



Designation: A523/A523M – 21

# Standard Specification for Plain End Seamless and Electric-Resistance-Welded Steel Pipe for High-Pressure Pipe-Type Cable Circuits<sup>1</sup>

This standard is issued under the fixed designation A523/A523M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This specification covers two types, seamless (S) and electric-resistance-welded (E), of steel pipe used as conduit for the installation of high-pressure pipe-type electrical cables in NPS 4 to NPS 12 [DN 100 to DN 300], inclusive, with nominal (average) wall thicknesses 0.219 to 0.562 in. [5.56 to 14.27 mm], 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 ASME 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 This specification is expressed in both inch-pound units and in SI units; however, unless the purchase order or contract specifies the applicable M specification designation (SI units), the inch-pound units shall apply. The values stated in either inch-pound or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore each system shall be used independently of the other.

<sup>1</sup> 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.

Combining values from the two systems may result in nonconformance with the 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 ASTM Standards:<sup>2</sup>

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A751 Test Methods and Practices for Chemical Analysis of Steel Products

2.2 ASME Standard:

B36.10 Welded and Seamless Wrought Steel Pipe<sup>3</sup>

## 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 [meters] or number of lengths),

3.1.2 Name of material (steel pipe),

3.1.3 Type S or E (seamless or electric-resistance-welded),

3.1.4 Grade (Table 1),

3.1.5 Size (NPS [DN] or diameter and nominal wall thickness or pounds per foot [kg/m]),

<sup>2</sup> 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.

<sup>3</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

\*A Summary of Changes section appears at the end of this standard

**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. [50 mm], %:   |                   |                   |
| Basic minimum elongation for walls 5/16 in. [7.9 mm] and over in thickness, longitudinal strip tests, and for small sizes tested in full section.   | 35                | 30                |
| When standard round 2-in. [50-mm] gage length test specimen is used   | 28                | 22                |
| For longitudinal strip tests, the width of the gage section shall be 1 1/2 in. [40 mm] and a deduction for each 1/32 in. [0.8 mm] decrease in wall thickness below 5/16 in. [7.9 mm] from the basic minimum elongation of the following percentage points | 1.75 <sup>A</sup> | 1.50 <sup>A</sup> |

<sup>A</sup> The following table<sup>B</sup> gives the minimum computed values:

| Wall Thickness |        | Elongation in 2 in. [50 mm], min, % |         |
|----------------|--------|-------------------------------------|---------|
| in.            | [mm]   | Grade A                             | Grade B |
| 5/16 (0.312)   | [7.92] | 35.0                                | 30.0    |
| 9/32 (0.281)   | [7.14] | 33.2                                | 28.5    |
| 1/4 (0.250)    | [6.35] | 31.5                                | 27.0    |
| 7/32 (0.219)   | [5.56] | 29.8                                | 25.5    |
| 3/16 (0.188)   | [4.78] | 28.0                                | 24.0    |
| 5/32 (0.156)   | [3.96] | 26.2                                | 22.5    |
| 1/8 (0.125)    | [3.18] | 24.5                                | 21.0    |
| 3/32 (0.094)   | [2.39] | 22.8                                | 19.5    |
| 1/16 (0.062)   | [1.57] | 21.0                                | 18.0    |

<sup>B</sup> This table gives the computed minimum elongation values for each 1/32 in. [0.8 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     | $E = 56t + 17.50$<br>$[E = 2.2t + 17.5]$ |
| B     | $E = 48t + 15.00$<br>$[E = 1.9t + 15.0]$ |

where:

$E$  = elongation in 2 in. [50 mm], %, and  
 $t$  = actual thickness of specimen, in. [mm].

- 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: basic-oxygen, electric-furnace, or any other currently recognized practice.

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 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 A751.

**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 4 1/2-in. [115 mm] outside diameter and 5 1/16-in. [140 mm] outside diameter sizes and from each lot of 200 lengths, or fraction thereof, of each size 6 5/8-in. [170 mm] outside diameter through 12 3/4-in. [325 mm] outside diameter pipe. Samples for chemical analysis shall be taken in accordance with Test Methods, Practices, and Terminology A751. 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.

**TABLE 2 Chemical Requirements**

| Grade Type          | 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. <sup>A</sup> | 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. <sup>A</sup> | 0.26           | 0.30    | 1.15           | 1.20    | 0.035           | 0.045   | 0.050       | 0.060   |

<sup>A</sup> Electric-Resistance-Welded pipe.

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 [DN 200].

## 9. Flattening Test Requirements

9.1 *Seamless Pipe*—For seamless pipe, a section not less than 2½ in. [65 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:

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

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. [100 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 [DN 250] and smaller shall not be more than ¼ in. [0.4 mm] smaller and NPS 12 [DN 300] pipe shall not be more than ½-in. [0.8-mm] smaller than the tabulated outside diameter for a distance of 4 in. [100 mm] from the end. The pipe shall permit passage over the ends for a distance of 4 in. [100 mm] of a ring gauge having a bore ¼-in. [1.6 mm] larger than the tabulated diameter of NPS 10 [DN 250] and smaller pipe, and a bore ⅜ in. [2.4 mm] larger for NPS 12 [DN 300] pipe.

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.

