig. 1-3. Thickness Nomogram for Pipe of 21/45 Iron Strength, Low-Range Load

Thicknesses are net, and computations are made using nominal pipe diameter for inside diameter. S equals 21,000. R equals 45,000. The encircled values at the end of each curve are for pipe size, in inches.

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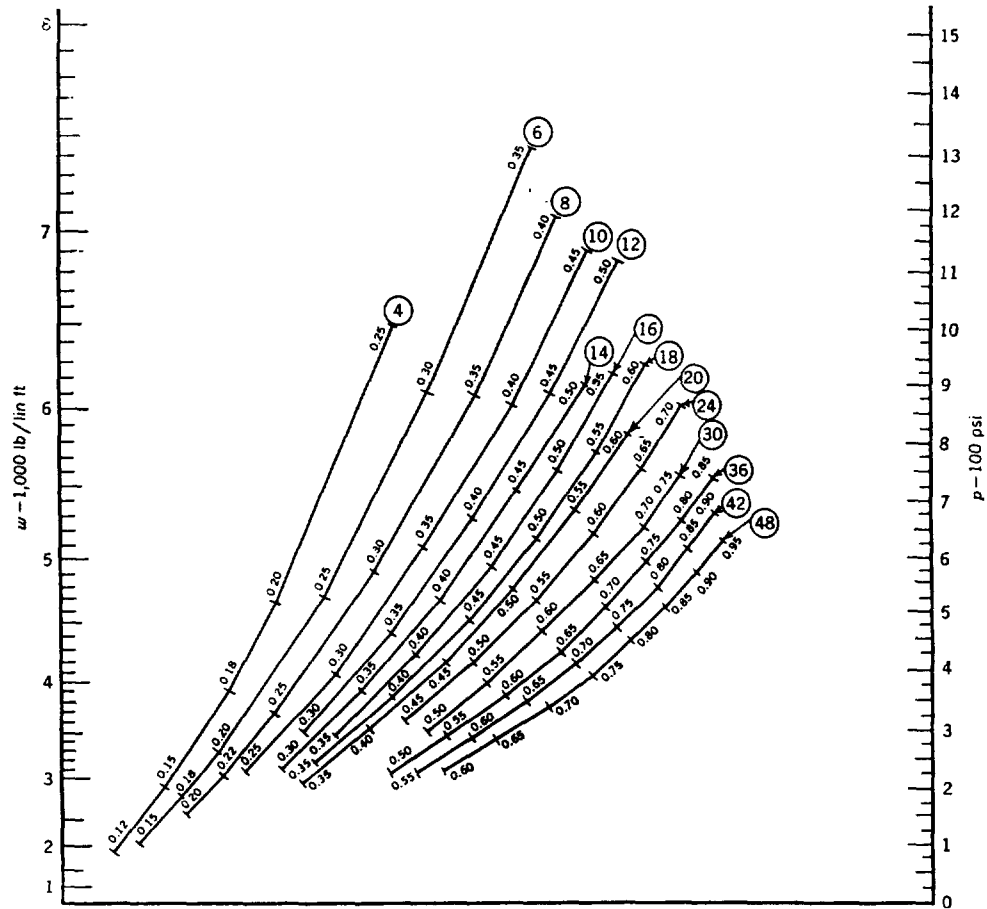


Fig. 1-4. Thickness Nomogram for Pipe of 21/45 Iron Strength, Medium-Range Load

Thicknesses are net, and computations are made using nominal pipe diameter for inside diameter. S equals 21,000, R equals 45,000. The encircled values at the end of each curve are for pipe size, in inches.

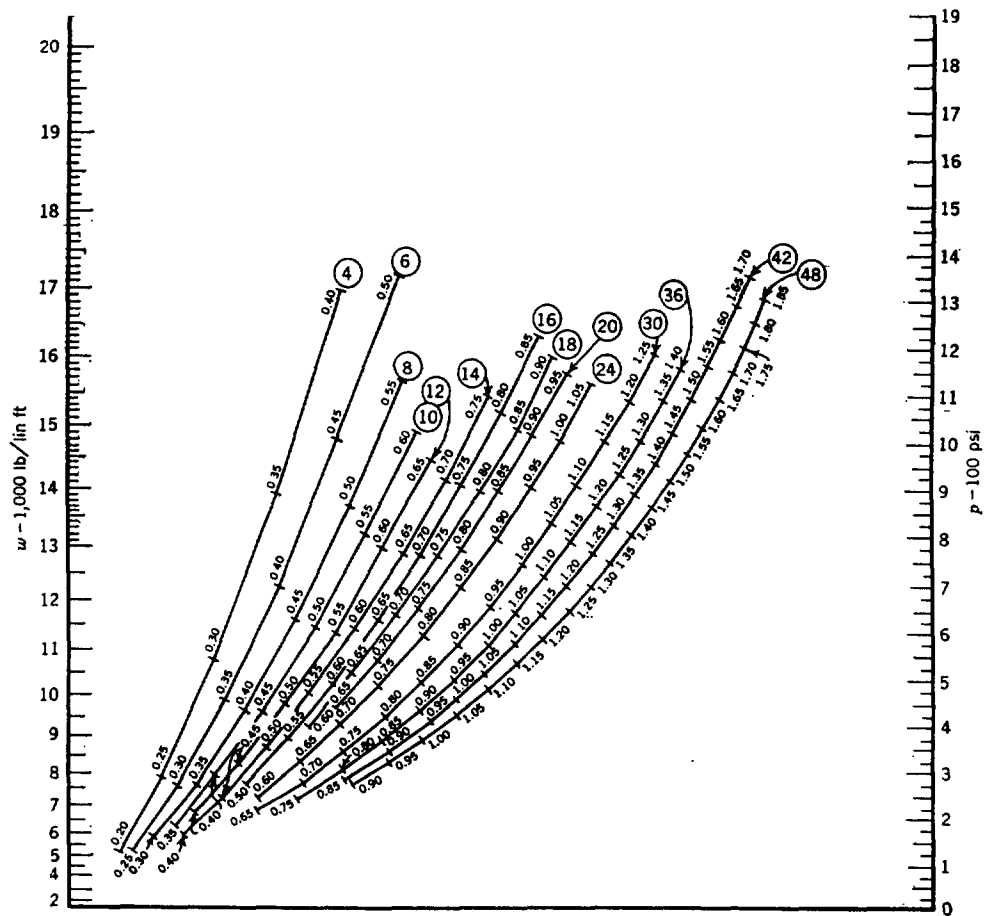


Fig. 1-5. Thickness Nomogram for Pipe of 21/45 Iron Strength, High-Range Load

Thicknesses are net, and computations are made using nominal pipe diameter for inside diameter. S equals 21,000, R equals 45,000. The encircled values at the end of each curve are for pipe size, in inches.

Sec. 1-3—Design Theory—Determination of Net Thickness. Earth Load, and Truck Superload

Sec. 1-3.1—Determination of Net Thickness

Tests made for ANSI Committee A21* showed that, when a pipe has both an external load applied in three-edge bearing (such as the laboratory ring test) and an internal pressure, the relation between external load and internal pressure at the point of breaking can be represented, with sufficient accuracy, by a parabola drawn as in Fig. 1-6.

The mathematical relationships expressed by the formula for the load-pressure curve are the basis for the whole system of pipe thickness calculations used in this standard.

The equation of the load-pressure parabola is

$$w = W \sqrt{\frac{P - p}{P}} \quad (1)$$

in which:

W = ring test crushing load with no internal pressure (lb/lin ft)

P = bursting pressure with no external load (psi)

p and w are any combination of internal pressure and external load that will just cause fracture.

The values of W and P are calculated as follows:

$$W = \frac{Rt^2}{0.0795(d + t)} \quad (2)$$

$$P = \frac{2St}{d} \quad (3)$$

* See Ref. 3, "Foreword," p. x.

in which:

R = ring modulus of rupture (psi)

S = bursting tensile strength (psi)

t = net thickness (in.)

d = nominal pipe size (in.).

The symbols S and R denote the strength of the iron in the pipe and are based on periodic full-length bursting tests and ring tests as specified in ANSI Standards A21.6 (AWWA C106), A21.7, A21.8 (AWWA C108), and A21.9.

The design values of w to be used in solving Eq 1, either by nomogram or by trial calculation, are determined as follows:

For Case 1,

$$w = \frac{2.5W_e}{L_f} \quad (4)$$

For Case 2,

$$w = \frac{2.5(W_e + W_t)}{L_f} \quad (5)$$

in which:

w = ring test load equivalent of trench load (lb/lin ft), including a 2.5 safety factor

W_e = earth load (lb/ft) (Table 1-8 and Sec. 1-3.2)

W_t = truck superload (lb/ft) (Table 1-8 and Sec. 1-3.3)

L_f = load factor dependent on laying condition (Table 1-9)

2.5 = safety factor.

The load factor L_f converts the trench load (earth load only or earth

load plus truck superload) to an equivalent load in the laboratory ring test. Table 1-4 gives values of w computed from Eq 4 and 5 for standard depths of cover using the earth loads and truck superloads in Table 1-8 and the load factors in Table 1-9.

The design values of p to be used in solving Eq 1, either by nomogram or by trial calculation, are determined as follows:

For Case 1,

$$p = 2.5 (p_w + p_s) \quad (6)$$

For Case 2,

$$p = 2.5 p_w \quad (7)$$

in which:

p = internal pressure (psi), including a 2.5 safety factor

p_w = working pressure (psi)

p_s = allowance for surge pressure (psi) (Table 1-10)

2.5 = safety factor.

Table 1-5 gives values of p computed by Eq 6 and 7 for standard working pressures using the allowances for surge pressure in Table 1-10.

As described in Sec. 1-2.2, calculations for net thickness for water pipe are made for two conditions of combined loading: Case 1, which includes surge pressure but not truck superload; and Case 2, which includes truck superload but not surge pressure. The larger of the two thicknesses is used for design. Truck superload and surge pressure are transient and occasional loads, and it is considered extremely unlikely that they will occur simultaneously.

When Eq 2 and 3 are substituted in Eq 1, the result is a high-order equation which cannot be solved directly for the net thickness t by conventional mathematical procedure. It is necessary to resort to graphical solution

or to successive approximation. The more convenient method for routine work is to use a nomogram as shown in Fig. 1-1 through 1-5. Such nomograms are prepared by the following steps:

a. Using the appropriate iron strength values of S and R , calculate W and P for a series of thicknesses for each pipe size by means of Eq 2 and 3.

b. For each thickness select two values of p and compute the corresponding values of w using Eq 1.

c. Set up parallel scales for w and p , using linear increments for the p scale and increments proportional to the square of the load for the w scale.

d. Using a straightedge to connect the corresponding values of w and p , locate and mark the intersection of the two lines determined by the two sets of values for each thickness.

e. Repeat for the full series of thicknesses to lay out the curve for each pipe size.

If it is desired to determine net thickness for iron strengths or loads and pressures not covered in the nomograms in Fig. 1-1 through 1-5, a trial calculation method may be used to solve Eq 1, as follows:

a. Based on the values of w and p corresponding to the design conditions, assume a trial value of t .

b. Using the known iron strength values S and R and the trial value of t , calculate W and P from Eq 2 and 3.

c. Using these values of W and P and the design value of p , solve Eq 1 for w .

d. Compare this calculated value of w to the design value of w and assume a smaller or larger value of t , as required, for the second trial calculation.

e. Continue until a change in assumed thickness of less than 0.01 in. results in a calculated w equal to or greater than the design w .

A graphical method may also be used for determining thicknesses for conditions not covered in the nomograms in Fig. 1-1 through 1-5. The parabolic graphical method is described in Sec. 1-12.3 of ANSI A21.1-1957 (AWWA H1-57).

Sec. 1-3.2—Earth Loads (W_e)

For computation of earth loads on cast-iron pipe the type of installation is identified as shown in Fig. 1-7. Ditch condition (Fig. 1-7a, b, c) denotes pipe laid in a relatively narrow trench and backfilled to the original ground surface. The trench width at the top of the pipe determines the load and the ditch may be widened above the top of the pipe for installation convenience (Fig. 1-7 b, c) without increasing the load on the pipe. Embankment condition includes two types of installation: positive projection condition (Fig. 1-7d) which denotes pipe laid on top of a subgrade and covered with fill, and negative projection condition (Fig. 1-7e) which denotes pipe laid in a trench in the subgrade and covered with fill, which extends substantially above the subgrade. Methods for calculating earth loads for these three installation conditions are given below:

1-3.2.1—Ditch Condition

The ditch condition is the most common method of installing cast-iron pipe and is the basis of the earth loads shown in Table 1-8. The load is obtained by selecting the lesser of the two loads computed by Eq 8 and 9.

$$W_e = C_d w B_d^2 \quad (\text{ditch condition}) \quad (8)$$

$$W_e = C_e w B_e^2 \quad (\text{positive projection condition}) \quad (9)$$

in which:

W_e = earth load, lb per linear ft

C_d = calculation coefficient, ditch condition

C_e = calculation coefficient, positive projection condition

w = soil density (120 lb/cu ft assumed in standard calculations)

B_d = width of trench at top of pipe (ft) (for standard calculations use nominal pipe diameter plus 2 ft)

B_e = outside diameter of pipe, ft.

This procedure was established by work done at Iowa State College,* which proved that for certain combinations of pipe size, trench width, and depth of cover, the load given by Eq 9 for positive projection condition should be used when it is the lesser of the two loads even though the pipe is laid in a trench.

The calculation coefficient C_d is obtained from Fig. 1-8 or from the following equation:

$$C_d = \frac{1 - e^{-2K\mu' \frac{H}{B_d}}}{2K\mu'} \quad (10)$$

in which:

K = ratio of active horizontal pressure at any point in the fill to the vertical pressure which causes the active horizontal pressure

μ' = coefficient of sliding friction between fill materials and sides of trench

$K\mu' = 0.130$ for standard calculations

* SPANGLER, M. G. *Soil Engineering*. International Textbook Co., Scranton, Pa. (2nd ed., 1960). p. 416.

e = the base of natural logarithms (2.71828) in which:

H = depth of cover to top of pipe (ft).

r_{sd} = settlement ratio*
 p = projection ratio*

The calculation coefficient, C_e , is obtained from Fig. 1-9 or from the following equation:

$$C_e = \frac{e^{2K\mu \frac{H}{B_e}} - 1}{2K\mu} \quad (11)$$

or

$$C_e = \frac{e^{2K\mu \frac{H_e}{B_e}} - 1}{2K\mu} + \left(\frac{H}{B_e} - \frac{H_e}{B_e} \right) e^{2K\mu \frac{H_e}{B_e}} \quad (12)$$

in which:

μ = coefficient of internal friction in fill materials

$K\mu$ = 0.1924 for standard calculations

H_e = Height of equal settlement (ft) (vertical height from the top of conduit to the level at and above which the fill materials directly over the conduit settle equally with the adjacent fill materials).

Equation 11 is used when the height of fill, H , is equal to or less than the height of equal settlement, H_e . Equation 12 is used when the height of fill, H , is greater than the height of equal settlement, H_e .

The height of equal settlement, H_e , is obtained from the following equation:

$$e^{2K\mu \frac{H_e}{B_e}} - 2K\mu \frac{H_e}{B_e} = 2K\mu(r_{sd}p) + 1 \quad (13)$$

For standard calculations the value of the product $r_{sd}p$ is taken to be 0.75. For this value, the height of equal settlement calculated by Eq 13 is, $H_e = 1.75 B_e$ and Eq 12 reduces to:

$$C_e = 1.961 \frac{H}{B_e} - 0.934 \quad (12a)$$

In most cases Eq 12a is used to calculate C_e because the depth of cover usually exceeds 1.75 times the pipe outside diameter.

Table 1-8 and Fig. 1-10 show earth loads computed by the above procedures for cast-iron pipe laid in trenches with widths, B_d , equal to the nominal pipe diameter plus 2 ft. Figure 1-11 shows a chart of earth loads computed by the above procedures for pipe installed in trenches where B_d is equal to the nominal pipe diameter plus 1 ft.

Figures 1-12 and 1-13 show charts computed by the above procedures for pipe laid in trenches with sides sloped 1:1 and 2:1, respectively.

For standard calculations, $K\mu = 0.1924$ is used for C_e and $K\mu' = 0.130$ is used for C_d in order to obtain conservative earth loads. Other values of $K\mu$ and $K\mu'$, which may be used in calculating earth loads for special soil conditions, are shown below with the corresponding soil type:

Soil Type	Value of $K\mu$ or $K\mu'$
Granular materials without cohesion	0.1924
Sand and gravel, maximum	0.165

* For a definition of these terms see: SPANGLER, M. G. *Soil Engineering*. International Textbook Co., Scranton, Pa. (2nd ed., 1960). p. 403.

