Designation: A 523 – 96 (Reapproved 2005)

Standard Specification for Plain End Seamless and Electric-Resistance-Welded Steel Pipe for High-Pressure Pipe-Type Cable Circuits[1]

This standard is issued under the fixed designation A 523; 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 electric-resistance-welded steel pipe used as conduit for the installation of high-pressure pipe-type electrical cables in NPS 4 to NPS 12, inclusive, with nominal (average) wall thicknesses 0.219 to 0.562 in., depending on size. Pipe having other dimensions (Note 2) may be furnished, provided such pipe complies with all other requirements of this specification.

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 B36.10.

1.2 Pipe ordered under this specification is suitable for welding and for forming operations involving flaring, belling, and bending.

1.3 Pipe for this purpose shall be furnished in Grade A or Grade B as specified in the purchase order. Grade A is more suitable for forming operations involving bending, flaring, or belling and this grade is normally preferred. This provision is not intended to prohibit the cold bending, flaring, or belling of Grade B pipe.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 The following hazard caveat applies to the test method portion, Section 20, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

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

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

E 59 Practice for Sampling Steel and Iron for Determination of Chemical Composition [3]

2.2 *ANSI Standard:*

B36.10 Welded and Seamless Wrought Steel Pipe[4]

3. Ordering Information

3.1 Orders for material under this specification should include the following, as required, to describe the desired material adequately:

3.1.1 Quantity (feet or number of lengths),

3.1.2 Name of material (steel pipe),

3.1.3 Method of manufacture (seamless or electric-resistance-welded),

3.1.4 Grade (Table 1),

3.1.5 Size (outside diameter and nominal wall thickness or weight per foot),

3.1.6 Length when other than specified in Section 13,

3.1.7 End finish (Section 16),

3.1.8 Skelp for tension tests, if permitted 20.2,

3.1.9 When mill applied coating is required (Section 10), and

3.1.10 ASTM specification number.

4. Process

4.1 The steel shall be made by one or more of the following processes: open-hearth, basic-oxygen, or electric-furnace.

4.2 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

[1] This specification is under the jurisdiction of ASTM Committee A01 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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This specification was initiated by the IEEE Insulated Conductors Committee in recognition of the need for a specification embodying the special requirements of pipe for high-voltage electrical circuits. It was prepared for acceptance as an ASTM specification by a task group of Subcommittee A01.09 of ASTM Committee A01.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Withdrawn.

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

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TABLE 1 Tensile Requirements

	Grade A	Grade B
Tensile strength, min, ksi (MPa)	48 (330)	60 (415)
Yield strength, min, ksi (MPa)	30 (205)	35 (240)
Elongation in 2 in. or 50 mm, %:		
Basic minimum elongation for walls 5/16 in. (7.94 mm) and over in thickness, longitudinal strip tests, and for small sizes tested in full section.	35	30
When standard round 2-in. or 50-mm gage length test specimen is used	28	22
For longitudinal strip tests, the width of the gage section shall be 1½ in. (38.1 mm) and a deduction for each 1/32 in. (0.79 mm) decrease in wall thickness below 5/16 in. (7.94 mm) from the basic minimum elongation of the following percentage points	1.75[A]	1.50[A]

[A] The following table[B] gives the minimum computed values:

Wall Thickness		Elongation in 2 in. or 50 mm, min, %	
in.	mm	Grade A	Grade B
5/16 (0.312)	7.94	35.0	30.0
9/32 (0.281)	7.14	33.2	28.5
¼ (0.250)	6.35	31.5	27.0
7/32 (0.219)	5.56	29.8	25.5
3/16 (0.188)	4.76	28.0	24.0
5/32 (0.156)	3.97	26.2	22.5
⅛ (0.125)	3.18	24.5	21.0
3/32 (0.094)	2.38	22.8	19.5
1/16 (0.062)	1.59	21.0	18.0

[B] This table gives the computed minimum elongation values for each 1/32 in. (0.79 mm) decrease in wall thickness. Where the wall thickness lies between two values shown above, the minimum elongation value shall be determined by the following equation:

Grade	Equation
A	$E = 56t + 17.50$
B	$E = 48t + 15.00$

where:
E = elongation in 2 in. or 50 mm, %, and
t = actual thickness of specimen, in.

producer shall remove the transition material by any established procedure that positively separates the grades.

5. Chemical Composition

5.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 2 and the chemical analysis shall be in accordance with Test Methods, Practices, and Terminology A 751.

