Designation: A 714 – 99

Standard Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe[1]

This standard is issued under the fixed designation A 714; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers seamless and welded high-strength low-alloy steel pipe NPS ½ to NPS 26, inclusive. Pipe having other dimensions may be furnished provided such pipe complies with all other requirements of this specification. This material is intended for pressure piping service, and other general purposes, where savings in weight or added durability are important.

NOTE 1—The dimensionless designator NPS (nominal pipe size) has been substituted in this standard for such traditional terms as "nominal diameter," "size," and "nominal size."

NOTE 2—A comprehensive listing of standardized pipe dimensions is contained in ANSI Standard B36.10.

1.2 *Class*—These high-strength low-alloy steels have enhanced resistance to general atmospheric corrosion by weathering as commonly encountered in rural, urban, marine, and industrial environments. They are supplied in two classes: Class 2, having corrosion resistance equivalent to that of carbon steel with copper (0.20 minimum Cu); and Class 4, having corrosion resistance substantially better than that of Class 2 (Note 3). Class 4 steels when properly exposed to the atmosphere can be used bare (unpainted) for many applications.

NOTE 3—For methods of estimating the atmospheric corrosion resistance of low alloy steels see Guide G 101 or actual data.

1.3 *Type*—Pipe may be furnished in the following types of manufacturing processes:

Type F—Furnace-butt welded, continuous welded,
Type E—Electric-resistance welded, and
Type S—Seamless.

1.3.1 Pipe ordered under this specification is suitable for welding.

1.3.2 Type E pipe may be furnished either nonexpanded or cold-expanded at the option of the manufacturer.

1.3.3 Types F, E, and S pipe are commonly furnished in nonheat-treated condition. Type S pipe may be furnished in normalized (or other) heat-treated condition, when so specified.

1.3.4 Types F, E, and S pipe in single random lengths may be furnished with hot-dipped galvanized coating of zinc, subject to inquiry to the producer.

1.3.5 Couplings, when furnished, shall be of the same class, heat-treated condition, and grade of material as the pipe ordered.

1.4 *Grade*—This specification designates eight grades of steel composition as listed in Table 1 and corresponding tensile requirements for the grades as listed in Table 2.

1.4.1 For Class 2 pipe, Grade I, II, or III shall be specified, and copper-bearing steel is required as specified in Table 1.

1.4.2 For Class 4 pipe, Grade IV, V, VI, VII, or VIII shall be specified. Alternatively, for Class 4, Type S, and Type E pipe, a steel composition corresponding to a grade listed in Table 1 of Specification A 588/A 588M may be specified, subject to negotiation.

1.5 When Class 4 pipe is joined by welding or is used in welded construction, the user is cautioned that the selection of welding procedure and resultant composition of fused metal should be suitable for Class 4 material and the intended service.

1.6 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

A 53 Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless[2]

A 90 Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles[3]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[4]

A 588/A 588M Specification for High Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4 in. (100 mm) Thick[5]

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment[6]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[4]

[1] This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.09 on Carbon Steel Tubular Products.

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[2] *Annual Book of ASTM Standards*, Vol 01.01.
[3] *Annual Book of ASTM Standards*, Vol 01.06.
[4] *Annual Book of ASTM Standards*, Vol 01.03.
[5] *Annual Book of ASTM Standards*, Vol 01.04.
[6] *Annual Book of ASTM Standards*, Vol 01.05.

TABLE 1 Chemical Requirements

Element	Composition, %							
	Grade I		Grade II		Grade III		Grade IV	
	Heat	Product	Heat	Product	Heat	Product	Heat	Product
Carbon, max	0.22	0.26	0.22	0.26	0.23	0.27	0.10	0.13
Manganese	1.25 max	1.30 max	0.85 to 1.25	1.30 max	1.35 max	1.40 max	0.60 max	0.65 max
Phosphorus	...	...	0.04 max	0.05 max	0.04 max	0.05 max	0.03 to 0.08	[A]
Sulfur, max	0.05	0.063	0.05	0.063	0.05	0.06	0.05	0.06
Silicon	...	...	0.30 max	0.33 max	0.30 max	0.35 max	...	...
Copper	0.20 min	0.18 min	0.20 min	0.18 min	0.20 min	0.18 min	0.25 to 0.45	0.22 to 0.48
Vanadium	...	...	0.02 min	0.01 min	0.02[B] min	0.01 min	...	...
Nickel	...	...	...	...	...	...	0.20 to 0.50	0.17 to 0.53
Chromium	...	...	...	...	...	...	0.80 to 1.20	0.74 to 1.26
Molybdenum	...	...	...	...	...	...	...	...

