Steel Water Pipe— A Guide for Design and Installation

MANUAL OF WATER SUPPLY PRACTICES

M11

Fourth Edition

American Water Works Association

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Errata to

AWWA Manual M11
Steel Pipe—A Guide for Design and Installation, 4th ed.

(December 2013)

Chapter 1

1. On page 1, paragraph 2, line 6 under History, the metric conversion should read 15,000 psi (103.42 MPa).

2. On page 7, paragraph 2, lines 6 and 7 under Stress and Strain, "min" should read "µin."

3. On page 8, paragraph 2, lines 2 and 4, respectively, the metric conversions should read 30,000,000 psi (207 TPa) and 30 psi (207 kPa).

4. On page 10, paragraph 1, line 2, the metric conversion should read 30 psi (207 kPa).

5. On page 10, paragraph 1, line 4, "5,000 min/in." should read "5,000 µin./in."

6. On page 10, paragraph 2, line 6, "5,000 min/in." should read "5,000 µin./in."

7. On page 10, paragraph 2, line 8, "300,000 min/in." should read "300,000 µin./in."

8. On page 11, paragraph 5, lines 6 and 10, under Analysis Based on Strain, "1,750 min/in." should read "1,750 µin./in."

9. On page 11, paragraph 7, line 2, under Analysis Based on Strain, "5,000 min/in." should read "5,000 µin./in."

10. On page 18, Eq 1-1 should read

$$\sigma_n = \sigma_2 (\cos^2 \alpha) + \sigma_1 (\sin^2 \alpha) \tag{1-1}$$

Chapter 6

11. On page 62, Table 6-1, column 1, Type of Soil, replace "Coarse-grained soils with little or no fines (SP, SM, GP, GW)" with "Coarse-grained soils with little or no fines (SP, SW, GP, GW)."

12. On page 67, line 5, replace (P = 0.7(4)(28,152) = 7,883 kg/m^2) with (P = 0.07(4)(28,152) = 7,883 kg/m^2).

Chapter 6 (*continued*)

13. On page 67, line 12, replace W_c = (1,922 (2) + 13,180) 2*r*/1,000 = 34*r* with
    W_c = (1,922 (0.61) + 13,180) 2*r*/1,000 = 28.7*r*.

14. On page 67, line 18, replace "3 ft (0.914 mm) cover" with "3 ft (0.914 m) cover."

Chapter 7

15. On page 73, the example problem should read

$$k = 0.02 - 0.00012(120 - 90) = 0.0164$$

$$S_{cs} = 0.0164 \times \frac{40{,}000}{(0.3125)^2} \log_e \left(\frac{21}{0.3125}\right) = 28{,}300 \text{ psi}$$

$$Sls = -3{,}000 \text{ psi} \qquad (7\text{-}5)$$

$$S_e = 1{,}000\,[28.3^2 + (-3.0^2) - (-3.0 \times 28.3)]^{1/2} = 29{,}900 \text{ psi}$$

$$29{,}900 < 30{,}000$$

16. On page 85, Table 7-2, for $x = 0.05L$, replace $-0.0715(wL^2/12)$ with $-0.715(wL^2/12)$.

Chapter 9

17. On page 122, last line of paragraph 3 under Elbows and Miter End Cuts should read
    "…the deflection per miter weld shall be limited to 30°. The radius of the elbow shall be…."

18. On page 133, first sentence of paragraph 3 should read
    "Usually the blowoff will be below ground."

Chapter 13

19. On page 194, Calculation of Size, under Eq 13-5 the definition of σ should read
    σ = safe bearing capacity of the soil, lbf/ft² (N/m²)