TABLE 2 Chemical Requirements

	Composition, %							
	Carbon, max		Manganese, max		Phosphorus, max		Sulfur, max	
	Heat	Product	Heat	Product	Heat	Product	Heat	Product
Grade A								
Seamless	0.22	0.25	0.90	0.95	0.035	0.045	0.050	0.060
E.R.W.[A]	0.21	0.25	0.90	0.95	0.035	0.045	0.050	0.060
Grade B								
Seamless	0.27	0.30	1.15	1.20	0.035	0.045	0.050	0.060
E.R.W.[A]	0.26	0.30	1.15	1.20	0.035	0.045	0.050	0.060

[A] Electric-Resistance-Welded pipe.

6. Heat Analysis

6.1 When specified in the purchase order, the manufacturer shall report the heat analysis of each heat of steel used in the manufacture of pipe to this specification. The analysis shall conform to the requirements specified in Section 5 for the grade of pipe ordered.

7. Product Analysis

7.1 When specified in the purchase order, a product analysis report shall be furnished by the manufacturer on two pipes from each lot of 400 lengths, or fraction thereof, of 4½-in. outside diameter and 5 9/16-in. outside diameter sizes and from each lot of 200 lengths, or fraction thereof, of each size 6⅝-in. outside diameter through 12¾-in. outside diameter pipe. Samples for chemical analysis, except for spectrographic analysis, shall be taken in accordance with Practice E 59. The chemical composition thus determined shall conform to the requirements specified in Section 5.

7.2 *Product Analysis Retests*—If both lengths of pipe representing the lot fail the specified product analysis, the lot shall be rejected, or at the option of the manufacturer, all of the remaining lengths of the lot shall be tested individually for conformance to the specified requirements. If only one of the lengths of pipe representing the lot fails the specified check analysis, the lot shall be rejected or, at the option of the manufacturer, two retest analyses shall be made on two additional lengths selected from the same lot. If both of these retest analyses conform to the specified requirements, the lot shall be accepted except for the length which failed on the initial analysis. If one or both of the retest analyses fail the specified requirements, the entire lot shall be rejected, or, at the option of the manufacturer, each of the remaining lengths shall be tested individually. Only analysis of the rejecting element or elements is necessary in checking the remaining lengths.

8. Tensile Requirements

8.1 The material shall conform to the requirements as to tensile properties prescribed in Table 1.

8.2 The yield point shall be determined by the drop of the beam or by the halt in the gauge of the testing machine, by the use of dividers, or by other approved methods. When a definite yield point is not exhibited, the yield strength corresponding to a permanent offset of 0.2 % of the gauge length of the specimen or to a total extension of 0.5 % of the gauge length of the specimen under load shall be determined.

8.3 The test specimen taken across the weld 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.

9. Flattening Test Requirements

9.1 *Seamless Pipe*—For seamless pipe, a section not less than 2½ 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 9.5, shall occur until the distance between the plates is less than the value of H calculated by the following equation:

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

where:

H = distance between flattening plates, in. (mm),
e = deformation per unit length (constant for a given grade of steel, 0.09 for Grade A and 0.07 for Grade B),
t = specified wall thickness, in. (mm), and
D = specified outside diameter, in. (mm).

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.

9.2 *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 9.2.1 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 test for ductility exclusive of the weld, no cracks or breaks on the inside or outside surfaces, except as provided for in 9.5, 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.

9.2.1 For pipe produced in single lengths, the flattening test specified in 9.2 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.

9.3 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 15.

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

9.5 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. Coatings

10.1 Unless otherwise specified, the pipe shall not be given a mill coating of paint, oil, or any other material either inside or outside.

11. Dimensions and Weight

11.1 Dimensions and weight of pipe included in this specification are listed in Table 3.

12. Dimensions, Weight, and Permissible Variations

12.1 *Weight*—The weight of the pipe as specified in Table 3 shall not vary by more than the following amounts:

Extra-strong and lighter wall thickness	±5 %
Minimum permissible length	±10 %

12.2 *Diameter*—The outside diameter shall not vary more than ±1 % from the diameter specified. Pipe NPS 10 and smaller shall not be more than 1/64 in. (0.4 mm) smaller and NPS 12 pipe shall not be more than 1/32-in. (0.8-mm) smaller than the tabulated outside diameter for a distance of 4 in. (101.6 mm) from the end. The pipe shall permit passage over the ends for a distance of 4 in. of a ring gauge having a bore 1/16-in. larger than the tabulated diameter of NPS 10 and smaller pipe, and a bore 3/32 in. (2.4 mm) larger for NPS 12 pipe.