Element	Composition, %							
	Grade V		Grade VI		Grade VII		Grade VIII	
	Heat	Product	Heat	Product	Heat	Product	Heat	Product
Carbon, max	0.16	0.20	0.15	0.18	0.12	0.15	0.19	0.23
Manganese	0.40 to 1.01	0.35 to 1.06	0.50 to 1.00	0.45 to 1.05	0.20 to 0.50	0.17 to 0.53	0.80 to 1.25	0.74 to 1.31
Phosphorus	0.035 max	0.045 max	0.035 max	0.045 max	0.07 to 0.15	[A]	0.04 max	0.05 max
Sulfur, max	0.040	0.050	0.045	0.055	0.05	0.06	0.05	0.06
Silicon	...	...	...	...	0.25 to 0.75	0.20 to 0.80	0.30 to 0.65	0.25 to 0.70
Copper	0.80 min	0.75 to 1.25	0.30 to 1.00	0.27 to 1.03	0.25 to 0.55	0.22 to 0.58	0.25 to 0.40	0.22 to 0.43
Vanadium	...	...	...	...	...	...	0.02 to 0.10	0.01 to 0.11
Nickel	1.65 min	1.60 to 2.24	0.40 to 1.10	0.35 to 1.15	0.65 max	0.68 max	0.40 max	0.43 max
Chromium	...	...	0.30 max	0.33 max	0.30 to 1.25	0.24 to 1.31	0.40 to 0.65	0.36 to 0.69
Molybdenum	...	...	0.10 to 0.20	0.09 to 0.21	...	...	...	...

[A] Because of the degree to which phosphorus segregates, product analysis for this element is not technologically appropriate for rephosphorized steels unless misapplication is clearly indicated.
[B] For Grade III, columbium may be used in conformance with the following limits: 0.005 % min (heat) and 0.004 % min (product).

TABLE 2 Tensile Requirements

	Class 2 Pipe			Class 4 Pipe					
	Grade I	Grade II	Grade III	Grade IV	Grade V, Type F	Grade V, Type E and S	Grade VI, Type E and S	Grade VII,[A] Type E and S	Grade VIII, Type E and S
Tensile strength, min, psi (MPa)	70 000 (485)	70 000 (485)	65 000 (450)	58 000 (400)	55 000 (380)	65 000 (450)	65 000 (450)	65 000 (450)	70 000 (485)
Yield strength, min, psi (MPa)	50 000 (345)	50 000 (345)	50 000 (345)	36 000 (250)	40 000 (275)	46 000 (315)	46 000 (315)	45 000 (310)	50 000 (345)
Elongation in 2 in. (50.8 mm) min, %	22	22	20	[B,C]	[B,C]	[B,C]	[B,C]	22	21
Elongation in 8 in. (203.2 mm) min, %	19	18	18	. . .	. . .	. . .	. . .	. . .	. . .

[A] Not available in wall thicknesses over ½ in.
[B] The minimum elongation in 2 in. (50.8 mm) shall be determined by the following equation:

$$e = 625\ 000(A^{0.2}/U^{0.9})$$

where:
e = *minimum elongation in 2 in. (50.8 mm), rounded to nearest 0.5 %,*
A = *cross-sectional area of the tension test specimen in square inches, based on specified outside diameter or nominal specimen width and specified wall thickness rounded to the nearest 0.01 in.*^{2} *If the area thus calculated is greater than 0.75 in.*^{2}*, then the value of 0.75 in.*^{2} *shall be used, and*
U = *specified tensile strength, psi.*
[C] See Table X1.1 for minimum elongation values for various size tension specimens and grades.

B 6 Specification for Zinc (Slab Zinc)[7]

G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low Alloy Steels[8]

[7] *Annual Book of ASTM Standards*, Vol 02.04.

[8] *Annual Book of ASTM Standards*, Vol 03.02.

2.2 *ANSI Standard:*
B36.10 Welded and Seamless Wrought Steel Pipe[9]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*
3.1.1 *defect*, *n*—any imperfection of sufficient size or magnitude to be cause for rejection.
3.1.2 *imperfection*, *n*—any discontinuity or irregularity found in the pipe.