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Saturated top soil, maximum	0.150
Clay, ordinary maximum	0.130
Saturated clay, maximum	0.110

1-3.2.2—Positive-Projection Embankment

The positive-projection condition may be encountered with pipe laid on top of a subgrade and covered with fill for highway or dam construction. The earth load is calculated from Eq 9 using Eq 12a for calculation of C_e when standard values of $r_{sd}p$ and $K\mu$ are used. For such standard values the load may also be read directly from Fig. 1-12 which was constructed from loads computed by Eq 9. The loads in Fig. 1-12 are based on soil weighing 110 lb/cu ft and may be adjusted to soil of 120 lb/cu ft by multiplying the graph load by 120/110. For calculation of pipe thicknesses, special load factors are used for positive projection embankment condition as shown in Table 1-9.

1-3.2.3—Negative-Projection Embankment Condition

The negative-projection embankment condition may be encountered in highway or dam construction when the pipe is laid in a relatively narrow trench cut in the subgrade, a more desirable method than installation directly on top of the subgrade. Loads for negative projection are calculated as follows.

$$W_e = C_n w B_d^2 \quad (14)$$

in which:

C_n = calculation coefficient (negative projection condition).

Other terms are as defined for Eq 8 and 9.

The calculation coefficient, C_n , is read from Fig. 1-14 after the values

of p' and H/B_d have been determined as follows:

$$p' = h/B_d$$

h = depth of cover in trench from top of pipe to subgrade (ft)

H = total height of fill from top of pipe to top of embankment (ft)

B_d = width of subgrade trench at top of pipe (ft)

Equation 14 is considered to give the maximum load that could occur on pipe laid in trenches under embankment conditions such as the case of embankment or additional fill added at some time, generally years, after the pipe was laid as a ditch conduit and backfill placed. In many embankment cases, Eq 14 may give loads which are too conservative.

In cases where pipe is laid in a subgrade trench with the embankment completed shortly thereafter, the load may be closer to that given by Eq 8 for ditch condition, and the embankment fill above the subgrade trench may be considered as equivalent to an increase of the trench width above the top of the pipe without significant effect on the earth load.

For other cases the load may lie somewhere between those given by Eq 8 and Eq 14. The correct load depends largely on relative soil compaction in the subgrade trench and overlying embankment and selection of the proper load for pipe design will be governed by engineering judgment based on the specific factors in each installation.

1-3.2.4—Sample Calculation of Earth Load

Determine earth load on 12-in. cast-iron pipe with 5 ft of cover. Pipe laid

in a flat-bottom trench $(d + 2)$ ft wide.

Step 1. Calculate earth load for ditch condition using Eq 8.

$$C_d = \frac{1 - e^{-2K\mu' \frac{H}{B_d}}}{2K\mu'} \quad (10)$$

$$K\mu' = 0.130$$

$$H = 5 \text{ ft}$$

$$B_d = \frac{12}{12} + 2 = 3 \text{ ft}$$

$$C_d = \frac{1 - e^{-2(0.130) \left(\frac{5}{3}\right)}}{2(0.130)} = \frac{0.3516}{0.260} = 1.35$$

$$\begin{aligned} W_e &= C_d w B_d^2 \\ &= 1.35(120)(3)^2 \\ &= 1,460 \text{ lb/ft} \end{aligned} \quad (8)$$

Step 2. Calculate earth load for projection condition using Eq 9.

$$\begin{aligned} H_e &= 1.75 B_e = 1.75 \left(\frac{13.20}{12} \right) \\ &= 1.75(1.10) = 1.92 \text{ ft} \end{aligned}$$

H is greater than H_e , therefore use Eq 12 or 12a to calculate C_e . Using Eq 12a:

$$C_e = 1.961 \frac{H}{B_e} - 0.934 \quad (12a)$$

$$= 1.961 \left(\frac{5}{1.10} \right) - 0.934$$

$$= 7.98$$

$$\begin{aligned} W_e &= C_e w B_e^2 \\ &= 7.98(120)(1.10)^2 \\ &= 1,159 \text{ lb/ft} \end{aligned} \quad (9)$$

Step 3. Select lesser load from Step 1 or 2. The load for projection condition is the lesser. Therefore, the earth load, W_e , is 1,159 lb/ft. This load is shown in Table 1-8.

Sec. 1-3.3—Truck Superloads (W_t)

The procedures in this section may be used to compute truck superloads

for unpaved roads, flexible pavement or rigid pavement; one truck or two passing trucks; and any wheel load and impact factor. For unpaved road or flexible pavement Eq 15 is used. For rigid pavement Eq 16 is used.

$$W_t = CRPF \quad (15)$$

$$W_t = KB_ePF \quad (16)$$

in which:

W_t = Truck superload (lb/lin ft)

C = Surface load factor for unpaved road or flexible pavement (for one truck, see Table 1-11; for two trucks, see Table 1-12).

R = Reduction factor which takes account of the fact that the part of the pipe directly below the wheels receives the truck superload in its full intensity but is aided in carrying the load by adjacent parts of the pipe that receive little or no load from the truck. (See Table 1-13.)

P = Wheel load (lb)

F = Impact factor

K = Surface load factor for rigid pavement (see Table 1-14).

B_e = Outside diameter of pipe (ft) (see Table 1-15).

Equations 15 and 16 may be used in computing AASHO truck loading which is described in "Standard Specifications for Highway Bridges," American Assn. of State Highway Officials, 1961. The wheel loads and impact factors to be used in the equations are given in Art. 1.2.5 and

1.2.12 of the AASHTO specification, as follows:

AASHTO Truck	Gross Weight	Wheel Load, P
H-10	10 tons	8,000 lb
H-15	15 tons	12,000 lb
H-20	20 tons	16,000 lb

Depth of Cover	Impact Factor, F
0 ft to 1 ft, 0 in.	1.30
1 ft, 1 in., to 2 ft, 0 in.	1.20
2 ft, 1 in., to 2 ft, 11 in.	1.10
3 ft, 0 in., or more	1.00

The truck superload allowances given in Tables 1-4 and 1-8 are intended for standard conditions.

They are based on two passing trucks with adjacent wheels 3 ft apart, 9,000-lb wheel load, unpaved road or flexible pavement, 1.50 impact factor. These loads in most cases equal or exceed the static load from a single AASHTO H-20 truck with 16,000 lb on each rear wheel. These truck superloads are based on having the design depth of cover over the pipe. Consideration should be given to the loads that may be transmitted to the pipe if either truck superloads or heavy construction equipment is permitted to pass over the pipe at less than the design depth of cover.

TABLE 1-9
Load Factors for Cast-Iron Pipe in Ditch and Embankment Conditions

Pipe Size in.	$\frac{H^*}{B_s}$	Laying Condition			Pipe Size in.	$\frac{H^*}{B_s}$	Laying Condition		
		A	B	F			A	B	F
		Load Factor (L_f)					Load Factor (L_f)		
Ditch and Negative Projection Condition†					Ditch and Negative Projection Condition† (Continued)				
3		1.15	1.28	1.74	54		1.15	1.75	2.29
4		1.15	1.29	1.75	60		1.15	1.77	2.31
6		1.15	1.32	1.78					
8		1.15	1.34	1.80					
10		1.15	1.36	1.83					
					Positive-Projection Condition†				
12		1.15	1.38	1.85		0.5	1.50	2.16	
14		1.15	1.41	1.88		1.0	1.36	1.84	
16		1.15	1.43	1.90		1.5	1.29	1.74	
18		1.15	1.45	1.93		2.0	1.26	1.68	
20		1.15	1.47	1.95		3.0	1.26	1.64	
						5.0	1.26	1.60	
24		1.15	1.52	2.00		10.0	1.26	1.58	
30		1.15	1.58	2.08					
36		1.15	1.64	2.14					
42		1.15	1.69	2.20					
48		1.15	1.72	2.25					

* H is depth of cover to top of pipe, in feet; B_s is outside diameter of pipe, in feet (see Table 1-15).

† See Fig. 1-7 and See Sec. 1-3.2.

TABLE 1-10
Allowances for Surge Pressure

Pipe Size in.	Surge Pressure psi	Pipe Size in.	Surge Pressure psi
3-10	120	24	85
12-14	110	30	80
16-18	100	36	75
20	90	42-60	70

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TABLE 1-11
Surface Load Factors (C) for One Truck on Unpaved Road or Flexible Pavement*

Pipe Size in.	Depth of Cover—ft												
	2	2½	3	3½	4	5	6	8	10	12	16	20	24
	Surface Load Factor												
3	0.028	0.020	0.014	0.011	0.009	0.006	0.004	0.002	0.0015	0.001	0.0006	0.0004	0.0002
4	0.034	0.024	0.017	0.013	0.011	0.007	0.005	0.003	0.002	0.0015	0.0008	0.0005	0.0003
6	0.048	0.034	0.025	0.020	0.015	0.010	0.007	0.004	0.003	0.002	0.001	0.0007	0.0004
8	0.062	0.044	0.033	0.026	0.020	0.013	0.009	0.006	0.0035	0.0025	0.0013	0.0008	0.0005
10	0.074	0.054	0.040	0.031	0.025	0.016	0.012	0.007	0.004	0.003	0.0016	0.001	0.0006
12	0.087	0.063	0.048	0.036	0.030	0.019	0.014	0.008	0.005	0.0035	0.002	0.0012	0.0007
14	0.099	0.072	0.055	0.042	0.034	0.022	0.016	0.010	0.006	0.004	0.0025	0.0015	0.0008
16	0.110	0.082	0.061	0.047	0.038	0.025	0.018	0.011	0.007	0.005	0.003	0.0017	0.001
18	0.122	0.090	0.068	0.052	0.042	0.028	0.020	0.012	0.008	0.0055	0.0035	0.002	0.0012
20	0.132	0.098	0.075	0.058	0.046	0.031	0.022	0.013	0.009	0.006	0.004	0.0025	0.0015
24	0.150	0.113	0.087	0.068	0.054	0.037	0.026	0.015	0.010	0.007	0.0045	0.003	0.0017
30	0.171	0.132	0.102	0.081	0.065	0.045	0.031	0.019	0.012	0.009	0.005	0.0035	0.002
36	0.188	0.148	0.117	0.093	0.076	0.052	0.037	0.022	0.015	0.010	0.006	0.004	0.0025
42	0.200	0.160	0.129	0.103	0.085	0.059	0.043	0.025	0.017	0.012	0.007	0.0045	0.003
48	0.210	0.170	0.139	0.113	0.093	0.066	0.048	0.029	0.019	0.013	0.008	0.005	0.0033
54	0.216	0.178	0.147	0.120	0.101	0.072	0.053	0.032	0.021	0.015	0.0085	0.0055	0.0036
60	0.222	0.184	0.153	0.126	0.107	0.077	0.057	0.035	0.023	0.016	0.009	0.006	0.004

* These factors are for a single concentrated wheel load centered over an effective pipe length of 3 ft. They were computed by the methods explained in Article 24.20 and Chap. 16 of M. G. Spangler's *Soil Engineering* (2nd ed., 1960; International Textbook Co., Scranton, Pa.).

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TABLE 1-12
Surface Load Factors (C) for Two Passing Trucks on Unpaved Road or Flexible Pavement*

Pipe Size in.	Depth of Cover—ft													
	2	2½	3	3½	4	5	6	8	10	12	16	20	24	
	Surface Load Factor													
3	0.019	0.012	0.008	0.006	0.005	0.004	0.0035	0.003	0.0025	0.002	0.001	0.0007	0.0005	
4	0.032	0.022	0.016	0.012	0.009	0.006	0.005	0.004	0.0035	0.003	0.002	0.0013	0.0010	
6	0.058	0.042	0.032	0.024	0.020	0.014	0.010	0.007	0.006	0.005	0.003	0.0019	0.0015	
8	0.076	0.058	0.044	0.036	0.030	0.022	0.017	0.011	0.009	0.007	0.004	0.0027	0.0021	
10	0.092	0.072	0.056	0.046	0.039	0.028	0.021	0.014	0.011	0.008	0.005	0.0033	0.0026	
12	0.108	0.086	0.070	0.056	0.047	0.034	0.027	0.018	0.012	0.009	0.006	0.0039	0.0030	
14	0.122	0.098	0.078	0.065	0.055	0.040	0.031	0.020	0.014	0.010	0.007	0.0046	0.0036	
16	0.136	0.110	0.090	0.074	0.062	0.046	0.036	0.024	0.016	0.012	0.009	0.0060	0.0046	
18	0.149	0.122	0.101	0.084	0.070	0.052	0.041	0.027	0.019	0.014	0.010	0.0066	0.0051	
20	0.162	0.136	0.115	0.096	0.080	0.060	0.048	0.032	0.022	0.016	0.012	0.0079	0.0061	
24	0.185	0.152	0.126	0.106	0.091	0.067	0.053	0.036	0.026	0.019	0.013	0.0086	0.0067	
30	0.212	0.176	0.146	0.124	0.107	0.080	0.064	0.044	0.032	0.024	0.016	0.0106	0.0081	
36	0.235	0.202	0.169	0.146	0.127	0.095	0.075	0.052	0.038	0.028	0.019	0.0125	0.0097	
42	0.251	0.218	0.188	0.162	0.140	0.108	0.087	0.059	0.044	0.034	0.023	0.0152	0.0117	
48	0.264	0.234	0.205	0.178	0.157	0.122	0.097	0.067	0.050	0.038	0.026	0.0172	0.0132	
54	0.274	0.244	0.216	0.190	0.170	0.133	0.108	0.074	0.057	0.044	0.028	0.0190	0.0140	
60	0.281	0.256	0.228	0.202	0.181	0.144	0.117	0.081	0.061	0.047	0.030	0.0210	0.0150	

* The factors are for two trucks with 6-ft rear wheel spacing passing with inside rear wheels 3 ft apart. Effective pipe length is 3 ft, coinciding with the distance between the adjacent inside wheels. The factors were computed by the methods explained in Sec. 24.20 and Chap. 10 of M. G. Spangler's *Soil Engineering* (2nd ed., 1960; International Textbook Co., Scranton, Pa.)

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TABLE 1-13
Reduction Factors (R)

Pipe Size in.	Depth of Cover—ft				Pipe Size in.	Depth of Cover—ft			
	2½-3½	4-7	8-10	>10		2½-3½	4-7	8-10	>10
	Reduction Factor					Reduction Factor			
3-12	1.00	1.00	1.00	1.00	20	0.83	0.90	0.95	1.00
14	0.92	1.00	1.00	1.00	24-30	0.81	0.85	0.95	1.00
16	0.88	0.95	1.00	1.00	36-60	0.80	0.85	0.90	1.00
18	0.85	0.90	1.00	1.00					

TABLE 1-14
Surface Load Factors (K) For One Truck and Two Passing Trucks on Rigid Pavement*

Depth of Cover ft	One Truck				Two Passing Trucks			
	Pavement Thickness—in.				Pavement Thickness—in.			
	4	6	8	10	4	6	8	10
	Surface Load Factor							
2	0.0244	0.0149	0.0101	0.0076	0.0410	0.0263	0.0186	0.0142
2½	0.0213	0.0139	0.0097	0.0072	0.0364	0.0246	0.0177	0.0136
3	0.0186	0.0126	0.0090	0.0070	0.0333	0.0228	0.0167	0.0129
3½	0.0164	0.0114	0.0085	0.0066	0.0290	0.0206	0.0156	0.0122
4	0.0144	0.0102	0.0079	0.0061	0.0262	0.0187	0.0146	0.0117
5	0.0114	0.0084	0.0066	0.0054	0.0210	0.0156	0.0123	0.0102
6	0.0093	0.0071	0.0057	0.0047	0.0170	0.0133	0.0107	0.0088
8	0.0065	0.0052	0.0043	0.0036	0.0114	0.0097	0.0081	0.0069
10	0.0046	0.0039	0.0033	0.0029	0.0080	0.0070	0.0062	0.0055
12	0.0034	0.0030	0.0026	0.0023	0.0059	0.0054	0.0049	0.0045
16	0.0022	0.0019	0.0017	0.0016	0.0034	0.0032	0.0030	0.0028
20	0.0013	0.0011	0.0010	0.0009	0.0024	0.0023	0.0022	0.0021
24	0.0008	0.0007	0.0006	0.0005	0.0015	0.0014	0.0013	0.0012

* These factors were computed by the methods explained in "Vertical Pressure on Culverts under Wheel Loads on Concrete-Pavement Slabs", Bull. ST65, Portland Cement Assn., Chicago, Ill. In Bulletin ST65, K is expressed as c/L^3 . These factors are based on a modulus of subgrade reaction of 100 lb/cu in. and a modulus of elasticity of 4,000,000 psi for the pavement concrete. The factors for two passing trucks are based on the inside rear wheels passing 3 ft apart.