TABLE 3 Dimensions, Weight, and Test Pressures

NPS Designator	Outside Diameter, in.	Wall Thickness		Nominal Weight		Test Pressure			
						Grade A		Grade B	
		in.	mm	lb/ft	kg/m	psi	MPa	psi	MPa
4	4½	0.237	6.02	10.79	16.1	1900	13.10	2200	15.17
		0.250	6.35	11.35	16.9	2000	13.79	2300	15.86
		0.281	7.14	12.66	18.8	2200	15.17	2500	17.24
		0.312	7.92	13.96	20.7	2500	17.24	2500	17.24
5	5 9/16	0.219	5.56	12.50	18.6	1400	9.65	1700	11.72
		0.258	6.55	14.62	21.8	1700	11.72	1900	13.10
		0.281	7.14	15.85	23.6	1800	12.41	2100	14.48
		0.312	7.92	17.50	26.0	2000	13.79	2400	16.55
		0.344	8.74	19.17	28.6	2200	15.17	2500	17.24
6	6 5/8	0.250	6.35	17.02	25.3	1400	9.65	1600	11.03
		0.280	7.11	18.97	28.2	1500	10.34	1800	12.41
		0.312	7.92	21.04	31.3	1700	11.72	2000	13.79
		0.344	8.74	23.08	34.3	1900	13.10	2200	15.17
		0.375	9.52	25.03	37.2	2000	13.79	2400	16.55
		0.500[A]	12.70[A]	32.71[A]	48.7[A]	2500	17.24	2500	17.24
8	8 5/8	0.250	6.35	22.36	33.3	1000	6.89	1200	8.27
		0.277	7.04	24.70	36.8	1200	8.27	1300	8.96
		0.312	7.92	27.70	41.2	1300	8.96	1500	10.34
		0.322	8.18	28.55	42.6	1300	8.96	1600	11.03
		0.344	8.74	30.42	45.3	1400	9.65	1700	11.72
		0.375	9.52	33.04	49.2	1600	11.03	1800	12.41
		0.438	11.13	38.30	57.0	1800	12.41	2100	14.48
		0.500	12.70	43.39	64.6	2100	14.48	2400	16.55
10	10¾	0.250	6.35	28.04	41.7	850	5.86	1000	6.89
		0.279	7.09	31.20	46.4	1000	6.89	1200	8.27
		0.307	7.80	34.24	50.9	1000	6.89	1200	8.27
		0.344	8.74	38.23	56.9	1100	7.58	1300	8.96
		0.365	9.27	40.48	60.2	1200	8.27	1400	9.65
		0.438	11.13	48.24	71.6	1500	10.34	1700	11.72
		0.500	12.70	54.74	8.15	1700	11.72	2000	13.79
		0.562[A]	14.27[A]	61.15[A]	91.0[A]	1900	13.10	2200	15.17
12	12¾	0.250	6.35	33.38	49.7	700	4.83	800	5.52
		0.281	7.14	37.42	55.7	800	5.52	950	6.55
		0.312	7.92	41.45	61.7	900	6.21	1000	6.89
		0.330	8.38	43.77	65.1	1000	6.89	1200	8.27
		0.344	8.74	45.58	67.8	1000	6.89	1200	8.27
		0.375	9.52	49.56	73.7	1100	7.58	1200	8.27
		0.438	11.13	57.59	86.7	1200	8.27	1400	9.65
		0.500	12.70	65.42	97.3	1400	9.65	1600	11.03
		0.562[A]	14.27[A]	73.15[A]	108.8[A]	1600	11.03	1900	13.10

[A] Designates weights heavier than extra-strong.

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12.3 *Thickness*—The minimum wall thickness at any point shall not be more than 12.5 % under, or the maximum thickness more than 15.0 % over, the nominal wall thickness specified.

13. Lengths

13.1 Unless otherwise specified in the purchase order, the finished length of pipe for the entire shipment shall conform to the following:

Minimum permissible length	35 ft 0 in. (10.7 m)
Maximum permissible length	50 ft 0 in. (15.2 m)

14. Jointers

14.1 Jointers shall not be permitted.

15. Workmanship

15.1 The condition of the inside of the pipe is of utmost importance to avoid damage to the cable during installation.

15.2 The pipe bore shall be smooth and free of protruding weld beads, slivers, or any other projections that cannot be readily removed with a power wire brush or by shot, sand, or grit blasting. The internal finish of the longitudinal seam of electric-resistance-welded pipe shall be smooth and free of sharp edges and sharp grooves. The interior of all pipes shall be free of loose scale. Pipe ends shall not be rounded out by hammering.

15.3 The finished pipe shall be reasonably straight and free of laminations and defects. Any imperfection shall be considered a defect when the depth is in excess of 12½ % of the tabulated wall thickness of the pipe.

16. End Finish

16.1 When pipe ends are to be flared for butt-welding with the use of backing rings, the ends shall be beveled to an angle of 30 +5, −0° measured from a line drawn perpendicular to the axis of the pipe, and with a root face of 1/16 ± 1/32 in. (1.6 ± 0.8 mm). The pipe ends shall have burrs removed from both the inside and outside edges.

16.2 When pipe ends are to be prepared for bell and spigot jointing, the ends shall be cut square with the axis of the pipe. The inside and outside edges shall be smooth and free of burrs.