4. Ordering Information

4.1 Orders for material under this specification should include the following, as required, to describe the desired material adequately:
4.1.1 Quantity (feet, or metres, or number of lengths),
4.1.2 Name of material (steel pipe),
4.1.3 Class of pipe (Class 2 or Class 4, see 1.2),
4.1.4 Method of manufacture or Type of pipe (Types F, E, or S, see 1.3),
4.1.5 Grade (see 1.4),
4.1.6 Heat treatment, when required (see 1.3.3),
4.1.7 Surface finish (bare, oiled, coated, or galvanized),
4.1.8 Size (either NPS and weight class or schedule number, or both; or outside diameter and nominal wall thickness),
4.1.9 Length (specific or random, see Section 14),
4.1.10 End finish (plain or threaded, see Section 15),
4.1.11 Skelp for tension tests, if permitted (see 11.2),
4.1.12 Couplings, if threaded; no couplings, if not desired; couplings power-tight, if so desired,
4.1.13 Specification number,
4.1.14 End use of material, and
4.1.15 Special requirements.

5. Materials and Manufacture

5.1 The steel shall be made by one or more of the following processes: open-hearth, basic-oxygen, or electric-furnace.
5.2 Steel may be cast in ingots or may be strand cast. When steels of different grades are sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by any established procedure that positively separates the grades.
5.3 The pipe shall be made by the seamless, furnace-buttwelded (continuous-welded), or electric resistance-welded process.

6. Chemical Composition

6.1 When subjected to the heat and product analysis, respectively, the steel shall conform to the requirements prescribed in Table 1. Chemical analysis shall be in accordance with Test Methods, Practices, and Terminology A 751.
6.2 For Grade I, the choice and use of alloying elements, combined with carbon, manganese, sulfur, and copper within the limits prescribed in Table 1 to give the mechanical properties prescribed in Table 2, shall be made by the manufacturer and included and reported in the heat analysis for information purposes only to identify the type of steel applied. For Class 4 material, the atmospheric corrosion–resistance index, calculated on the basis of the chemical composition of the steel as described in Guide G 101, shall be 6.0 or higher.

NOTE 4—The user is cautioned that the Guide G 101 predictive equation for calculation of an atmospheric corrosion–resistance index has been verified only for the composition limits stated in that guide. It is not applicable, for example, for Specification A 714 Grade V because the copper and nickel contents of this grade are greater than the limits specified in Guide G 101.

6.3 *Heat Analysis*—An analysis of each heat of open-hearth, basic-oxygen or electric-furnace steel shall be made from a test ingot taken during the pouring of the heat. The chemical composition thus determined shall conform to the requirements specified in Table 1 for heat analysis.
6.4 *Product Analysis*:
6.4.1 An analysis may be made by the purchaser from finished pipe manufactured in accordance with this specification, or an analysis may be made from flat-rolled stock from which the welded pipe is manufactured. When product analyses are made, two sample lengths from each lot of 500 lengths or fraction thereof shall be selected. The chemical composition thus determined shall conform to the requirements specified in Table 1 for product analysis.
6.4.2 In the event that the chemical composition of one of the sample lengths does not conform to the requirements shown in Table 1 for product analysis, an analysis shall be made on two additional lengths selected from the same lot, each of which shall conform to the requirements specified in Table 1 for product analysis, or the lot is subject to rejection.

7. Tensile Requirements

7.1 The material shall conform to the requirements as to tensile properties prescribed in Table 2 for the grade of Class 2 or Class 4 pipe specified.
7.2 The yield strength corresponding to a permanent offset of 0.2 % of the gage length of the specimen or to a total extension of 0.5 % of the gage length under load shall be determined.
7.3 The test specimen taken across the weld of welded pipe shall show a tensile strength not less than the minimum tensile strength specified for the grade of pipe ordered. This test will not be required for pipe under NPS 8.
7.4 Transverse tension test specimens for electric-welded pipe NPS 8 and larger shall be taken opposite the weld. All transverse test specimens shall be approximately 1½in. (38.1 mm) wide in the gage length, and shall represent the full wall thickness of the pipe from which the specimen was cut.

8. Bending Requirements

8.1 For pipe NPS 2 and under, a sufficient length of pipe shall withstand being bent cold through 90° around a cylindrical mandrel, the diameter of which is twelve times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld. Double-extra-strong pipe need not be subjected to the bend test.

[9] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

9. Flattening Test

9.1 The flattening test shall be made on pipe over NPS 2 with wall thicknesses extra strong and lighter.

9.2 *Seamless Pipe*:

9.2.1 For seamless pipe a section not less than 2 ½ in. (63.5 mm) in length shall be flattened cold between parallel plates in two steps. During the first step, which is a test for ductility, no cracks or breaks on the inside or outside or end surfaces, except as provided for in 9.7, shall occur until the distance between the plates is less than the value of H calculated as follows:

$$H = \frac{(1 + e)t}{(e + t/D)}$$

where:

H = distance between flattening plates, in. or mm,
e = deformation per unit length (constant for a given grade of steel, 0.07),
t = specified wall thickness, in. or mm, and
D = specified outside diameter, in. or mm.