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TABLE 1-15
Outside Diameters of Cast-Iron Pipe

Pipe Size in.	Outside Diameter in.	Outside Diameter (B_o) ft	Pipe Size in.	Outside Diameter in.	Outside Diameter (B_o) ft
3	3.96	0.330	20	21.60	1.800
4	4.80	0.400	24	25.80	2.150
6	6.90	0.575	30	32.00	2.667
8	9.05	0.754	36	38.30	3.192
10	11.10	0.925	42	44.50	3.708
12	13.20	1.100	48	50.80	4.233
14	15.30	1.275	54	57.10	4.758
16	17.40	1.450	60	63.40	5.283
18	19.50	1.625			

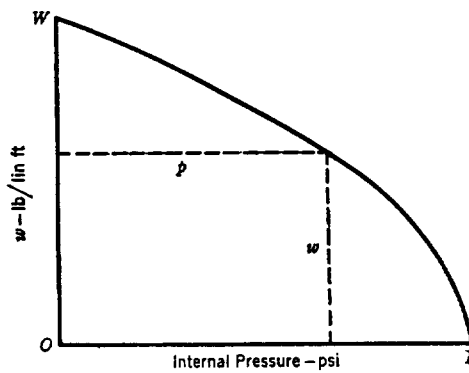


Fig. 1-6. Load-Pressure Curve

The parabola represents the relation between external load and internal pressure at the point of breaking.

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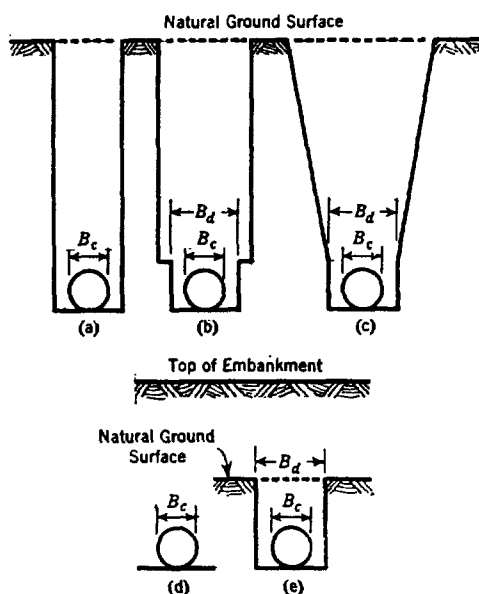


Fig. 1-7. Installation Conditions for Earth Load Calculations

Fig. 1-7(a)-(c) are for ditch conditions; Fig. 1-7(d) and (e) are for positive and negative projection embankment conditions, respectively.

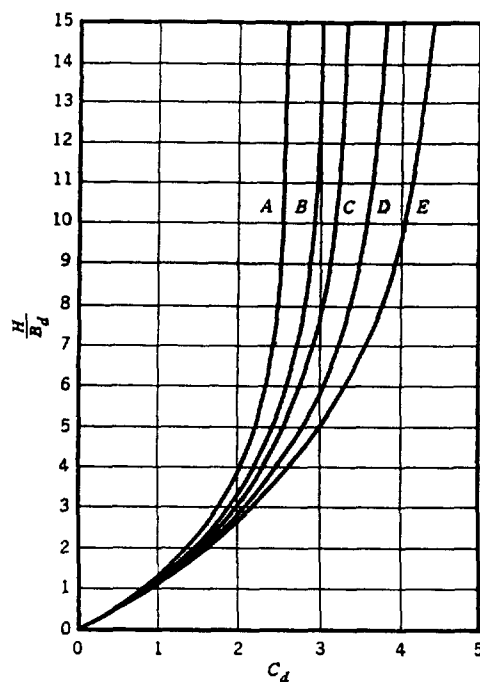


Fig. 1-8. Calculation Coefficients (C_d) for Ditch Condition

Curve A is for C_d for K_μ and K_μ' of 0.1924, the minimum for granular materials without cohesion; Curve B, C_d for K_μ and K_μ' of 0.165, the maximum for sand and gravel; Curve C, C_d for K_μ and K_μ' of 0.150, the maximum for saturated topsoil; Curve D, C_d for K_μ and K_μ' of 0.130, the ordinary maximum for clay; and Curve E, C_d for K_μ and K_μ' of 0.110, the maximum for saturated clay.

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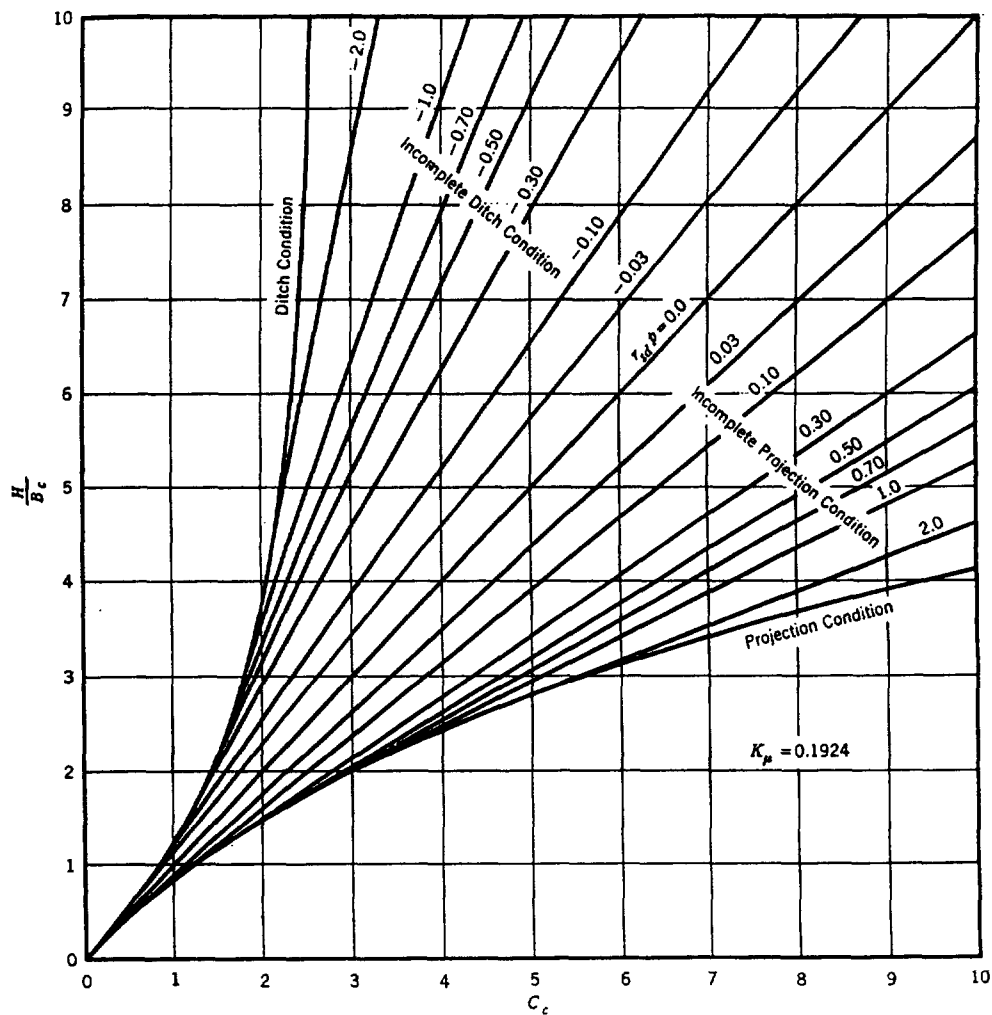


Fig. 1-9. Calculation Coefficients (C_c) for Positive-Projection Condition
 The values of C_c may also be determined by Eq 11 or Eq 12, given in the text.

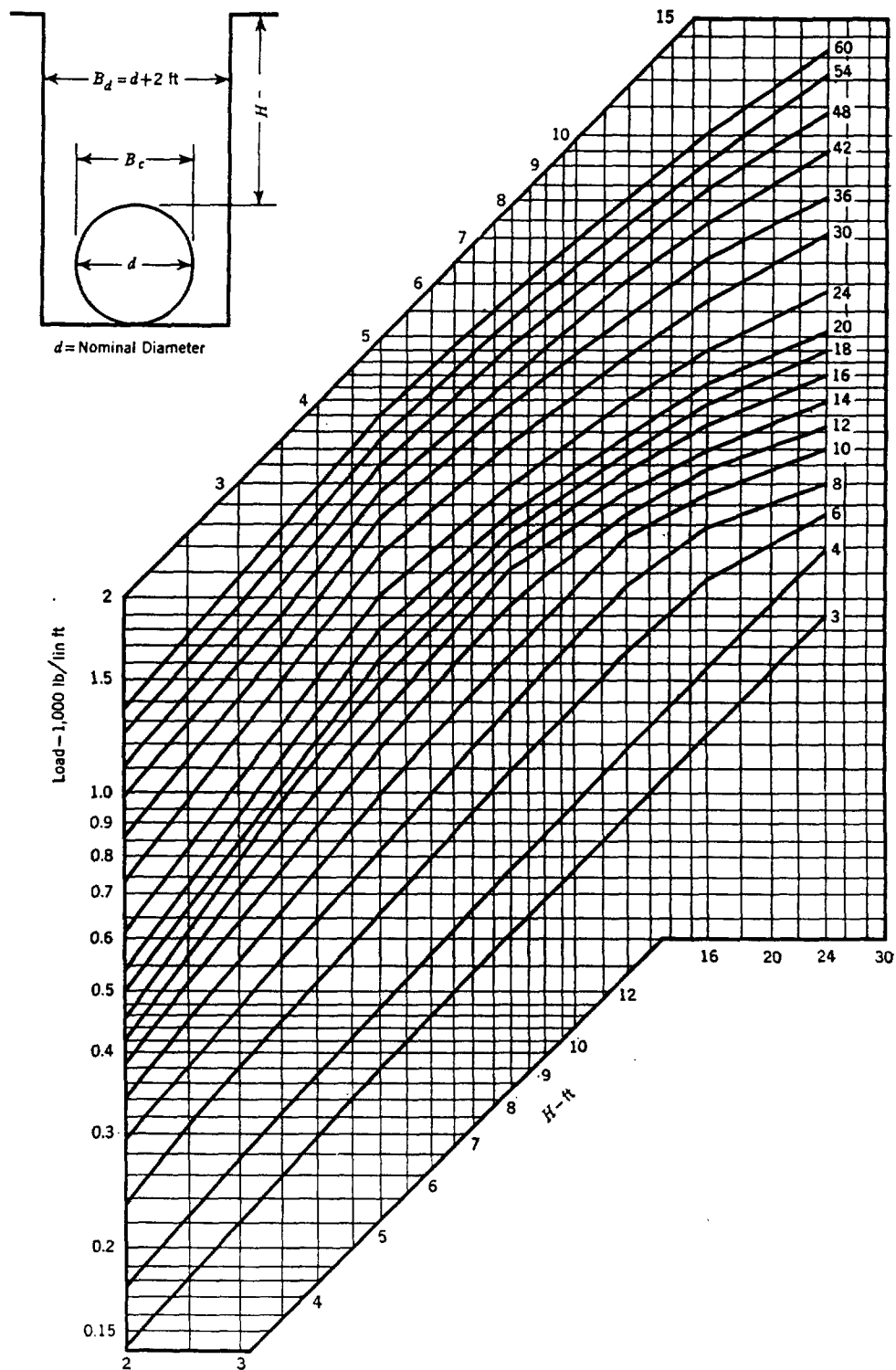


Fig. 1-10. Earth Loads on Pipe for Trench Width of $(d + 2)$ ft

Values associated with each curve are for pipe size, in inches. It is assumed that the unit weight of fill is 120 lb/cu ft, that K_μ equals 0.1924 and K_μ' equals 0.130, and that r_{edp} is 0.75 for all sizes. B_c is pipe OD. For 3- and 8-60-in. pipe, OD is as shown in Table 1-15. OD of 4- and 6-in. pipe is 5.00 and 7.10 in., respectively.

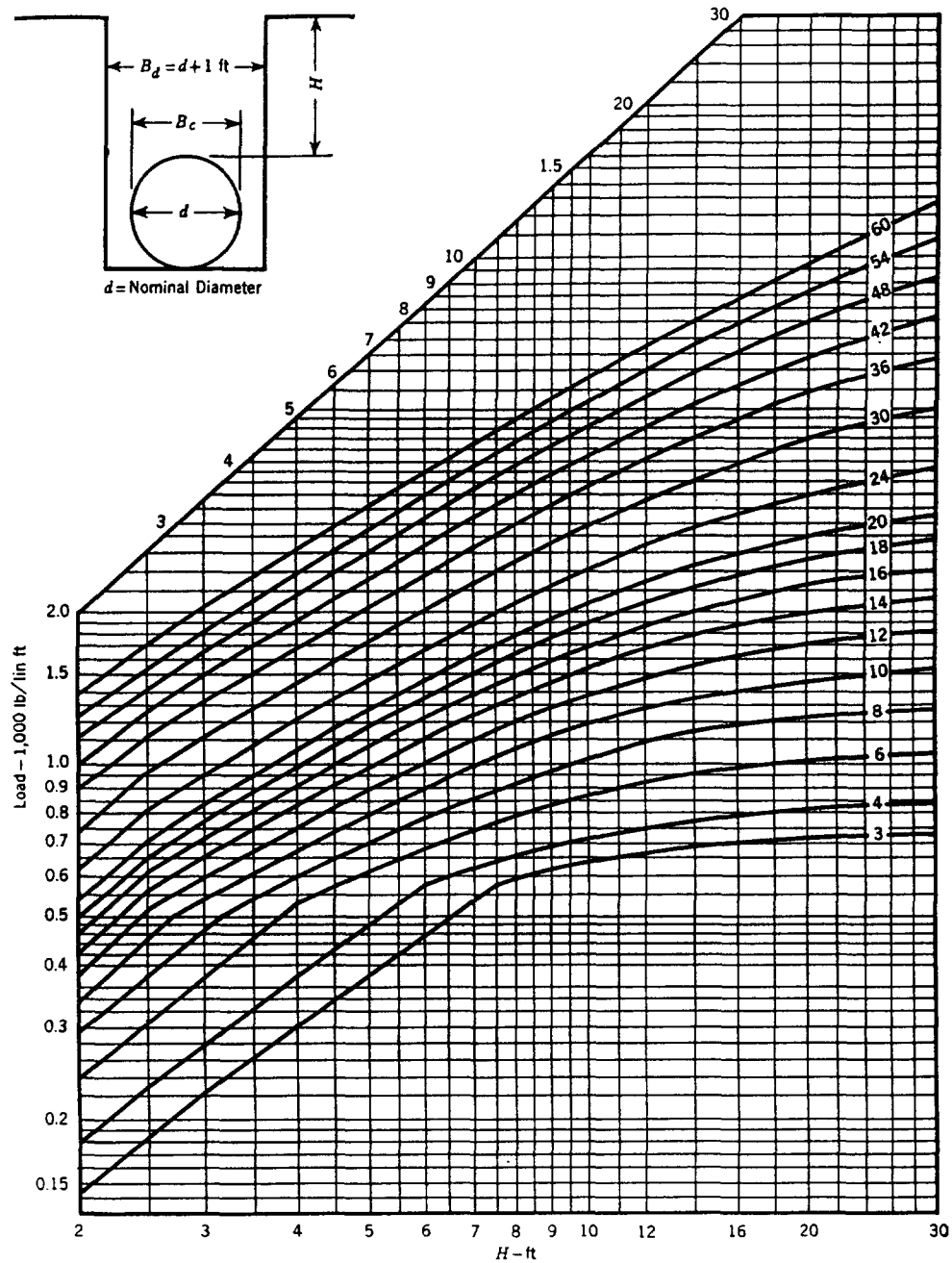


Fig. 1-11. Earth Loads on Pipe for Trench Width of $(d + 1)$ ft

Values associated with each curve are for pipe size, in inches. It is assumed that the unit weight of fill is 120 lb/cu ft, that K_μ equals 0.1924 and K_μ' equals 0.130. For wide ditches, r_{adp} is 0.75. B_c is pipe OD. For 3- and 8-60-in. pipe, OD is as shown in Table 1-15. OD of 4- and 6-in. pipe is 5.00 and 7.10 in., respectively.