20. On page 200, Table 13-4, for 24-in. Pipe OD, 250 psi, Tie Bolt Diameter, in., should read "1 $\frac{1}{8}$."

21. On page 200, Table 13-4, line 2 of NOTE, replace "undo" with "undue."

22. On page 203, Table 13-5, for 1 $\frac{3}{8}$-in. dia., replace "*A*" metric with (222.25).

23. On page 203, Table 13-5, for 1 $\frac{5}{8}$-in. dia., replace "*A*" metric with (273.05).

24. On page 205, Figure 13-20, Note 4, replace "The minimum wall thickness..." with
    "The minimum weld thickness…."

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AWWA MANUAL M11

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American Water Works
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Science and Technology

AWWA unites the drinking water community by developing and distributing authoritative scientific and technological knowledge. Through its members, AWWA develops industry standards for products and processes that advance public health and safety. AWWA also provides quality improvement programs for water and wastewater utilities.

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Foreword

This manual was first authorized in 1943. In 1949, committee 8310D appointed one of its members, Russel E. Barnard, to act as editor in chief in charge of collecting and compiling the available data on steel pipe. The first draft of the report was completed by January 1957; the draft was reviewed by the committee and other authorities on steel pipe. The first edition of this manual was issued in 1964 with the title *Steel Pipe-Design and Installation*.

The second edition of this manual was approved in June 1984 and published in 1985 with the title *Steel Pipe—A Guide for Design and Installation*.

The third edition of the manual was approved in June 1988 and published in 1989.

This fourth edition of the manual was approved March 2003. Major revisions to the third edition included in this edition are (1) the manual was metricized and edited throughout; (2) a discussion of Chemistry, Casting and Heat Treatment (Sec. 1.3) and a discussion of stress evaluation in spiral-welded pipe (Sec. 1.12) were added to chapter 1; (3) Table 4-1 was revised to reflect new steel grades and Charpy test requirements for pipe with wall thicknesses greater than ½ in. (12.7 mm); (4) calculations for external fluid pressure (Sec. 4.4) was revised to include consideration of pipe stiffness added by the cement–mortar coating and lining; (5) in Table 6-1, values of E' used for calculation of pipe deflection were revised to reflect increasing soil stiffness with increasing depth of cover; (6) in chapter 7, the discussion of ring girder design was revised, and a design example was added; (7) chapter 9, Fittings and Appurtenances, was revised to reflect the provisions of AWWA C208-96; (8) a new section on installation of flanged joints was added to chapter 12; and (9) thrust-restraint design calculations in chapter 13 were revised.

This manual provides a review of experience and design theory regarding steel pipe used for conveying water, with appropriate references cited. Application of the principles and procedures discussed in this manual must be based on responsible judgment.

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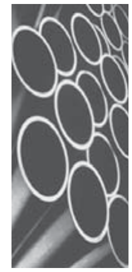


Chapter 1

History, Uses, and Physical Characteristics of Steel Pipe

HISTORY

Steel pipe has been used for water lines in the United States since the early 1850s (Elliot 1922). The pipe was first manufactured by rolling steel sheets or plates into shape and riveting the seams. This method of fabrication continued with improvements into the 1930s. Pipe wall thicknesses could be readily varied to fit the different pressure heads of a pipeline profile.

Because of the relatively low tensile strength of the early steels and the low efficiency of cold-riveted seams and riveted or drive stovepipe joints, engineers initially set a safe design stress at 10,000 psi (68.95 MPa). As riveted-pipe fabrication methods improved and higher strength steels were developed, design stresses progressed with a 4-to-l safety factor of tensile strength, increasing from 10,000 (68.95) to 12,500 (86.18), to 13,750 (94.8), and finally to 15,000 psi (103.42). Design stresses were adjusted as necessary to account for the efficiency of the riveted seam. The pipe was produced in diameters ranging from 4 in. (100 mm) through 144 in. (3,600 mm) and in thickness from 16 gauge to 1.5 in. (38 mm). Fabrication methods consisted of single-, double-, triple-, and quadruple-riveted seams, varying in efficiency from 45 percent to 90 percent, depending on the design.