9.2.2 During the second step, which is a test for soundness, the flattening shall be continued until the specimen breaks or the opposite walls of the pipe meet. Evidence of laminated or unsound material that is revealed during the entire flattening test shall be cause for rejection.

9.3 *Electric-Resistance-Welded Pipe*— A specimen at least 4 in. (101.6 mm) in length shall be flattened cold between parallel plates in three steps with the weld located either 0° or 90° from the line of direction of force as required in 9.3.1. During the first step, which is a test for ductility of the weld, no cracks or breaks on the inside or outside surfaces shall occur until the distance between the plates is less than two thirds of the original outside diameter of the pipe. As a second step, the flattening shall be continued. During the second step, which is a test for ductility exclusive of the weld, no cracks or breaks on the inside or outside surfaces shall occur until the distance between the plates is less than one third of the original outside diameter of the pipe but is not less than five times the wall thickness of the pipe. During the third step, which is a test for soundness, the flattening shall be continued until the specimen breaks or the opposite walls of the pipe meet. Evidence of laminated or unsound material or of incomplete weld that is revealed during the entire flattening test shall be cause for rejection.

9.3.1 For pipe produced in single lengths, the flattening test specified in 9.3 shall be made on both crop ends cut from each length of pipe. The tests from each end shall be made alternately with the weld at 0° and at 90° from the line of direction of force. For pipe produced in multiple lengths, the flattening test shall be made on crop ends representing the front and back of each coil with the weld at 90° from the line of direction of force, and on two intermediate rings representing each coil with the weld 0° from the line of direction of force.

9.4 *Butt-Welded Pipe*—For butt-welded pipe, a specimen not less than 4 in. (101.6 mm) in length shall be flattened cold between parallel plates in three steps. The weld shall be located 90° from the line of direction of force. During the first step, which is a test for quality of the weld, no cracks or breaks on the inside, outside, or end surfaces shall occur until the distance between the plates is less than 0.85 times the original outside diameter for butt-welded pipe. As a second step, the flattening shall be continued. During the second step, which is a test for ductility exclusive of the weld, no cracks or breaks on the inside, outside, or end surfaces, except as provided for in 9.7, shall occur until the distance between the plates is less than 60 % of the original outside diameter for butt-welded pipe. During the third step, which is a test for soundness, the flattening shall be continued until the specimen breaks or the opposite walls of the pipe meet. Evidence of laminated or unsound material or of incomplete weld that is revealed during the entire flattening test shall be cause for rejection.

9.5 Surface imperfections in the test specimen before flattening, but revealed during the first step of the flattening test, shall be judged in accordance with the finish requirements in Section 17.

9.6 Superficial ruptures as a result of surface imperfections shall not be cause for rejection.

9.7 When low D-to-t ratio tubulars are tested, because the strain imposed due to geometry is unreasonably high on the inside surface at the 6 and 12 o'clock locations, cracks at these locations shall not be cause for rejection if the D-to-t ratio is less than ten.

10. Hydrostatic Test

10.1 Each length of Type F, E, or S pipe shall be tested at the mill to the hydrostatic pressures prescribed for butt weld or Grade B pipe as specified in Table X2 (for plain end pipe) or Table X3 (for threaded-and-coupled pipe) of Specification A 53. The hydrostatic test may be applied, at the discretion of the manufacturer, on pipe with plain ends, with threads only, or with threads and couplings and may be applied in single lengths or multiple lengths.

10.2 The maximum specified hydrostatic test pressure shall not exceed 2500 psi (17.2 MPa) for NPS 3 and under, or 2800 psi (19.3 MPa) for all over NPS 3. The hydrostatic pressure shall be maintained for not less than 5 s for all sizes of seamless and welded pipe.

11. Test Methods

11.1 The test specimens and the tests required by this specification shall conform to those described in the latest issue of Test Methods and Definitions A 370.

11.2 The longitudinal tension test specimen shall be taken from the end of the pipe or, by agreement between the manufacturer and the purchaser, may be taken from the skelp, at a point approximately 90° from the weld, and shall not be flattened between gage marks. The sides of each specimen shall be parallel between gage marks. If desired, the tension test may be made on the full section of pipe. When impracticable to pull a test specimen in full thickness, the standard 2-in. (50.8-mm) gage length tension test specimen shown in Fig. 6 of Test Methods and Definitions A 370 may be used.

11.3 Transverse weld test specimens from electric-welded pipe shall be taken with the weld at the center of the specimen. All transverse test specimens shall be approximately 1½ in. (38.1 mm) wide in the gage length and shall represent the full wall thickness of the pipe from which the specimen was cut.