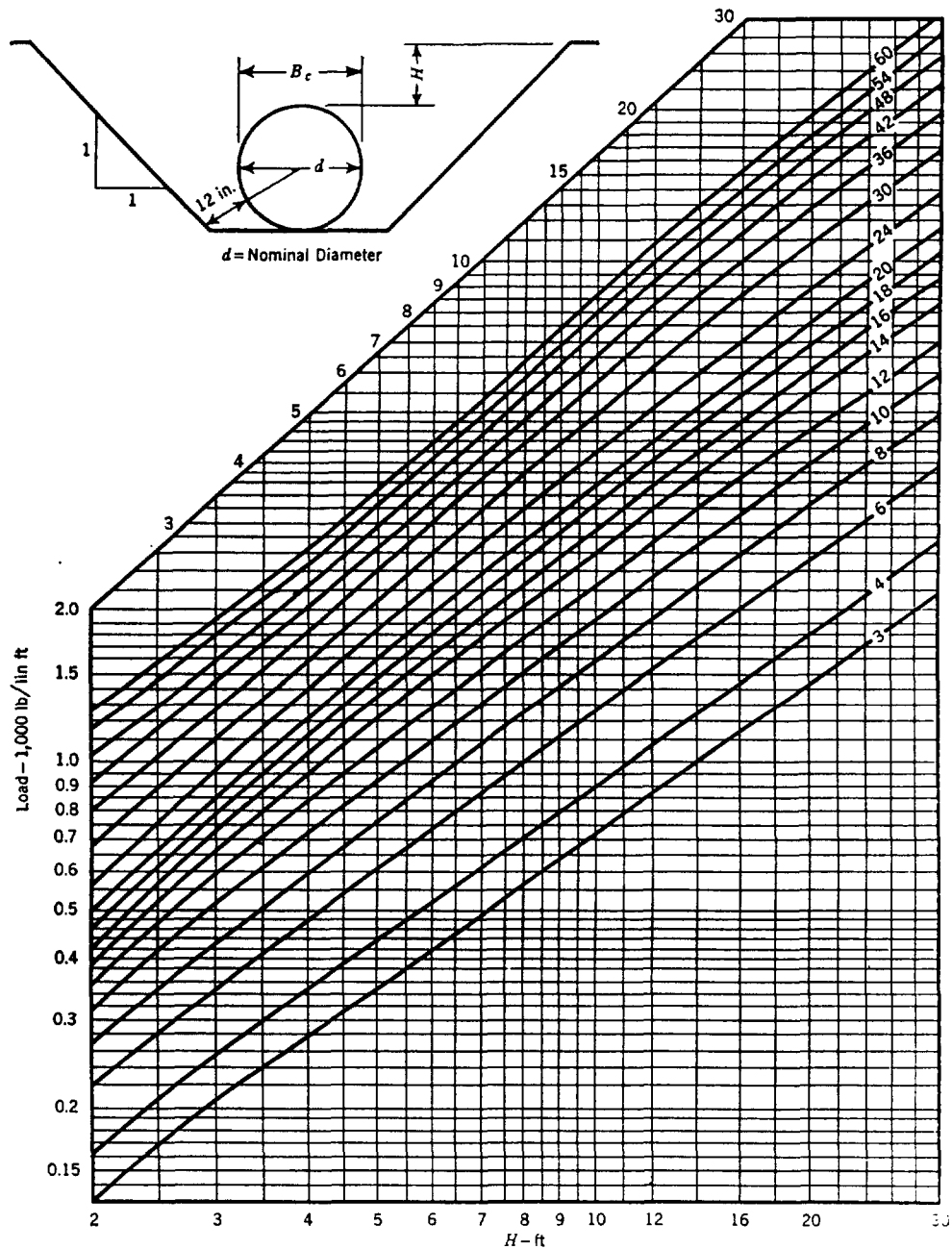


Fig. 1-12. Earth Loads on Pipe in Trench With 1:1 Side Slopes

Values associated with each curve are for pipe size, in inches. It is assumed that the unit weight of fill is 110 lb/cu ft; this load may be adjusted to soil of 120 lb/cu ft by multiplying the graph load by 120/110. For wide ditches, r_{adP} is 0.75. K_{μ} equals 0.1924, K_{μ}' equals 0.130. B_c is pipe OD. For 3- and 8-60-in. pipe, OD is as shown in Table 1-15. OD of 4- and 6-in. pipe is 5.00 and 7.10 in., respectively.

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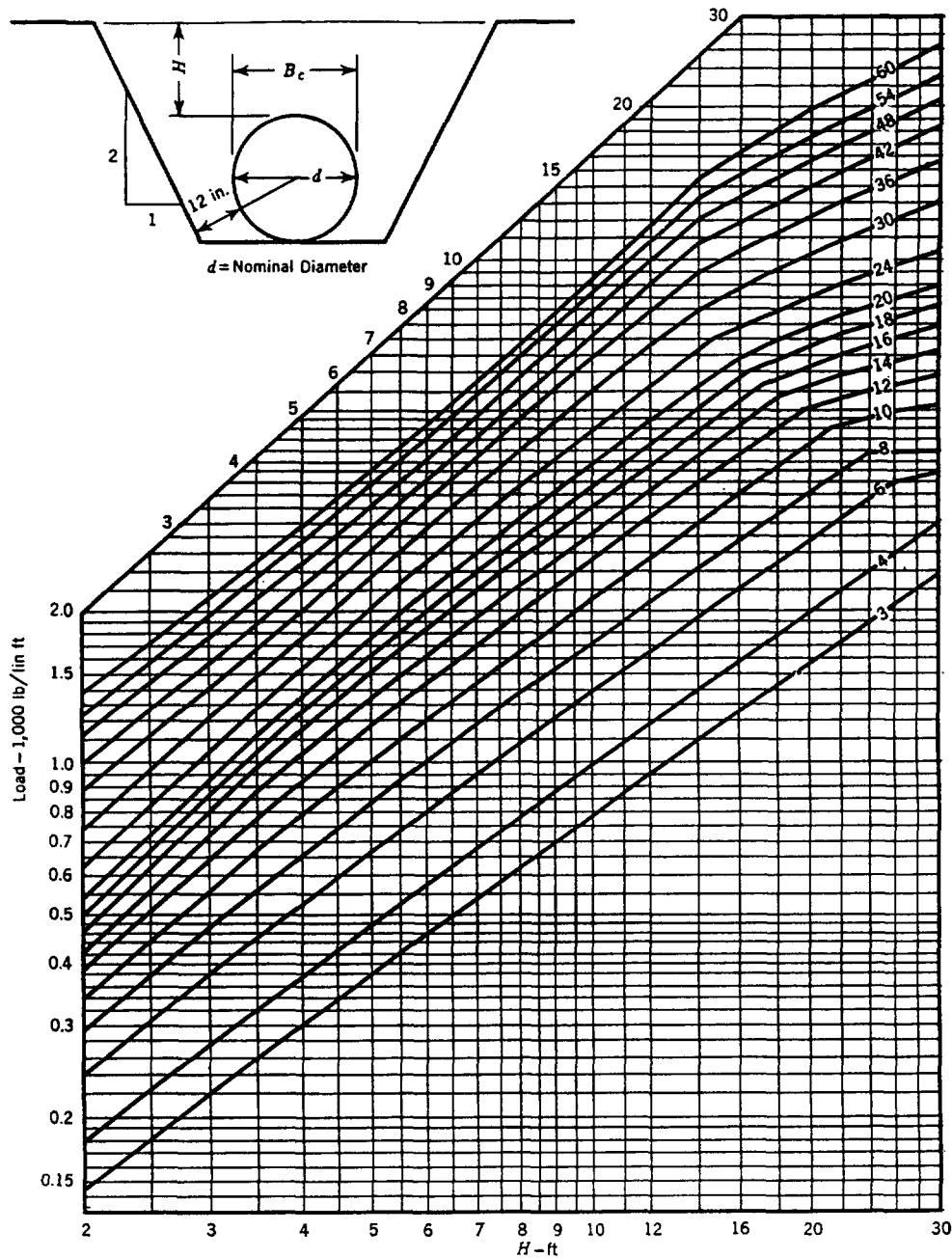


Fig. 1-13. Earth Loads on Pipe in Trench With 2:1 Side Slopes

Values associated with each curve are for pipe size, in inches. It is assumed that the unit weight of fill is 120 lb/cu ft. For wide ditches, r_{adp} equals 0.75. K_{μ} equals 0.1924, $K_{\mu'}$ equals 0.130. B_c is pipe OD. For 3- and 8-in. pipe, OD is as shown in Table 1-15. OD of 4- and 6-in. pipe is 5.00 and 7.10 in., respectively.

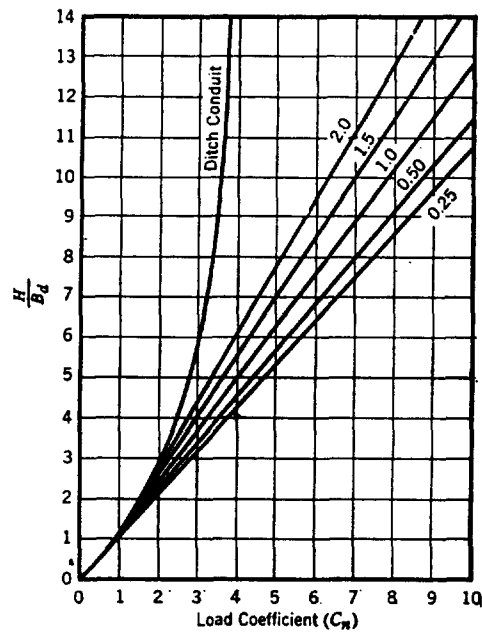


Fig. 1-14. Calculation Coefficients (C_n) for Negative-Projection Conditions

The values associated with the five curves to the right are for p' . $K_{\mu'}$ equals 0.130. $r_{sd}p$ equals 0.0.

Sec. 1-4—Thickness Determination for Pipe on Piers or Piling Aboveground or Underground

Sec. 1-4.1—Scope

This section gives the procedures for determining the net thickness of cast-iron pipe supported at intervals rather than continuously. These procedures are applicable to pipe installed on piling bents and piers, with or without earth cover, as well as to pipe installed on bridges and other structures with hangers and other types of spaced supports.

Sec. 1-4.2—Pipe Installed Aboveground Without Earth Cover

a. Determine the ring test load equivalent of external load, including 2.5 safety factor, as follows:

$$w = \frac{2.5(W_p + W_w)}{L_f} \quad (17)$$

in which:

w = ring test load equivalent (lb/ft)

W_p = weight of pipe (lb/ft) (see Table 1-16)

W_w = weight of contained water (lb/ft) (see Table 1-16)

L_f = load factor (see Table 1-17)

b. Select the internal pressure for Case 1 from Table 1-5 which includes surge pressure and 2.5 safety factor.

c. Enter the above values of ring test load equivalent and internal pressure in the appropriate nomogram and read the net thickness. To obtain total calculated thickness, corrosion allowance and casting tolerance are added to this net thickness as described in Sec. 1-2.2.

Sec. 1-4.3—Pipe Installed Underground With Earth Cover

Thicknesses are computed for two cases as described in Sec. 1-2.2 and the larger of the two thicknesses is used for design.

Case 1:

a. Determine the ring test load equivalent from the following formula:

$$w = \frac{2.5W_e}{L_f} \quad (18)$$

in which:

w = ring test load equivalent (lb/ft)

W_e = earth load (see Table 1-8)

L_f = load factor (see Table 1-17)

b. Select the internal pressure to Case 1 from Table 1-5 which includes surge pressure and 2.5 safety factor.

c. Enter the above values of ring test load equivalent and internal pressure in the appropriate nomogram and read the net thickness.

Case 2:

a. Determine the ring test load equivalent from the following formula:

$$w = \frac{2.5(W_e + W_t)}{L_f} \quad (19)$$

in which W_t is the truck superload in pounds per foot (see Table 1-8) and other factors are as defined for Eq 18.

b. Select the internal pressure for Case 2 from Table 1-5 which includes a safety factor of 2.5.

PLAINTIFF'S EXHIBIT

CT-1259

**ANSI A21.50-1976
(AWWA C150-76)**

Revision of
A21.50-1971
(AWWA C150-71)

AMERICAN NATIONAL STANDARD
for the
THICKNESS DESIGN OF
DUCTILE-IRON PIPE

SECRETARIATS

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

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WALTER AMORY, *Vice-Chairman*

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EDWARD C. SEARS, *Vice-Chairman*
JAMES B. RAMSEY, *Secretary*

Organization Represented

Name of Representative

American Gas Association
American Society of Civil Engineers
American Society of Mechanical Engineers
American Society for Testing and Materials
American Water Works Association

Cast Iron Pipe Research Association

Individual Producer
Manufacturers' Standardization Society of
the Valve and Fittings Industry
New England Water Works Association
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Foreword

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

American National Standards Committee A21, 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 A21.50, the standard for thickness design of ductile-iron pipe, 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

The basic design procedures are unchanged from the 1965 and 1971

editions. Certain design parameters have been changed to the following.

1. Trench load, which includes earth load and truck load, is expressed as vertical pressure in pounds per square inch. Earth loads for all pipe sizes are based on the prism load concept. Truck load is based on a single AASHTO* H-20 truck with 16 000-lb wheel load and 1.5 impact factor. Truck load is included at all depths of cover. In addition to tabulated truck loads, equations are included for complete calculation of truck loads.

2. The design ring bending stress is 48 000 psi, which provides safety factors under trench loading of at least 1.5 based on ring yield strength, and at least 2.0 based on ultimate strength of the material.

3. The design pipe deflection is 3 per cent of the outside diameter. Tests have shown that 3 per cent deflection is permissible without causing any damage to cement linings of ductile-iron pipe.

4. The standard laying conditions have been expanded to include five types. Types 1, 2, and 5 replace A, B, and S, respectively, in A21.50-1971. Types 3 and 4 have been added to provide a wider selection of laying conditions.

5. The design for internal pressure is based on a 2.0 safety factor. The design pressure is obtained by adding 100-psi surge allowance to the working pressure and multiplying the sum by the 2.0 safety factor. (If anticipated surge pressures are greater than 100

* American Association of State Highway and Transportation Officials.

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psi, the maximum anticipated pressure must be used.) The resulting design pressure is then applied to the minimum yield strength in tension of 42 000 psi.

6. 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 expanded to include 3-12-in. pipe.

7. The tables have been modified to reflect the preceding changes. Also, a table has been added to show rated working pressure and maximum depth of cover for all the standard laying conditions and standard thickness classes.

American National Standard
for the
**Thickness Design of
Ductile-Iron Pipe**

Sec. 50-1—Scope

This standard covers the thickness design of ductile-iron pipe complying with the requirements of ANSI A21.51 (AWWA, C151), "Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds for Water or Other Liquids."

Section 50-2 outlines the design procedure and Sec. 50-3 gives a design example.

Section 50-4 explains the bases of design.

As opposed to using procedures in Sec. 50-2 or 50-4, the designer may reference Tables 12-14 directly.

Table 12 lists thicknesses for standard laying conditions and depths of cover up to 32 ft.

Table 13 lists thicknesses for 150-350 psi water working pressure.

The greater thickness from Table 12 or 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 thickness classes.

**Sec. 50-2—Procedure for
Calculating Thickness**

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

50-2.1 Step 1—Design for trench load.

a. Determine trench load P_t . Table 1 gives trench load, including earth load, P_e , plus truck load P_r , for 2.5-32 ft cover.

b. Determine the standard laying condition from the descriptions in Table 2 and select the appropriate table for diameter-thickness ratios from Tables 7-11. Each table lists diameter-thickness ratios calculated for both bending stress and deflection over a range of trench loads.

c. For bending stress design, enter the column headed "Bending Stress Design" in the appropriate table of Tables 7-11 and locate the tabulated trench load, P_t , nearest to the calculated P_t from paragraph 50-2.1.a. (If the calculated P_t is halfway between two tabulated values, use the larger P_t value.)

Select the corresponding $\frac{D}{t}$ value for this P_s .

Divide the pipe's outside diameter D (Table 5) by the $\frac{D}{t}$ value to obtain the net thickness t .

d. For deflection design, enter the column headed "Deflection Design" in the appropriate table of Tables 7-11 and locate the tabulated trench load, P_s , nearest to the calculated P_s from paragraph 50-2.1.a. (If the calculated P_s is less than the minimum P_s listed in the table, design for trench load is not controlled by deflection and this determination need not be completed.) If the calculated P_s is halfway between two tabulated values, use the larger P_s value.

Select the corresponding $\frac{D}{t_1}$ value for this P_s .

Divide the pipe's outside diameter D (Table 5) by the $\frac{D}{t_1}$ value to obtain minimum manufacturing thickness t_1 . Deduct 0.08-in. service allowance to obtain net thickness t .

e. Compare the net thicknesses from steps c and d and select the larger of the two. This will be the net thickness required for trench load.

50-2.2 *Step 2—Design for internal pressure.* Calculate the net thickness required for internal pressure using the equation for hoop stress:

$$t = \frac{P_i D}{2S}$$

in which t is net thickness in inches; P_i is the design internal pressure, which is equal to the safety factor of 2.0 times the sum of working pressure (P_w) in pounds per square inch, plus 100 psi surge allowance (P_s) for water pipe. That is, $P_i = 2.0 (P_w + P_s)$.

If anticipated surge pressures are greater than 100 psi, then the maximum anticipated pressure must be used. D is outside diameter of pipe in inches, and S is minimum yield strength in tension (42 000 psi).

50-2.3 *Step 3—Selection of net thickness and addition of allowances.*

a. Select the net thickness t from step 1 or 2, whichever thickness is larger.

b. Add the service allowance of 0.08 in. to the net thickness t . The resulting thickness is the minimum manufacturing thickness t_1 .

c. Add the casting tolerance from Table 3 to the minimum manufacturing thickness t_1 . The resulting thickness is the total calculated thickness.

50-2.4 *Step 4—Selection of standard thickness and class.* Use the total calculated thickness from Sec. 50-2.3.c to select a standard class thickness from Table 5. Select the standard thickness nearest to the calculated thickness. When the calculated thickness is halfway between two standard thicknesses, select the larger of the two.

In specifying and ordering pipe, use the class number listed in Table 5 for this standard thickness.