Lock-Bar pipe, introduced in 1905, had nearly supplanted riveted pipe by 1930. Fabrication involved planing 30-ft (9.1-m) long plates to a width approximately equal to half the intended circumference, upsetting the longitudinal edges, and rolling the plates into 30-ft (9.1-m) long half-circle troughs. H-shaped bars of special configuration were applied to the mating edges of two 30-ft (9.1-m) troughs and clamped into position to form a full-circle pipe section.

According to the general procedure of the times, a 55,000-psi (379.2 MPa) tensile-strength steel was used. With a 4-to-1 safety factor, this resulted in a 13,750-psi (94.8 MPa) design stress. Lock-Bar pipe had notable advantages over riveted pipe: it had only one or two straight seams and no round seams. The straight seams were considered 100-percent efficient as compared to the 45-percent to 70-percent efficiency for riveted seams. Manufactured in sizes from 20 in. (500 mm) through 74 in. (1,850 mm), from plate ranging in thickness from 3⁄16 in. (4.8 mm) to ½ in. (12.7 mm), Lock-Bar played an increasingly greater role in the market until the advent of automatic electric welding in the mid 1920s.

By the early 1930s, both the riveting and Lock-Bar methods gradually were replaced by welding. Pipe produced using automatic electric-fusion welding was advantageous because fewer pieces were used, fewer operations were performed, and because of faster production, smaller seam protrusion, and 100-percent welded-seam efficiency. The fabricators of fusion-welded pipe followed similar initial production sequences as for Lock-Bar. Through the 1930s and into the 1940s, 30-ft (9.1-m) plates were used. By the 1950s, some firms had obtained 40-ft (12.2-m) rolls, and a few formed 40-ft (12.2-m) lengths in presses.

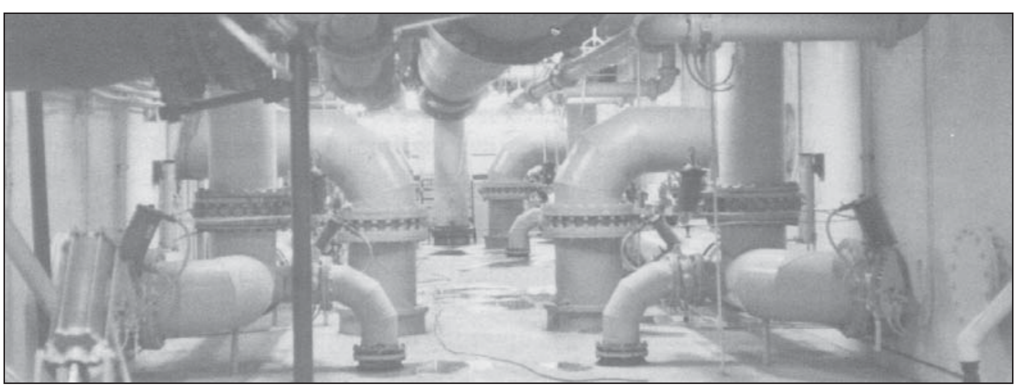
In the 1930s, a new approach was used to design stresses. Prior to that time, it had been common practice to work with a safety factor of 4-to-1 based on the tensile strength. As welded pipe became predominant, using 50 percent of the material yield stress became widely accepted.

Helically formed and welded pipe was developed in the early 1930s and was used extensively in diameters from 4 in. (100 mm) through 36 in. (875 mm). Welding was performed using the electric fusion method. After World War II, German machines were imported, and subsequently, domestic ones were developed that could spirally form and weld through diameters of 144 in. (3,600 mm).

USES

Steel water pipe meeting the requirements of appropriate AWWA standards has been found satisfactory for many applications, some of which follow:

Aqueducts	Treatment-plant piping (Figure 1-1)
Supply lines	Self-supporting spans
Transmission mains	Force mains
Distribution mains	Circulating-water lines
Penstocks	Underwater crossings, intakes, and outfalls



The installation of pipe in this plant was simplified using the specially designed fittings and lightweight pipe.

Figure 1-1 Steel pipe in filtration plant gallery