17. Repair of Defects

17.1 Repair of defects in seamless pipe and in the base metal of welded pipe shall be permissible except where:

17.1.1 More than one repair is required in any length equivalent to ten times the tabulated outside diameter of the pipe,

17.1.2 Where the depth exceeds 33⅓ % of the tabulated wall thickness, and

17.1.3 Where the length of the defect, in which the depth exceeds 12½ % of the wall thickness, is greater than 25 % of the tabulated outside diameter of the pipe.

17.2 All repairs shall be made by removing the defect completely, thoroughly cleaning the cavity, and then welding. Each length of repaired pipe shall be tested hydrostatically in accordance with Section 19.

17.3 No repair of the longitudinal weld is permitted.

18. Number of Tests and Retests

18.1 One of each of the tests specified in Sections 8 and 9, except 9.2, shall be made on one length of pipe from each lot of 500 lengths, or fraction thereof, of each size. A length is defined as the length as ordered, except that in the case of orders for cut lengths shorter than single random, the term lot shall apply to the lengths as rolled, prior to cutting to the required short lengths.

18.2 The number of flattening tests required for electric-resistance-welded pipe shall be as given in 9.2.1.

18.3 Each length of pipe shall be subjected to the hydrostatic test specified in Section 19.

18.4 If the results of the mechanical tests of any lot do not conform to the requirements specified in Sections 8 and 9, except 9.2.1, retests may be made on additional pipe of double the original number tested from the same lot, each test conforming to the requirements specified.

18.5 If any section of the pipe fails to comply with the requirements of 9.2 for pipe produced in single lengths, other sections may be cut from the same end of the same length until satisfactory tests are obtained, except that the finished pipe shall not be shorter than 80 % of its length after the initial cropping; otherwise, the length shall be rejected. For pipe produced in multiple lengths, retests may be cut from each end of each individual length in the multiple. Such tests shall be made with the weld alternately 0° and 90° from the line of direction of force.

19. Hydrostatic Test

19.1 Each length of pipe shall be tested at the mill to the hydrostatic pressures prescribed in Table 3. The hydrostatic pressure shall be maintained for not less than 5 s.

20. Test Methods

20.1 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. When impracticable to pull a test specimen in full thickness, the standard 2-in. or 50-mm gauge length tension test specimen shown in Fig. 6 of Test Methods and Definitions A 370 may be used.

20.2 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 gauge marks. The sides of each specimen shall be parallel between gauge marks.

20.3 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 gauge length and shall represent the full wall thickness of the pipe from which the specimen was cut.

20.4 Test specimens for flattening tests shall consist of sections cut from a pipe. Specimens for flattening tests shall be smooth on the ends and free of burrs, except when made on crop ends taken from welded pipe.

20.5 All specimens shall be tested at room temperature.

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21. Inspection

21.1 The inspector representing the purchaser shall have entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be conducted so as not to interfere unnecessarily with the operation of the works.

22. Rejection

22.1 Each length of pipe received from the manufacturer may be inspected by the purchaser and, if it does not meet the requirements of this specification based on the inspection and test method as outlined in this specification, the length may be rejected and the manufacturer shall be notified. Disposition of rejected pipe shall be a matter of agreement between the manufacturer and the purchaser.

22.2 Pipe found in fabrication or in installation to be unsuitable for the intended use, under the scope and requirements of this specification, may be set aside and the manufacturer notified. Such pipe shall be subject to mutual investigation as to the nature and severity of the deficiency and the forming or installation, or both, conditions involved. Disposition shall be a matter for agreement.

23. Product Marking

23.1 Each length of pipe shall be legibly marked by rolling, stamping, or stenciling to show the name or brand of the manufacturer; the kind of pipe, that is, seamless (S) or electric resistance welded (E); grade; outside diameter; weight per foot or wall thickness; and the specification number (see Appendix X1).

23.2 *Bar Coding*—In addition to the requirements in 23.1, bar coding is acceptable as a supplemental identification method. The purchaser may specify in the order a specific bar coding system to be used.

APPENDIX

(Nonmandatory Information)

X1. DEFINITIONS OF TYPES OF PIPE

X1.1 *Type E, Electric-Resistance-Welded Pipe*—Pipe produced in individual lengths or in continuous lengths from coiled skelp and subsequently cut into individual lengths, having a longitudinal butt joint wherein coalescence is produced by the heat obtained from resistance of the pipe to the flow of electric current in a circuit of which the pipe is a part, and by the application of pressure.

X1.2 *Type S, Wrought Steel Seamless Pipe*—A tubular product made without a welded seam. It is manufactured by hot working steel and if necessary, by subsequently cold finishing the hot-worked tubular product to produce the desired shape, dimensions, and properties.

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