Sec. 50-3—Design Example for Calculating Thickness

PROBLEM: Calculate the thickness for 30-in. ductile-iron pipe laid on a flat-bottom trench with backfill lightly consolidated to centerline of pipe, laying condition Type 2, under 10 ft of cover for a working pressure of 200 psi.

50-3.1 *Step 1—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, $P_s = P_e + P_t$ | = 9.0 psi |

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b. Select Table 8 for diameter-thickness ratios for laying condition Type 2.

c. Entering P_v of 9.0 psi in Table 8, the bending stress design requires $\frac{D}{t}$ of 128. From Table 5, diameter D of 30-in. pipe is 32.00 in.

Net thickness t for bending stress

$$= \frac{D}{\frac{D}{t}} = \frac{32.00}{128} = 0.25 \text{ in.}$$

d. Also, from Table 8, the deflection design requires $\frac{D}{t_1}$ of 108.

Minimum thickness t_1 for deflection design

$$= \frac{D}{\frac{D}{t_1}} = \frac{32.00}{108} = 0.30 \text{ in.}$$

Deduct service allowance $\underline{-0.08 \text{ in.}}$

Net thickness t for deflection control 0.22 in

e. The larger net thickness is 0.25 in., obtained by the design for bending stress.

50-3.2 *Step 2—Design for internal pressure.*

$P_i = 2.0$ (Working pressure + 100 psi surge allowance)

(If anticipated surge pressures are greater than 100 psi, then the actual anticipated pressures must be used.)

$P_i = 2.0$ (200 + 100)

= 600 psi

$t = \frac{P_i D}{2S} = \frac{600 \times 32.00}{2 \times 42\,000} = 0.23 \text{ in.}$

Net thickness t for internal pressure is 0.23 in.

50-3.3 *Step 3—Selection of net thickness and addition of allowances.* The larger of the thicknesses is given by the design for trench load, Step 1, and 0.25 in. is selected.

Net thickness = 0.25 in.

Service allowance = 0.08 in.

Minimum thickness = 0.33 in.

Casting tolerance = 0.07 in.

Total calculated thickness = 0.40 in.

50-3.4 *Step 4—Selection of standard thickness and class.* The total calculated thickness of 0.40 in. is nearest to 0.39, Class 50, in Table 5. Therefore, Class 50 is selected for specifying and ordering.

Sec. 50-4—Design Method

50-4.1 The thickness of ductile-iron pipe is determined by considering trench load and internal pressure separately.

Calculations are made for the thicknesses required to resist the bending stress and the deflection caused by trench load. The larger of the two is selected as the thickness required to resist trench load. Calculations are then made for the thickness required to resist the hoop stress of internal pressure.

The larger of these is selected as the net design thickness. To this net thickness is added a service allowance to obtain the minimum manufacturing thickness and a casting tolerance to obtain the total calculated thickness.

The standard thickness and the thickness class for specifying and ordering are selected from a table of standard class thicknesses.

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

50-4.2 *Trench load, P_v .* Trench load is expressed as vertical pressure in pounds per square inch, and is equal to the sum of earth load P_e and truck load P_t .

50-4.3 *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/cu ft. If the designer antici-

pates additional loads because of frost, the design load should be increased accordingly.

50-4.4 *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 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.

50-4.5 *Design for trench load.* Tables 7-11, the tables of diameter-thickness ratios used to design for trench load, were computed by Eq 2 and 3. Equation 2 is based on the bending stress at the bottom of the pipe. The design bending stress f is

48 000 psi, 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. Equation 3 is based on the deflection of the pipe ring section. The design deflection Δx is 3 per cent 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_z are given in Table 2.

Tables similar to Tables 7-11 may be compiled for laying conditions other than those shown in this standard by calculating the trench loads P_t for a series of diameter-thickness ratios, $\frac{D}{t}$ and $\frac{D}{t_1}$, using Eq 2 and 3 with values of E' , K_b , and K_z appropriate to the bedding and backfill conditions.

Design Equations

$$t = \frac{P_t D}{2S} \quad (1)$$

$$P_t = \frac{f}{3 \left(\frac{D}{t} \right) \left(\frac{D}{t} - 1 \right) \left[K_b - \frac{K_z}{\frac{8E}{E' \left(\frac{D}{t} - 1 \right)^4 + 0.732}} \right]} \quad (2)$$

$$P_t = \frac{\frac{\Delta x}{D}}{12K_z} \left[\frac{8E}{\left(\frac{D}{t_1} - 1 \right)^4} + 0.732E' \right] \quad (3)$$

$$P_t = \frac{wH}{144} = \frac{120H}{144} = \frac{H}{1.2} \quad (4)$$

$$P_t = \frac{C \cdot R \cdot P \cdot F}{12D} \quad (5)$$

$$C = \frac{1}{3} - \frac{2}{3\pi} \arcsin \left[H \sqrt{\frac{A^2 + H^2 + 1.5^2}{(A^2 + H^2)(H^2 + 1.5^2)}} \right] + \frac{AH}{\pi \sqrt{A^2 + H^2 + 1.5^2}} \left[\frac{1}{A^2 + H^2} + \frac{1}{H^2 + 1.5^2} \right] \quad (6)$$

Explanation of Symbols for Equations

- A = Outside radius of pipe in feet = $\frac{D}{24}$
 C = Surface load factor (Table 6)
 D = Outside diameter in inches (Table 5)
 E = Modulus of elasticity (24×10^6 psi)
 E' = Modulus of soil reaction in pounds per square inch (Table 2)
 F = Impact factor—1.5
 f = Design bending stress—48 000 psi
 H = Depth of cover in feet
 K_b = Bending moment coefficient (Table 2)
 K_s = Deflection coefficient (Table 2)
 P = Wheel load—16 000 lb
 P_e = Earth load in pounds per square inch
 P_i = Design internal pressure in pounds per square inch = 2.0 (working pressure + 100 psi surge allowance)
 P_t = Truck load in pounds per square inch
 P_s = Trench load in pounds per square inch = $P_e + P_t$
 R = Reduction factor which takes account of the fact that the part of the pipe directly below the wheels is aided in carrying the truck load by adjacent parts of the pipe that receive little or no load from the wheels (Table 4)
 S = Minimum yield strength in tension—42 000 psi
 t = Net thickness in inches
 t_1 = Minimum thickness in inches ($t + 0.08$)
 w = Soil weight—120 pounds per cubic foot
 Δx = Design deflection in inches $\left(\frac{\Delta x}{D} = 0.03 \right)$

NOTE: In Eq 6, angles are in radians.

TABLE 50.1
Earth Loads P_e , Truck Loads P_t , and Trench Loads P_v —psi

Depth of Cover ft	P_e	3-in. Pipe		4-in. Pipe		6-in. Pipe		8-in. Pipe	
		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 ft	P_e	10-in. Pipe		12-in. Pipe		14-in. Pipe		16-in. Pipe	
		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

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TABLE 50.1—(cont.)

Depth of Cover ft	P_s	18-in. Pipe		20-in. Pipe		24-in. Pipe		30-in. Pipe	
		P_t	P_s	P_t	P_s	P_t	P_s	P_t	P_s
2.5	2.1	7.8	9.9	7.5	9.6	7.1	9.2	6.7	8.8
3	2.5	5.9	8.4	5.7	8.2	5.4	7.9	5.2	7.7
4	3.3	3.9	7.2	3.9	7.2	3.6	6.9	3.5	6.8
5	4.2	2.6	6.8	2.6	6.8	2.4	6.6	2.4	6.6
6	5.0	1.9	6.9	1.9	6.9	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
8	6.7	1.2	7.9	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
10	8.3	0.8	9.1	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
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

Depth of Cover ft	P_s	36-in. Pipe		42-in. Pipe		48-in. Pipe		54-in. Pipe	
		P_t	P_s	P_t	P_s	P_t	P_s	P_t	P_s
2.5	2.1	6.2	8.3	5.8	7.9	5.4	7.5	5.0	7.1
3	2.5	4.9	7.4	4.6	7.1	4.4	6.9	4.1	6.6
4	3.3	3.4	6.7	3.3	6.6	3.1	6.4	3.0	6.3
5	4.2	2.3	6.5	2.3	6.5	2.2	6.4	2.1	6.3
6	5.0	1.7	6.7	1.7	6.7	1.6	6.6	1.6	6.6
7	5.8	1.3	7.1	1.3	7.1	1.2	7.0	1.2	7.0
8	6.7	1.1	7.8	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
10	8.3	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
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

TABLE 50.2

Design Values for Standard Laying Conditions

Laying Condition*	Description	E'	Bedding Angle deg	K ₁	K ₂
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 ½ pipe diameter, 4-in. minimum. Backfill compacted to top of pipe. (Approx. 80 per cent 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. (Approx. 90 per cent Standard Proctor, AASHTO T-99)**	700	150	0.128	0.085

* See Fig. 1.

† 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 material, and frozen earth."

** AASHTO T-99, "Moisture Density Relations of Soils Using a 5.5 lb (2.5 kg) Rammer 12-in. (305-mm) Drop."

TABLE 50.3

Allowances for Casting Tolerance

Size in.	Casting Tolerance in.
3-8	0.05
10-12	0.06
14-42	0.07
48	0.08
54	0.09

TABLE 50.4

Reduction Factors R for Truck Load Calculations

Size in.	Depth of Cover—ft			
	<4	4-7	8-10	>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
36-54	0.80	0.85	0.90	1.00

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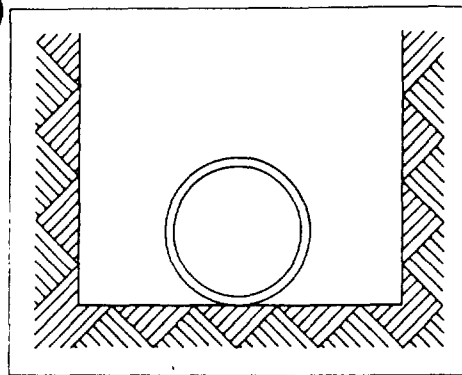
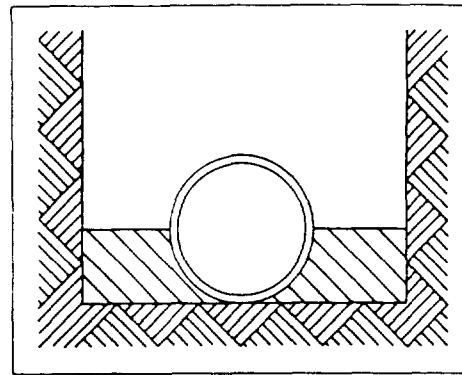
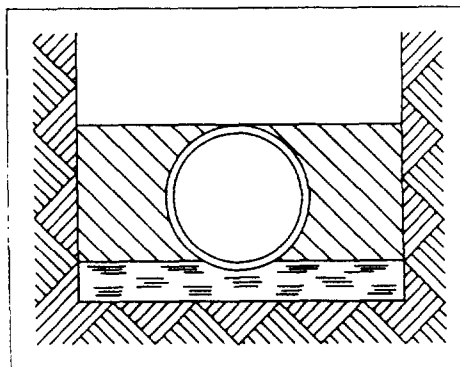
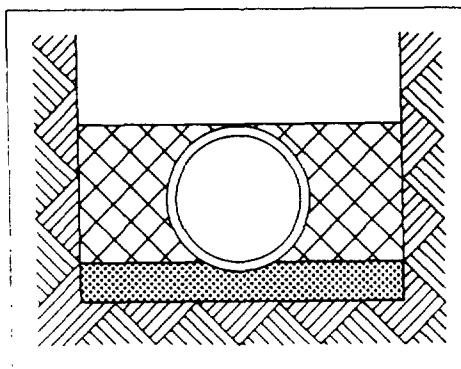
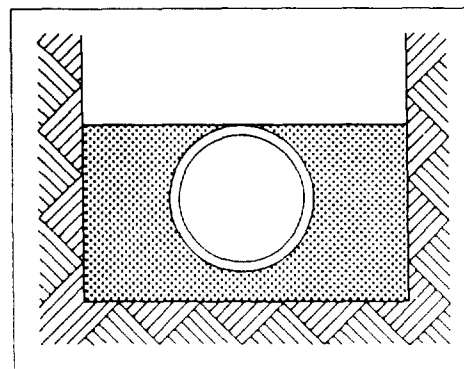
*Type 1**Type 2**Type 3**Type 4**Type 5*

Figure 1. Standard Pipe Laying Conditions

See Table 2

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TABLE 50.5

Standard Thickness Classes of Ductile-Iron Pipe

Size in.	Outside Diameter—in.	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	0.40	0.43
8	9.05	0.27	0.30	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	57.10	0.57	0.65	0.73	0.81	0.89	0.97	1.05

TABLE 50.6
Surface Load Factors for Single Truck on Unpaved Road

Depth of Cover ft	Pipe Size—in.							
	3	4	6	8	10	12	14	16
	Surface Load Factor—C							
2.5	0.0196	0.0238	0.0340	0.0443	0.0538	0.0634	0.0726	0.0814
3	0.0146	0.0177	0.0253	0.0330	0.0402	0.0475	0.0546	0.0614
4	0.0088	0.0107	0.0153	0.0201	0.0245	0.0290	0.0335	0.0379
5	0.0059	0.0071	0.0102	0.0134	0.0163	0.0194	0.0224	0.0254
6	0.0042	0.0050	0.0072	0.0095	0.0116	0.0138	0.0159	0.0181
7	0.0031	0.0038	0.0054	0.0071	0.0087	0.0103	0.0119	0.0135
8	0.0024	0.0029	0.0042	0.0055	0.0067	0.0079	0.0092	0.0104
9	0.0019	0.0023	0.0033	0.0043	0.0053	0.0063	0.0073	0.0083
10	0.0015	0.0019	0.0027	0.0035	0.0043	0.0051	0.0060	0.0068
12	0.0011	0.0013	0.0019	0.0025	0.0030	0.0036	0.0042	0.0047
14	0.0008	0.0010	0.0014	0.0018	0.0022	0.0027	0.0031	0.0035
16	0.0006	0.0007	0.0011	0.0014	0.0017	0.0020	0.0024	0.0027
20	0.0004	0.0005	0.0007	0.0009	0.0011	0.0013	0.0015	0.0017
24	0.0003	0.0003	0.0005	0.0006	0.0008	0.0009	0.0011	0.0012
28	0.0002	0.0002	0.0003	0.0005	0.0006	0.0007	0.0008	0.0009
32	0.0002	0.0002	0.0003	0.0003	0.0004	0.0005	0.0006	0.0007

Depth of Cover ft	Pipe Size—in.							
	18	20	24	30	36	42	48	54
	Surface Load Factor—C							
2.5	0.0899	0.0980	0.1130	0.1321	0.1479	0.1604	0.1705	0.1784
3	0.0681	0.0746	0.0867	0.1028	0.1169	0.1286	0.1384	0.1466
4	0.0422	0.0464	0.0545	0.0657	0.0761	0.0853	0.0936	0.1008
5	0.0283	0.0312	0.0369	0.0449	0.0525	0.0595	0.0661	0.0720
6	0.0202	0.0223	0.0264	0.0323	0.0381	0.0435	0.0486	0.0534
7	0.0151	0.0167	0.0198	0.0243	0.0288	0.0329	0.0370	0.0409
8	0.0117	0.0129	0.0154	0.0189	0.0224	0.0258	0.0290	0.0322
9	0.0093	0.0103	0.0122	0.0151	0.0179	0.0206	0.0233	0.0259
10	0.0076	0.0084	0.0100	0.0123	0.0147	0.0169	0.0191	0.0213
12	0.0053	0.0059	0.0070	0.0086	0.0103	0.0119	0.0135	0.0151
14	0.0039	0.0043	0.0052	0.0064	0.0076	0.0088	0.0100	0.0112
16	0.0030	0.0033	0.0040	0.0049	0.0059	0.0068	0.0077	0.0087
20	0.0019	0.0021	0.0025	0.0032	0.0038	0.0044	0.0050	0.0056
24	0.0013	0.0015	0.0018	0.0022	0.0026	0.0030	0.0035	0.0039
28	0.0010	0.0011	0.0013	0.0016	0.0019	0.0022	0.0026	0.0029
32	0.0008	0.0008	0.0010	0.0012	0.0015	0.0017	0.0020	0.0022

TABLE 50.7

*Diameter-Thickness Ratios for Laying Condition Type 1**

Trench Load (P_s)—psi			Trench Load (P_s)—psi		
Bending Stress Design	Deflection Design	$\frac{Dt}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{Dt}{t}$ or $\frac{D}{t_1}$
4.40	3.46	170	6.33	4.71	128
4.43	3.48	169	6.40	4.76	127
4.46	3.50	168	6.46	4.82	126
4.50	3.51	167			
4.54	3.53	166	6.53	4.87	125
			6.60	4.93	124
4.57	3.55	165	6.67	4.99	123
4.61	3.57	164	6.74	5.05	122
4.64	3.59	163	6.82	5.11	121
4.68	3.61	162			
4.72	3.63	161	6.89	5.18	120
			6.97	5.25	119
4.76	3.65	160	7.05	5.32	118
4.80	3.67	159	7.13	5.39	117
4.84	3.69	158	7.21	5.46	116
4.88	3.71	157			
4.92	3.74	156	7.29	5.54	115
			7.38	5.62	114
4.96	3.76	155	7.47	5.71	113
5.00	3.78	154	7.56	5.79	112
5.04	3.81	153	7.65	5.88	111
5.08	3.83	152			
5.13	3.86	151	7.75	5.97	110
			7.85	6.07	109
5.17	3.89	150	7.95	6.17	108
5.21	3.91	149	8.05	6.27	107
5.26	3.94	148	8.16	6.38	106
5.30	3.97	147			
5.35	4.00	146	8.27	6.49	105
			8.38	6.61	104
5.40	4.03	145	8.49	6.73	103
5.45	4.06	144	8.61	6.86	102
5.49	4.09	143	8.74	6.99	101
5.54	4.13	142			
5.59	4.16	141	8.86	7.12	100
			8.99	7.26	99
5.65	4.20	140	9.13	7.41	98
5.70	4.23	139	9.27	7.57	97
5.75	4.27	138	9.41	7.73	96
5.80	4.31	137			
5.86	4.35	136	9.56	7.89	95
			9.71	8.07	94
5.91	4.39	135	9.87	8.25	93
5.97	4.43	134	10.03	8.44	92
6.03	4.47	133	10.20	8.64	91
6.09	4.52	132			
6.15	4.56	131	10.37	8.85	90
			10.55	9.06	89
6.21	4.61	130	10.74	9.29	88
6.27	4.66	129	10.93	9.53	87
			11.13	9.78	86

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TABLE 50.7—(cont.)

Trench Load (P_s)—psi			Trench Load (P_s)—psi		
Bending Stress Design	Deflection Design	$\frac{D^\dagger}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{D^\dagger}{t}$ or $\frac{D}{t_1}$
11.34	10.04	85	21.91	26.54	58
11.55	10.31	84	22.63	27.85	57
11.78	10.60	83	23.38	29.26	56
12.01	10.90	82			
12.25	11.22	81	24.18	30.77	55
			25.02	32.39	54
12.50	11.56	80	25.92	34.15	53
12.76	11.91	79	26.86	36.05	52
13.03	12.28	78	27.87	38.10	51
13.31	12.67	77			
13.60	13.08	76	28.94	40.32	50
			30.07	42.73	49
13.91	13.51	75	31.28	45.35	48
14.23	13.97	74	32.57	48.20	47
14.56	14.45	73	33.95	51.31	46
14.91	14.96	72			
15.27	15.50	71	35.42	54.72	45
			37.00	58.44	44
15.65	16.07	70	38.69	62.53	43
16.05	16.68	69	40.50	67.03	42
16.46	17.32	68	42.46	71.99	41
16.89	18.00	67			
17.35	18.73	66	44.56	77.47	40
			46.84	83.54	39
17.83	19.50	65	49.30	90.28	38
18.33	20.32	64	51.96	97.80	37
18.85	21.19	63	54.86	106.20	36
19.40	22.12	62			
19.98	23.12	61	58.02	115.62	35
			61.46	126.21	34
20.59	24.18	60	65.23	138.18	33
21.23	25.32	59	69.36	151.73	32
			73.92	167.15	31

* $E' = 150$; $K_b = 0.235$; $K_s = 0.108$.

† The $\frac{D}{t}$ for the tabulated P , nearest to the calculated P , is selected; when the calculated P is halfway between two tabulated values, the smaller $\frac{D}{t}$ should be used.

TABLE 50.8

*Diameter-Thickness Ratios for Laying Condition Type 2**

Trench Load (P_t)— <i>psi</i>			Trench Load (P_t)— <i>psi</i>		
Bending Stress Design	Deflection Design	$\frac{D}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{D}{t}$ or $\frac{D}{t_1}$
6.29	6.18	170	8.99	7.46	128
6.34	6.19	169	9.07	7.51	127
6.39	6.21	168	9.16	7.57	126
6.44	6.23	167			
6.50	6.25	166	9.25	7.63	125
			9.33	7.69	124
6.55	6.26	165	9.42	7.75	123
6.60	6.28	164	9.51	7.81	122
6.66	6.30	163	9.60	7.87	121
6.71	6.32	162			
6.77	6.34	161	9.70	7.94	120
			9.79	8.01	119
6.82	6.37	160	9.89	8.08	118
6.88	6.39	159	9.99	8.16	117
6.94	6.41	158	10.09	8.23	116
6.99	6.43	157			
7.05	6.46	156	10.19	8.31	115
			10.29	8.40	114
7.11	6.48	155	10.40	8.48	113
7.17	6.50	154	10.51	8.57	112
7.23	6.53	153	10.62	8.66	111
7.29	6.56	152			
7.35	6.58	151	10.73	8.76	110
			10.84	8.86	109
7.42	6.61	150	10.96	8.96	108
7.48	6.64	149	11.08	9.07	107
7.54	6.67	148	11.21	9.18	106
7.61	6.70	147			
7.67	6.73	146	11.33	9.29	105
			11.46	9.41	104
7.74	6.76	145	11.59	9.54	103
7.80	6.79	144	11.73	9.67	102
7.87	6.83	143	11.87	9.80	101
7.94	6.86	142			
8.01	6.89	141	12.01	9.94	100
			12.16	10.09	99
8.08	6.93	140	12.31	10.24	98
8.15	6.97	139	12.46	10.40	97
8.22	7.01	138	12.62	10.56	96
8.29	7.05	137			
8.37	7.09	136	12.79	10.73	95
			12.96	10.91	94
8.44	7.13	135	13.13	11.10	93
8.52	7.17	134	13.31	11.29	92
8.59	7.22	133	13.49	11.50	91
8.67	7.26	132			
8.75	7.31	131	13.68	11.71	90
			13.88	11.94	89
8.83	7.36	130	14.08	12.17	88
8.91	7.41	129	14.30	12.42	87
			14.51	12.67	86

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TABLE 50.8—(cont.)

Trench Load (P_s)—psi			Trench Load (P_s)—psi		
Bending Stress Design	Deflection Design	$\frac{D}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{D}{t}$ or $\frac{D}{t_1}$
14.74	12.94	85	26.95	31.26	57
14.97	13.22	84	27.77	32.71	56
15.21	13.52	83			
15.46	13.83	82	28.64	34.26	55
15.72	14.16	81	29.56	35.93	54
			30.53	37.74	53
15.99	14.50	80	31.57	39.69	52
16.28	14.86	79	32.67	41.80	51
16.57	15.24	78			
16.87	15.64	77	33.84	44.09	50
17.19	16.06	76	35.08	46.56	49
			36.41	49.26	48
17.52	16.51	75	37.83	52.19	47
17.86	16.98	74	39.34	55.40	46
18.22	17.48	73			
18.59	18.00	72	40.96	58.89	45
18.98	18.56	71	42.70	62.73	44
			44.57	66.93	43
19.39	19.14	70	46.57	71.56	42
19.82	19.77	69	48.73	76.66	41
20.27	20.43	68			
20.73	21.13	67	51.06	82.29	40
21.23	21.87	66	53.57	88.54	39
			56.30	95.48	38
21.74	22.67	65	59.25	103.21	37
22.28	23.51	64	62.46	111.85	36
22.85	24.41	63			
23.45	25.37	62	65.96	121.54	35
24.07	26.39	61	69.79	132.44	34
			73.98	144.74	33
24.74	27.49	60	78.57	158.68	32
25.43	28.66	59	83.64	174.54	31
26.17	29.91	58			

* $E' = 300$; $K_b = 0.210$; $K_s = 0.105$.

† The $\frac{D}{t}$ for the tabulated P_s nearest to the calculated P_s is selected; when the calculated P_s is halfway between two tabulated values, the smaller $\frac{D}{t}$ should be used.

TABLE 50.9

*Diameter-Thickness Ratios for Laying Condition Type 3**

Trench Load (P_v)—psi			Trench Load (P_v)—psi		
Bending Stress Design	Deflection Design	$\frac{Dt}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{Dt}{t}$ or $\frac{D}{t_1}$
3.25	7.26	310	5.62	7.52	226
3.29	7.27	308	5.70	7.53	224
3.33	7.27	306	5.79	7.54	222
3.37	7.27	304			
3.41	7.28	302	5.87	7.55	220
			5.96	7.56	218
3.45	7.28	300	6.04	7.58	216
3.49	7.28	298	6.13	7.59	214
3.54	7.29	296	6.22	7.60	212
3.58	7.29	294			
3.63	7.30	292	6.32	7.62	210
			6.41	7.63	208
3.67	7.30	290	6.51	7.65	206
3.72	7.30	288	6.60	7.66	204
3.76	7.31	286	6.70	7.68	202
3.81	7.31	284			
3.86	7.32	282	6.80	7.70	200
			6.91	7.72	198
3.91	7.32	280	7.01	7.74	196
3.96	7.33	278	7.12	7.76	194
4.01	7.33	276	7.22	7.78	192
4.06	7.34	274			
4.11	7.34	272	7.33	7.80	190
			7.45	7.82	188
4.17	7.35	270	7.56	7.84	186
4.22	7.35	268	7.68	7.87	184
4.28	7.36	266	7.80	7.89	182
4.33	7.36	264			
4.39	7.37	262	7.92	7.92	180
			8.04	7.95	178
4.45	7.38	260	8.16	7.98	176
4.51	7.38	258	8.29	8.01	174
4.57	7.39	256	8.42	8.04	172
4.63	7.39	254			
4.69	7.40	252	8.55	8.07	170
			8.62	8.09	169
4.76	7.41	250	8.69	8.11	168
4.82	7.42	248	8.75	8.13	167
4.89	7.42	246	8.82	8.14	166
4.96	7.43	244			
5.03	7.44	242	8.89	8.16	165
			8.96	8.18	164
5.10	7.45	240	9.03	8.20	163
5.17	7.46	238	9.10	8.22	162
5.24	7.47	236	9.17	8.24	161
5.31	7.48	234			
5.39	7.48	232	9.25	8.27	160
			9.32	8.29	159
			9.39	8.31	158
5.47	7.49	230	9.47	8.33	157
5.54	7.51	228	9.54	8.36	156

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TABLE 50.9—(cont.)

Trench Load (P_t)—psi			Trench Load (P_t)—psi		
Bending Stress Design	Deflection Design	$\frac{Dt}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{Dt}{t}$ or $\frac{D}{t_1}$
9.62	8.38	155	13.71	10.51	112
9.69	8.41	154	13.83	10.61	111
9.77	8.43	153			
9.85	8.46	152	13.96	10.71	110
9.92	8.49	151	14.09	10.81	109
			14.22	10.91	108
10.00	8.52	150	14.36	11.02	107
10.08	8.54	149	14.50	11.13	106
10.16	8.57	148			
10.24	8.60	147	14.64	11.25	105
10.33	8.64	146	14.78	11.37	104
			14.93	11.50	103
10.41	8.67	145	15.08	11.63	102
10.49	8.70	144	15.23	11.77	101
10.58	8.73	143			
10.66	8.77	142	15.39	11.91	100
10.75	8.81	141	15.55	12.06	99
			15.71	12.21	98
10.83	8.84	140	15.88	12.37	97
10.92	8.88	139	16.06	12.54	96
11.01	8.92	138			
11.10	8.96	137	16.23	12.72	95
11.19	9.00	136	16.42	12.90	94
			16.61	13.09	93
11.28	9.04	135	16.80	13.29	92
11.37	9.09	134	17.00	13.50	91
11.46	9.13	133			
11.56	9.18	132	17.21	13.72	90
11.65	9.23	131	17.42	13.95	89
			17.64	14.18	88
11.75	9.28	130	17.86	14.43	87
11.84	9.33	129	18.10	14.70	86
11.94	9.38	128			
12.04	9.44	127	18.34	14.97	85
12.14	9.49	126	18.59	15.26	84
			18.85	15.56	83
12.25	9.55	125	19.12	15.88	82
12.35	9.61	124	19.40	16.21	81
12.45	9.67	123			
12.56	9.74	122	19.68	16.56	80
12.67	9.80	121	19.99	16.93	79
			20.30	17.31	78
12.78	9.87	120	20.62	17.72	77
12.89	9.94	119	20.96	18.15	76
13.00	10.02	118			
13.11	10.09	117	21.31	18.61	75
13.23	10.17	116	21.68	19.09	74
			22.07	19.59	73
13.34	10.25	115	22.47	20.13	72
13.46	10.34	114	22.88	20.69	71
13.58	10.42	113			

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TABLE 50.9—(cont.)

Trench Load (P_s)—psi			Trench Load (P_s)—psi		
Bending Stress Design	Deflection Design	$\frac{D^\dagger}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{D^\dagger}{t}$ or $\frac{D}{t_1}$
23.32	21.29	70	38.97	46.72	50
23.78	21.93	69	40.33	49.25	49
24.26	22.60	68	41.78	51.99	48
24.76	23.32	67	43.33	54.98	47
25.29	24.08	66	44.98	58.25	46
25.85	24.88	65	46.76	61.81	45
26.43	25.74	64	48.66	65.72	44
27.04	26.66	63	50.71	70.01	43
27.68	27.64	62	52.91	74.72	42
28.36	28.68	61	55.28	79.92	41
29.08	29.80	60	57.84	85.67	40
29.83	30.99	59	60.61	92.04	39
30.63	32.27	58	63.61	99.11	38
31.47	33.64	57	66.86	106.99	37
32.36	35.12	56	70.40	115.80	36
33.31	36.70	55	74.27	125.67	35
34.30	38.41	54	78.49	136.78	34
35.37	40.25	53	83.11	149.32	33
36.49	42.24	52	88.19	163.54	32
37.69	44.39	51	93.79	179.71	31

* $E' = 400$; $K_1 = 0.189$; $K_2 = 0.103$.

† The $\frac{D}{t}$ for the tabulated P_s nearest to the calculated P_s is selected; when the calculated P_s is halfway between two tabulated values, the smaller $\frac{D}{t}$ should be used.

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TABLE 50.10

*Diameter-Thickness Ratios for Laying Condition Type 4**

Trench Load (P_s)—psi			Trench Load (P_s)—psi		
Bending Stress Design	Deflection Design	$\frac{D^+}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{D^+}{t}$ or $\frac{D}{t_1}$
5.93	9.70	310	9.95	9.97	226
6.00	9.70	308	10.08	9.98	224
6.07	9.71	306	10.21	9.99	222
6.14	9.71	304			
6.21	9.71	302	10.35	10.01	220
			10.49	10.02	218
6.29	9.72	300	10.62	10.03	216
6.36	9.72	298	10.77	10.05	214
6.43	9.73	296	10.91	10.06	212
6.51	9.73	294			
6.59	9.73	292	11.05	10.08	210
			11.20	10.09	208
6.67	9.74	290	11.35	10.11	206
6.74	9.74	288	11.50	10.13	204
6.83	9.75	286	11.66	10.15	202
6.91	9.75	284			
6.99	9.76	282	11.81	10.17	200
			11.97	10.19	198
7.08	9.76	280	12.13	10.21	196
7.16	9.77	278	12.29	10.23	194
7.25	9.77	276	12.45	10.25	192
7.34	9.78	274			
7.43	9.78	272	12.62	10.27	190
			12.79	10.30	188
7.52	9.79	270	12.96	10.32	186
7.61	9.79	268	13.13	10.35	184
7.71	9.80	266	13.30	10.37	182
7.80	9.81	264			
7.90	9.81	262	13.48	10.40	180
			13.66	10.43	178
8.00	9.82	260	13.84	10.46	176
8.10	9.83	258	14.02	10.50	174
8.20	9.83	256	14.20	10.53	172
8.31	9.84	254			
8.41	9.85	252	14.39	10.57	170
			14.48	10.59	169
8.52	9.86	250	14.57	10.60	168
8.63	9.86	248	14.67	10.62	167
8.74	9.87	246	14.76	10.64	166
8.85	9.88	244			
8.97	9.89	242	14.86	10.66	165
			14.96	10.69	164
9.08	9.90	240	15.05	10.71	163
9.20	9.91	238	15.15	10.73	162
9.32	9.92	236	15.25	10.75	161
9.44	9.93	234			
9.57	9.94	232	15.34	10.78	160
			15.44	10.80	159
9.69	9.95	230	15.54	10.82	158
9.82	9.96	228	15.64	10.85	157
			15.74	10.87	156

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TABLE 50.10—(cont.)

Trench Load (P_e)—psi			Trench Load (P_e)—psi		
Bending Stress Design	Deflection Design	$\frac{Dt}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{Dt}{t}$ or $\frac{D}{t_1}$
15.84	10.90	155	20.69	13.19	112
15.94	10.93	154	20.82	13.29	111
16.04	10.96	153			
16.14	10.98	152	20.96	13.39	110
16.24	11.01	151	21.10	13.50	109
			21.24	13.61	108
16.34	11.04	150	21.39	13.73	107
16.45	11.07	149	21.54	13.85	106
16.55	11.11	148			
16.65	11.14	147	21.69	13.98	105
16.76	11.17	146	21.84	14.11	104
			22.00	14.24	103
16.86	11.21	145	22.16	14.38	102
16.96	11.24	144	22.32	14.53	101
17.07	11.28	143			
17.18	11.31	142	22.49	14.68	100
17.28	11.35	141	22.66	14.84	99
			22.83	15.01	98
17.39	11.39	140	23.01	15.18	97
17.50	11.43	139	23.20	15.36	96
17.60	11.48	138			
17.71	11.52	137	23.38	15.55	95
17.82	11.56	136	23.58	15.75	94
			23.78	15.95	93
17.93	11.61	135	23.99	16.17	92
18.04	11.66	134	24.20	16.39	91
18.15	11.71	133			
18.26	11.76	132	24.42	16.62	90
18.37	11.81	131	24.64	16.87	89
			24.88	17.12	88
18.49	11.86	130	25.12	17.39	87
18.60	11.92	129	25.37	17.67	86
18.72	11.97	128			
18.83	12.03	127	25.63	17.97	85
18.95	12.09	126	25.90	18.28	84
			26.18	18.60	83
19.06	12.15	125	26.47	18.94	82
19.18	12.22	124	26.77	19.30	81
19.30	12.28	123			
19.42	12.35	122	27.09	19.67	80
19.54	12.42	121	27.42	20.07	79
			27.76	20.48	78
19.66	12.50	120	28.11	20.92	77
19.78	12.57	119	28.49	21.38	76
19.91	12.65	118			
20.04	12.73	117	28.87	21.87	75
20.16	12.82	116	29.28	22.38	74
			29.70	22.93	73
20.29	12.91	115	30.15	23.50	72
20.42	13.00	114	30.62	24.11	71
20.55	13.09	113			

TABLE 50.10—(cont.)

Trench Load (P_v)—psi			Trench Load (P_v)—psi		
Bending Stress Design	Deflection Design	$\frac{D^\dagger}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{D^\dagger}{t}$ or $\frac{D}{t_1}$
31.11	24.75	70	49.11	52.03	50
31.62	25.43	69	50.70	54.74	49
32.16	26.16	68	52.41	57.69	48
32.72	26.92	67	54.23	60.90	47
33.32	27.74	66	56.18	64.40	46
33.95	28.60	65	58.27	68.23	45
34.61	29.53	64	60.52	72.42	44
35.30	30.51	63	62.93	77.02	43
36.04	31.56	62	65.54	82.08	42
36.81	32.68	61	68.35	87.66	41
37.63	33.88	60	71.39	93.82	40
38.50	35.16	59	74.67	100.65	39
39.42	36.53	58	78.24	108.24	38
40.39	38.00	57	82.11	116.70	37
41.42	39.58	56	86.33	126.15	36
42.51	41.28	55	90.93	136.74	35
43.67	43.12	54	95.97	148.66	34
44.91	45.09	53	101.49	162.12	33
46.22	47.22	52	107.56	177.37	32
47.62	49.53	51	114.25	194.72	31

* $E' = 500$; $K_b = 0.157$; $K_s = 0.096$.

† The $\frac{D}{t}$ for the tabulated P_v nearest to the calculated P_v is selected; when the calculated P_v is halfway between two tabulated values, the smaller $\frac{D}{t}$ should be used.

TABLE 50.11

*Diameter-Thickness Ratios for Laying Condition Type 5**

Trench Load (P_0)—psi			Trench Load (P_0)—psi		
Bending Stress Design	Deflection Design	$\frac{D^+}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{D^+}{t}$ or $\frac{D}{t_1}$
3.06	15.09	660	6.41	15.13	450
3.10	15.09	655	6.54	15.14	445
3.15	15.09	650	6.68	15.14	440
3.20	15.09	645			
3.25	15.09	640	6.83	15.14	435
			6.98	15.14	430
3.30	15.09	635	7.13	15.14	425
3.35	15.09	630	7.29	15.15	420
3.40	15.09	625	7.46	15.15	415
3.46	15.09	620			
3.51	15.09	615	7.63	15.15	410
			7.80	15.16	405
3.57	15.10	610	7.98	15.16	400
3.63	15.10	605	8.17	15.16	395
3.68	15.10	600	8.36	15.17	390
3.75	15.10	595			
3.81	15.10	590	8.56	15.17	385
			8.77	15.17	380
3.87	15.10	585	8.98	15.18	375
3.94	15.10	580	9.20	15.18	370
4.00	15.10	575	9.43	15.19	365
4.07	15.10	570			
4.14	15.10	565	9.66	15.19	360
			9.91	15.20	355
4.21	15.10	560	10.16	15.20	350
4.29	15.10	555	10.42	15.21	345
4.36	15.10	550	10.69	15.22	340
4.44	15.11	545			
4.52	15.11	540	10.97	15.22	335
			11.26	15.23	330
4.60	15.11	535	11.56	15.24	325
4.69	15.11	530	11.87	15.24	320
4.77	15.11	525	12.19	15.25	315
4.86	15.11	520			
4.95	15.11	515	12.52	15.26	310
			12.66	15.27	308
5.05	15.11	510	12.80	15.27	306
5.14	15.11	505	12.94	15.27	304
5.24	15.12	500	13.08	15.28	302
5.35	15.12	495			
5.45	15.12	490	13.23	15.28	300
			13.37	15.29	298
5.56	15.12	485	13.52	15.29	296
5.67	15.12	480	13.67	15.30	294
5.78	15.12	475	13.83	15.30	292
5.90	15.13	470			
6.02	15.13	465	13.98	15.30	290
			14.14	15.31	288
6.15	15.13	460	14.30	15.31	286
6.28	15.13	455	14.46	15.32	284
			14.62	15.33	282

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TABLE 50.11—(cont.)

Trench Load (P_s)—psi			Trench Load (P_s)—psi		
Bending Stress Design	Deflection Design	$\frac{D}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{D}{t}$ or $\frac{D}{t_1}$
14.79	15.33	280	24.24	15.86	194
14.96	15.34	278	24.50	15.88	192
15.13	15.34	276			
15.30	15.35	274	24.77	15.91	190
15.48	15.35	272	25.04	15.93	188
			25.31	15.96	186
15.65	15.36	270	25.59	15.99	184
15.83	15.37	268	25.86	16.02	182
16.02	15.37	266			
16.20	15.38	264	26.13	16.06	180
16.39	15.39	262	26.41	16.09	178
			26.68	16.12	176
16.58	15.40	260	26.96	16.16	174
16.77	15.40	258	27.23	16.20	172
16.97	15.41	256			
17.16	15.42	254	27.51	16.24	170
17.36	15.43	252	27.65	16.26	169
			27.78	16.28	168
17.57	15.44	250	27.92	16.31	167
17.77	15.45	248	28.06	16.33	166
17.98	15.45	246			
18.19	15.46	244	28.19	16.35	165
18.40	15.47	242	28.33	16.37	164
			28.47	16.40	163
18.62	15.48	240	28.60	16.42	162
18.84	15.49	238	28.74	16.45	161
19.06	15.51	236			
19.28	15.52	234	28.87	16.48	160
19.51	15.53	232	29.01	16.50	159
			29.15	16.53	158
19.73	15.54	230	29.28	16.56	157
19.97	15.55	228	29.41	16.59	156
20.20	15.57	226			
20.43	15.58	224	29.55	16.62	155
20.67	15.59	222	29.68	16.65	154
			29.82	16.68	153
20.91	15.61	220	29.95	16.71	152
21.16	15.62	218	30.08	16.74	151
21.40	15.64	216			
21.65	15.65	214	30.21	16.78	150
21.90	15.67	212	30.34	16.81	149
			30.48	16.85	148
22.15	15.69	210	30.61	16.89	147
22.40	15.71	208	30.74	16.92	146
22.66	15.73	206			
22.92	15.75	204	30.87	16.96	145
23.18	15.77	202	30.99	17.00	144
			31.12	17.04	143
23.44	15.79	200	31.25	17.09	142
23.70	15.81	198	31.38	17.13	141
23.97	15.83	196			

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TABLE 50.11—(cont.)

Trench Load (P_s)—psi			Trench Load (P_s)—psi		
Bending Stress Design	Deflection Design	$\frac{D^+}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{D^+}{t}$ or $\frac{D}{t_1}$
31.50	17.17	140	37.01	21.45	97
31.63	17.22	139	37.17	21.66	96
31.76	17.27	138			
31.88	17.32	137	37.34	21.87	95
32.01	17.37	136	37.52	22.09	94
			37.70	22.32	93
32.13	17.42	135	37.89	22.56	92
32.25	17.47	134	38.08	22.82	91
32.38	17.53	133			
32.50	17.58	132	38.28	23.08	90
32.62	17.64	131	38.49	23.36	89
			38.71	23.65	88
32.75	17.70	130	38.93	23.95	87
32.87	17.76	129	39.17	24.27	86
32.99	17.83	128			
33.11	17.89	127	39.41	24.60	85
33.23	17.96	126	39.67	24.95	84
			39.94	25.31	83
33.35	18.03	125	40.22	25.70	82
33.47	18.11	124	40.51	26.10	81
33.59	18.18	123			
33.71	18.26	122	40.82	26.52	80
33.83	18.34	121	41.14	26.97	79
			41.48	27.44	78
33.95	18.42	120	41.84	27.93	77
34.07	18.51	119	42.21	28.46	76
34.19	18.60	118			
34.31	18.69	117	42.60	29.01	75
34.43	18.78	116	43.02	29.59	74
			43.45	30.20	73
34.55	18.88	115	43.92	30.85	72
34.68	18.98	114	44.40	31.53	71
34.80	19.09	113			
34.92	19.20	112	44.91	32.26	70
35.05	19.31	111	45.46	33.03	69
			46.03	33.85	68
35.17	19.43	110	46.64	34.71	67
35.30	19.55	109	47.28	35.63	66
35.43	19.68	108			
35.56	19.81	107	47.96	36.61	65
35.69	19.95	106	48.68	37.65	64
			49.44	38.77	63
35.83	20.09	105	50.25	39.95	62
35.96	20.24	104	51.11	41.21	61
36.10	20.39	103			
36.25	20.55	102	52.02	42.57	60
36.39	20.72	101	52.99	44.01	59
			54.02	45.56	58
36.54	20.89	100	55.12	47.23	57
36.69	21.07	99	56.28	49.01	56
36.85	21.26	98			

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TABLE 50.11—(cont.)

Trench Load (P_v)—psi			Trench Load (P_v)—psi		
Bending Stress Design	Deflection Design	$\frac{D}{t}$ or $\frac{D}{t_1}$	Bending Stress Design	Deflection Design	$\frac{D}{t}$ or $\frac{D}{t_1}$
57.53	50.93	55	84.50	97.01	42
58.86	53.00	54	87.85	103.31	41
60.28	55.23	53			
61.79	57.64	52	91.47	110.27	40
63.41	60.25	51	95.40	117.98	39
			99.67	126.56	38
65.14	63.07	50	104.32	136.11	37
67.00	66.13	49	109.40	146.78	36
68.99	69.46	48			
71.12	73.09	47	114.94	158.75	35
73.41	77.04	46	121.02	172.21	34
			127.69	187.41	33
75.88	81.36	45	135.03	204.63	32
78.54	86.10	44	143.14	224.22	31
81.40	91.29	43			

* $E' = 700$; $K_b = 0.128$; $K_s = 0.085$.

† The $\frac{D}{t}$ for the tabulated P_v nearest to the calculated P_v is selected; when the calculated P_v is halfway between two tabulated values, the smaller $\frac{D}{t}$ should be used.

TABLE 50.12
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	
		Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class
3	2.5	0.18	51	0.17	51	0.16	51	0.15	51	0.14	51
	3	0.17	51	0.16	51	0.16	51	0.15	51	0.14	51
	4	0.17	51	0.16	51	0.15	51	0.14	51	0.14	51
	5	0.16	51	0.16	51	0.15	51	0.14	51	0.14	51
	6	0.16	51	0.16	51	0.15	51	0.14	51	0.14	51
	7	0.16	51	0.16	51	0.15	51	0.14	51	0.14	51
	8	0.17	51	0.16	51	0.15	51	0.15	51	0.14	51
	9	0.17	51	0.16	51	0.15	51	0.15	51	0.14	51
	10	0.17	51	0.16	51	0.15	51	0.15	51	0.14	51
	12	0.17	51	0.17	51	0.16	51	0.15	51	0.14	51
	14	0.18	51	0.17	51	0.16	51	0.15	51	0.14	51
	16	0.18	51	0.17	51	0.17	51	0.15	51	0.14	51
	20	0.19	51	0.18	51	0.17	51	0.16	51	0.15	51
	24	0.19	51	0.19	51	0.18	51	0.16	51	0.15	51
	28	0.20	51	0.19	51	0.19	51	0.17	51	0.15	51
	32	0.21	51	0.20	51	0.19	51	0.18	51	0.15	51
4	2.5	0.19	51	0.18	51	0.17	51	0.15	51	0.15	51
	3	0.18	51	0.17	51	0.16	51	0.15	51	0.14	51
	4	0.17	51	0.16	51	0.16	51	0.15	51	0.14	51
	5	0.17	51	0.16	51	0.15	51	0.15	51	0.14	51
	6	0.17	51	0.16	51	0.15	51	0.15	51	0.14	51
	7	0.17	51	0.16	51	0.16	51	0.15	51	0.14	51
	8	0.17	51	0.16	51	0.16	51	0.15	51	0.14	51
	9	0.18	51	0.17	51	0.16	51	0.15	51	0.14	51
	10	0.18	51	0.17	51	0.16	51	0.15	51	0.14	51
	12	0.18	51	0.17	51	0.16	51	0.15	51	0.14	51
	14	0.19	51	0.18	51	0.17	51	0.15	51	0.15	51
	16	0.19	51	0.18	51	0.17	51	0.16	51	0.15	51
	20	0.20	51	0.19	51	0.18	51	0.16	51	0.15	51
	24	0.21	51	0.20	51	0.19	51	0.17	51	0.15	51
	28	0.22	51	0.21	51	0.20	51	0.18	51	0.15	51
	32	0.22	51	0.21	51	0.21	51	0.19	51	0.16	51
6	2.5	0.21	50	0.20	50	0.18	50	0.16	50	0.15	50
	3	0.20	50	0.19	50	0.18	50	0.16	50	0.15	50
	4	0.19	50	0.18	50	0.17	50	0.16	50	0.15	50
	5	0.19	50	0.17	50	0.17	50	0.15	50	0.15	50
	6	0.19	50	0.17	50	0.17	50	0.15	50	0.15	50
	7	0.19	50	0.18	50	0.17	50	0.16	50	0.15	50
	8	0.19	50	0.18	50	0.17	50	0.16	50	0.15	50
	9	0.20	50	0.18	50	0.17	50	0.16	50	0.15	50
	10	0.20	50	0.18	50	0.17	50	0.16	50	0.15	50
	12	0.21	50	0.19	50	0.18	50	0.16	50	0.15	50
	14	0.21	50	0.20	50	0.18	50	0.17	50	0.15	50
	16	0.22	50	0.21	50	0.19	50	0.17	50	0.15	50
	20	0.23	50	0.22	50	0.21	50	0.18	50	0.16	50
	24	0.24	50	0.23	50	0.22	50	0.19	50	0.16	50
	28	0.25	50	0.24	50	0.23	50	0.20	50	0.16	50
	32	0.26	50	0.25	50	0.24	50	0.22	50	0.17	50

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

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TABLE 50.12—(cont.)

Size in.	Depth of Cover ft	Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
		Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class
8	2.5	0.24	50	0.22	50	0.20	50	0.18	50	0.16	50
	3	0.23	50	0.21	50	0.19	50	0.17	50	0.16	50
	4	0.21	50	0.19	50	0.18	50	0.16	50	0.15	50
	5	0.21	50	0.19	50	0.18	50	0.16	50	0.15	50
	6	0.21	50	0.19	50	0.18	50	0.16	50	0.15	50
	7	0.21	50	0.19	50	0.18	50	0.16	50	0.15	50
	8	0.21	50	0.19	50	0.18	50	0.16	50	0.15	50
	9	0.22	50	0.20	50	0.18	50	0.17	50	0.15	50
	10	0.22	50	0.20	50	0.19	50	0.17	50	0.15	50
	12	0.23	50	0.21	50	0.19	50	0.17	50	0.16	50
	14	0.24	50	0.22	50	0.20	50	0.18	50	0.16	50
	16	0.25	50	0.23	50	0.21	50	0.18	50	0.16	50
	20	0.27	50	0.25	50	0.23	50	0.19	50	0.17	50
	24	0.28	50	0.26	50	0.24	50	0.21	50	0.17	50
10	2.5	0.27	50	0.25	50	0.23	50	0.20	50	0.17	50
	3	0.26	50	0.23	50	0.21	50	0.19	50	0.17	50
	4	0.24	50	0.22	50	0.20	50	0.18	50	0.17	50
	5	0.23	50	0.21	50	0.20	50	0.18	50	0.17	50
	6	0.23	50	0.21	50	0.20	50	0.18	50	0.17	50
	7	0.24	50	0.21	50	0.20	50	0.18	50	0.17	50
	8	0.24	50	0.22	50	0.20	50	0.18	50	0.17	50
	9	0.25	50	0.22	50	0.20	50	0.18	50	0.17	50
	10	0.25	50	0.23	50	0.21	50	0.19	50	0.17	50
	12	0.26	50	0.24	50	0.22	50	0.19	50	0.17	50
	14	0.28	50	0.25	50	0.23	50	0.20	50	0.18	50
	16	0.29	50	0.26	50	0.24	50	0.20	50	0.18	50
	20	0.31	51	0.28	50	0.26	50	0.22	50	0.18	50
	24	0.32	51	0.30	50	0.28	50	0.24	50	0.19	50
12	2.5	0.30	50	0.27	50	0.24	50	0.21	50	0.18	50
	3	0.28	50	0.25	50	0.23	50	0.20	50	0.18	50
	4	0.26	50	0.23	50	0.21	50	0.19	50	0.17	50
	5	0.25	50	0.23	50	0.21	50	0.19	50	0.17	50
	6	0.25	50	0.23	50	0.21	50	0.19	50	0.17	50
	7	0.26	50	0.23	50	0.21	50	0.19	50	0.17	50
	8	0.26	50	0.23	50	0.21	50	0.19	50	0.17	50
	9	0.27	50	0.24	50	0.22	50	0.19	50	0.17	50
	10	0.27	50	0.24	50	0.22	50	0.20	50	0.18	50
	12	0.29	50	0.26	50	0.23	50	0.20	50	0.18	50
	14	0.30	50	0.27	50	0.24	50	0.21	50	0.18	50
	16	0.31	50	0.29	50	0.26	50	0.21	50	0.18	50
	20	0.34	51	0.31	50	0.28	50	0.23	50	0.19	50
	24	0.36	52	0.33	51	0.31	50	0.25	50	0.20	50
	28	0.38	52	0.35	51	0.33	51	0.28	50	0.21	50
	32	0.39	53	0.37	52	0.35	51	0.30	50	0.23	50

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

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TABLE 50.12—(cont.)

Size in.	Depth of Cover ft	Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
		Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class
14	2.5	0.32	50	0.29	50	0.26	50	0.22	50	0.20	50
	3	0.31	50	0.27	50	0.24	50	0.21	50	0.19	50
	4	0.29	50	0.26	50	0.23	50	0.21	50	0.19	50
	5	0.28	50	0.25	50	0.23	50	0.20	50	0.19	50
	6	0.28	50	0.25	50	0.23	50	0.20	50	0.19	50
	7	0.28	50	0.25	50	0.23	50	0.21	50	0.19	50
	8	0.29	50	0.26	50	0.23	50	0.21	50	0.19	50
	9	0.30	50	0.26	50	0.24	50	0.21	50	0.19	50
	10	0.31	50	0.27	50	0.24	50	0.21	50	0.19	50
	12	0.32	50	0.29	50	0.26	50	0.22	50	0.19	50
	14	0.34	50	0.30	50	0.27	50	0.23	50	0.20	50
	16	0.35	51	0.32	50	0.29	50	0.24	50	0.20	50
	20	0.38	52	0.35	51	0.32	50	0.26	50	0.21	50
	24	0.40	52	0.38	52	0.34	50	0.28	50	0.22	50
	28	0.42	53	0.40	52	0.37	51	0.31	50	0.24	50
	32	0.44	54	0.42	53	0.39	52	0.34	50	0.26	50
16	2.5	0.34	50	0.30	50	0.27	50	0.23	50	0.20	50
	3	0.32	50	0.28	50	0.25	50	0.22	50	0.20	50
	4	0.30	50	0.27	50	0.24	50	0.21	50	0.19	50
	5	0.30	50	0.26	50	0.24	50	0.21	50	0.19	50
	6	0.30	50	0.26	50	0.24	50	0.21	50	0.19	50
	7	0.30	50	0.26	50	0.24	50	0.21	50	0.19	50
	8	0.31	50	0.27	50	0.25	50	0.22	50	0.19	50
	9	0.32	50	0.28	50	0.25	50	0.22	50	0.20	50
	10	0.33	50	0.29	50	0.26	50	0.22	50	0.20	50
	12	0.35	50	0.31	50	0.27	50	0.23	50	0.20	50
	14	0.36	51	0.33	50	0.29	50	0.24	50	0.20	50
	16	0.38	51	0.34	50	0.30	50	0.25	50	0.21	50
	20	0.41	52	0.38	51	0.34	50	0.27	50	0.22	50
	24	0.44	53	0.41	52	0.37	51	0.30	50	0.24	50
	28	0.46	54	0.43	53	0.40	52	0.33	50	0.27	50
	32	0.48	55	0.46	54	0.43	53	0.36	51	0.29	50
18	2.5	0.36	50	0.32	50	0.28	50	0.24	50	0.20	50
	3	0.34	50	0.29	50	0.26	50	0.23	50	0.20	50
	4	0.32	50	0.28	50	0.25	50	0.22	50	0.20	50
	5	0.31	50	0.27	50	0.25	50	0.22	50	0.19	50
	6	0.31	50	0.27	50	0.25	50	0.22	50	0.19	50
	7	0.32	50	0.28	50	0.25	50	0.22	50	0.20	50
	8	0.33	50	0.29	50	0.26	50	0.22	50	0.20	50
	9	0.34	50	0.30	50	0.26	50	0.23	50	0.20	50
	10	0.35	50	0.30	50	0.27	50	0.23	50	0.20	50
	12	0.37	51	0.32	50	0.29	50	0.24	50	0.21	50
	14	0.39	51	0.35	50	0.30	50	0.25	50	0.21	50
	16	0.41	52	0.37	51	0.32	50	0.26	50	0.22	50
	20	0.44	53	0.40	52	0.36	50	0.29	50	0.23	50
	24	0.47	54	0.44	53	0.40	52	0.32	50	0.26	50
	28	0.50	55	0.46	54	0.43	53	0.36	50	0.29	50
	32	0.53	56	0.49	55	0.46	54	0.39	51	0.32	50

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

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TABLE 50.12—(cont.)

Size in.	Depth of Cover ft	Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
		Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class
20	2.5	0.38	51	0.33	50	0.29	50	0.24	50	0.21	50
	3	0.35	50	0.31	50	0.27	50	0.23	50	0.20	50
	4	0.34	50	0.29	50	0.26	50	0.23	50	0.20	50
	5	0.33	50	0.28	50	0.26	50	0.23	50	0.20	50
	6	0.33	50	0.29	50	0.26	50	0.23	50	0.20	50
	7	0.34	50	0.29	50	0.26	50	0.23	50	0.20	50
	8	0.35	50	0.30	50	0.27	50	0.23	50	0.20	50
	9	0.36	50	0.31	50	0.28	50	0.24	50	0.21	50
	10	0.37	50	0.32	50	0.28	50	0.24	50	0.21	50
	12	0.39	51	0.34	50	0.30	50	0.25	50	0.21	50
	14	0.41	52	0.37	50	0.32	50	0.26	50	0.22	50
	16	0.43	52	0.39	51	0.34	50	0.27	50	0.22	50
	20	0.47	54	0.43	52	0.39	51	0.31	50	0.23	50
	24	0.50	55	0.47	54	0.42	52	0.34	50	0.28	50
	28	0.54	56	0.50	55	0.46	53	0.38	51	0.31	50
	32	0.57	—	0.53	56	0.49	54	0.42	52	0.34	50
24	2.5	0.42	51	0.35	50	0.31	50	0.26	50	0.22	50
	3	0.39	50	0.33	50	0.29	50	0.25	50	0.21	50
	4	0.37	50	0.31	50	0.28	50	0.24	50	0.21	50
	5	0.36	50	0.31	50	0.28	50	0.24	50	0.21	50
	6	0.36	50	0.31	50	0.28	50	0.24	50	0.21	50
	7	0.37	50	0.32	50	0.28	50	0.24	50	0.21	50
	8	0.39	50	0.33	50	0.29	50	0.25	50	0.21	50
	9	0.40	51	0.34	50	0.30	50	0.25	50	0.22	50
	10	0.41	51	0.35	50	0.31	50	0.26	50	0.22	50
	12	0.44	52	0.38	50	0.33	50	0.27	50	0.23	50
	14	0.46	53	0.41	51	0.35	50	0.28	50	0.23	50
	16	0.49	54	0.44	52	0.38	50	0.31	50	0.24	50
	20	0.54	55	0.49	54	0.43	52	0.36	50	0.25	50
	24	0.57	56	0.53	55	0.48	53	0.40	51	0.32	50
	28	0.61	—	0.57	56	0.52	55	0.43	52	0.36	50
	32	0.65	—	0.60	—	0.56	56	0.47	53	0.40	51
30	2.5	†	†	0.40	50	0.34	50	0.28	50	0.23	50
	3			0.37	50	0.32	50	0.27	50	0.23	50
	4			0.35	50	0.31	50	0.26	50	0.22	50
	5			0.35	50	0.31	50	0.26	50	0.22	50
	6			0.35	50	0.31	50	0.26	50	0.22	50
	7			0.36	50	0.31	50	0.26	50	0.23	50
	8			0.37	50	0.33	50	0.27	50	0.23	50
	9			0.39	50	0.34	50	0.28	50	0.23	50
	10			0.40	50	0.35	50	0.28	50	0.24	50
	12			0.44	51	0.37	50	0.30	50	0.24	50
	14			0.47	52	0.40	50	0.32	50	0.25	50
	16			0.51	53	0.43	51	0.37	50	0.26	50
	20			0.57	55	0.50	53	0.43	51	0.29	50
	24			0.62	56	0.56	54	0.48	52	0.37	50
	28			0.67	—	0.61	56	0.51	53	0.43	51
	32			0.71	—	0.66	—	0.55	54	0.47	52

* Total calculated thickness includes service allowance and casting tolerance added to net thickness.
† For pipe 30 in. and larger, consideration should be given to laying conditions other than Type 1.

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TABLE 50.12—(cont.)

Size in.	Depth of Cover ft	Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
		Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class
36	2.5	†	†	0.43	50	0.37	50	0.30	50	0.25	50
	3			0.40	50	0.35	50	0.29	50	0.24	50
	4			0.39	50	0.34	50	0.28	50	0.24	50
	5			0.38	50	0.34	50	0.28	50	0.24	50
	6			0.39	50	0.34	50	0.28	50	0.24	50
	7			0.40	50	0.35	50	0.29	50	0.24	50
	8			0.42	50	0.36	50	0.30	50	0.24	50
	9			0.43	50	0.37	50	0.30	50	0.25	50
	10			0.45	50	0.38	50	0.31	50	0.25	50
	12			0.49	51	0.42	50	0.33	50	0.26	50
	14			0.54	52	0.46	51	0.37	50	0.27	50
	16			0.58	53	0.49	51	0.42	50	0.28	50
	20			0.65	54	0.57	53	0.50	51	0.33	50
	24			0.71	56	0.63	54	0.55	52	0.43	50
	28			0.77	—	0.70	55	0.60	53	0.50	51
	32			0.82	—	0.76	—	0.64	54	0.55	52
42	2.5	†	†	0.46	50	0.40	50	0.32	50	0.26	50
	3			0.44	50	0.38	50	0.31	50	0.25	50
	4			0.42	50	0.37	50	0.30	50	0.25	50
	5			0.42	50	0.37	50	0.30	50	0.25	50
	6			0.42	50	0.37	50	0.30	50	0.25	50
	7			0.44	50	0.38	50	0.31	50	0.25	50
	8			0.46	50	0.39	50	0.32	50	0.26	50
	9			0.48	50	0.41	50	0.33	50	0.26	50
	10			0.50	51	0.42	50	0.33	50	0.27	50
	12			0.55	51	0.47	50	0.35	50	0.28	50
	14			0.60	52	0.52	51	0.42	50	0.29	50
	16			0.64	53	0.56	52	0.48	50	0.30	50
	20			0.73	54	0.64	53	0.57	52	0.37	50
	24			0.80	56	0.71	54	0.63	53	0.49	50
	28			0.87	—	0.79	55	0.69	54	0.57	52
	32			0.93	—	0.86	—	0.73	54	0.63	53
48	2.5	†	†	0.50	50	0.43	50	0.35	50	0.28	50
	3			0.48	50	0.42	50	0.34	50	0.28	50
	4			0.46	50	0.40	50	0.33	50	0.27	50
	5			0.46	50	0.40	50	0.33	50	0.27	50
	6			0.47	50	0.41	50	0.33	50	0.27	50
	7			0.48	50	0.42	50	0.34	50	0.28	50
	8			0.51	50	0.44	50	0.35	50	0.28	50
	9			0.53	50	0.45	50	0.36	50	0.29	50
	10			0.56	51	0.47	50	0.37	50	0.30	50
	12			0.61	51	0.53	50	0.39	50	0.31	50
	14			0.67	52	0.59	51	0.48	50	0.32	50
	16			0.72	53	0.64	52	0.55	51	0.33	50
	20			0.82	54	0.72	53	0.65	52	0.43	50
	24			0.91	56	0.80	54	0.72	53	0.56	51
	28			0.98	—	0.89	55	0.79	54	0.65	52
	32			1.05	—	0.97	—	0.84	55	0.72	53

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

† For pipe 30 in. and larger, consideration should be given to laying conditions other than Type 1.

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TABLE 50.12—(cont.)

Size in.	Depth of Cover ft	Laying Condition									
		Type 1		Type 2		Type 3		Type 4		Type 5	
		Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class	Total Calculated Thickness* in.	Use Class
54	2.5	†	†	0.54	50	0.46	50	0.37	50	0.30	50
	3			0.52	50	0.45	50	0.37	50	0.30	50
	4			0.51	50	0.44	50	0.36	50	0.30	50
	5			0.51	50	0.44	50	0.36	50	0.30	50
	6			0.52	50	0.45	50	0.37	50	0.30	50
	7			0.53	50	0.46	50	0.37	50	0.30	50
	8			0.56	50	0.48	50	0.38	50	0.31	50
	9			0.59	50	0.50	50	0.39	50	0.32	50
	10			0.62	51	0.52	50	0.41	50	0.32	50
	12			0.68	51	0.60	50	0.43	50	0.34	50
	14			0.74	52	0.67	51	0.54	50	0.35	50
	16			0.80	53	0.72	52	0.62	51	0.36	50
	20			0.91	54	0.81	53	0.73	52	0.48	50
	24			1.01	56	0.89	54	0.81	53	0.63	51
	28			1.09	—	0.99	55	0.88	54	0.73	52
	32			1.17	—	1.08	—	0.94	55	0.81	53

* Total calculated thickness includes service allowance and casting tolerance added to net thickness.
† For pipe 30 in. and larger, consideration should be given to laying conditions other than Type 1.

TABLE 50.13

Thickness for Internal Pressure

Pipe Size in.	Rated Water Working Pressure*—psi									
	150		200		250		300		350	
	Total Calculated Thickness in.†	Use Class	Total Calculated Thickness in.†	Use Class	Total Calculated Thickness in.†	Use Class	Total Calculated Thickness in.†	Use Class	Total Calculated Thickness in.†	Use Class
3	0.15	51	0.16	51	0.16	51	0.17	51	0.17	51
4	0.16	51	0.16	51	0.17	51	0.18	51	0.18	51
6	0.17	50	0.18	50	0.19	50	0.20	50	0.20	50
8	0.18	50	0.19	50	0.21	50	0.22	50	0.23	50
10	0.21	50	0.22	50	0.23	50	0.25	50	0.26	50
12	0.22	50	0.23	50	0.25	50	0.27	50	0.28	50
14	0.24	50	0.26	50	0.28	50	0.30	50	0.31	50
16	0.25	50	0.27	50	0.30	50	0.32	50	0.34	50
18	0.27	50	0.29	50	0.31	50	0.34	50	0.36	50
20	0.28	50	0.30	50	0.33	50	0.36	50	0.38	51
24	0.30	50	0.33	50	0.37	50	0.40	51	0.43	52
30	0.34	50	0.38	50	0.42	51	0.45	52	0.49	53
36	0.38	50	0.42	50	0.47	51	0.51	52	0.56	53
42	0.41	50	0.47	50	0.52	51	0.57	52	0.63	53
48	0.46	50	0.52	50	0.58	51	0.64	52	0.70	53
54	0.51	50	0.58	50	0.65	51	0.71	52	0.78	53

* These pipe are adequate for the rated working pressure plus a surge allowance of 100 psi.
† Total calculated thickness includes service allowance and casting tolerance added to net thickness.

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TABLE 50.14

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‡
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‡
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‡
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‡

* 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.

TABLE 50.14—(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				
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†
16	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
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

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

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

TABLE 50.14—(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†				
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.

‡ Calculated maximum depth of cover exceeds 100 ft.

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

3P—5M—4/78—43150

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