**TABLE 3 Dimensions, Weight, and Test Pressures**

| NPS<br>[DN] | Outside Di-<br>ameter,<br>in.<br>[mm] | Wall<br>Thickness  |                      | Nominal<br>Weight  |                      | Test Pressure |        |         |        |
|-------------|---------------------------------------|--------------------|----------------------|--------------------|----------------------|---------------|--------|---------|--------|
|             |                                       | in.                | [mm]                 | lb/ft              | [kg/m]               | Grade A       |        | Grade B |        |
|             |                                       |                    |                      |                    |                      | psi           | [MPa]  | psi     | [MPa]  |
| 4 [100]     | 4½<br>[115]                           | 0.237              | [6.02]               | 10.79              | [16.1]               | 1900          | [13.1] | 2200    | [15.2] |
|             |                                       | 0.250              | [6.35]               | 11.35              | [16.9]               | 2000          | [13.8] | 2300    | [15.9] |
|             |                                       | 0.281              | [7.14]               | 12.66              | [18.8]               | 2200          | [15.2] | 2500    | [17.2] |
|             |                                       | 0.312              | [7.92]               | 13.96              | [20.7]               | 2500          | [17.2] | 2500    | [17.2] |
| 5 [125]     | 5⅞<br>[140]                           | 0.219              | [5.56]               | 12.50              | [18.6]               | 1400          | [9.7]  | 1700    | [11.7] |
|             |                                       | 0.258              | [6.55]               | 14.62              | [21.8]               | 1700          | [11.7] | 1900    | [13.1] |
|             |                                       | 0.281              | [7.14]               | 15.85              | [23.6]               | 1800          | [12.4] | 2100    | [14.5] |
|             |                                       | 0.312              | [7.92]               | 17.50              | [26.0]               | 2000          | [13.8] | 2400    | [16.6] |
| 6 [150]     | 6⅝<br>[170]                           | 0.344              | [8.74]               | 19.17              | [28.6]               | 2200          | [15.2] | 2500    | [17.2] |
|             |                                       | 0.250              | [6.35]               | 17.02              | [25.3]               | 1400          | [9.7]  | 1600    | [11.0] |
|             |                                       | 0.280              | [7.11]               | 18.97              | [28.2]               | 1500          | [10.4] | 1800    | [12.4] |
|             |                                       | 0.312              | [7.92]               | 21.04              | [31.3]               | 1700          | [11.7] | 2000    | [13.8] |
| 8 [200]     | 8⅞ [220]                              | 0.344              | [8.74]               | 23.08              | [34.3]               | 1900          | [13.1] | 2200    | [15.2] |
|             |                                       | 0.375              | [9.52]               | 25.03              | [37.2]               | 2000          | [13.8] | 2400    | [16.6] |
|             |                                       | 0.500 <sup>A</sup> | [12.70] <sup>A</sup> | 32.71 <sup>A</sup> | [48.7] <sup>A</sup>  | 2500          | [17.2] | 2500    | [17.2] |
|             |                                       | 0.250              | [6.35]               | 22.36              | [33.3]               | 1000          | [6.9]  | 1200    | [8.3]  |
|             |                                       | 0.277              | [7.04]               | 24.70              | [36.8]               | 1200          | [8.3]  | 1300    | [9.0]  |
|             |                                       | 0.312              | [7.92]               | 27.70              | [41.2]               | 1300          | [9.0]  | 1500    | [10.3] |
|             |                                       | 0.322              | [8.18]               | 28.55              | [42.6]               | 1300          | [9.0]  | 1600    | [11.0] |
|             |                                       | 0.344              | [8.74]               | 30.42              | [45.3]               | 1400          | [9.7]  | 1700    | [11.7] |
|             |                                       | 0.375              | [9.52]               | 33.04              | [49.2]               | 1600          | [11.0] | 1800    | [12.4] |
|             |                                       | 0.438              | [11.13]              | 38.30              | [57.0]               | 1800          | [12.4] | 2100    | [14.5] |
| 10 [250]    | 10¾ [275]                             | 0.500              | [12.70]              | 43.39              | [64.6]               | 2100          | [14.5] | 2400    | [16.6] |
|             |                                       | 0.250              | [6.35]               | 28.04              | [41.7]               | 850           | [5.9]  | 1000    | [6.9]  |
|             |                                       | 0.279              | [7.09]               | 31.20              | [46.4]               | 1000          | [6.9]  | 1200    | [8.3]  |
|             |                                       | 0.307              | [7.80]               | 34.24              | [50.9]               | 1000          | [6.9]  | 1200    | [8.3]  |
|             |                                       | 0.344              | [8.74]               | 38.23              | [56.9]               | 1100          | [7.6]  | 1300    | [9.0]  |
|             |                                       | 0.365              | [9.27]               | 40.48              | [60.2]               | 1200          | [8.3]  | 1400    | [9.7]  |
|             |                                       | 0.438              | [11.13]              | 48.24              | [71.6]               | 1500          | [10.3] | 1700    | [11.7] |
|             |                                       | 0.500              | [12.70]              | 54.74              | [81.5]               | 1700          | [11.7] | 2000    | [13.8] |
|             |                                       | 0.562 <sup>A</sup> | [14.27] <sup>A</sup> | 61.15 <sup>A</sup> | [91.0] <sup>A</sup>  | 1900          | [13.1] | 2200    | [15.2] |
|             |                                       | 0.250              | [6.35]               | 33.38              | [49.7]               | 700           | [4.8]  | 800     | [5.5]  |
| 12 [300]    | 12¾ [325]                             | 0.281              | [7.14]               | 37.42              | [55.7]               | 800           | [5.5]  | 950     | [6.6]  |
|             |                                       | 0.312              | [7.92]               | 41.45              | [61.7]               | 900           | [6.2]  | 1000    | [6.9]  |
|             |                                       | 0.330              | [8.38]               | 43.77              | [65.1]               | 1000          | [6.9]  | 1200    | [8.3]  |
|             |                                       | 0.344              | [8.74]               | 45.58              | [67.8]               | 1000          | [6.9]  | 1200    | [8.3]  |
|             |                                       | 0.375              | [9.52]               | 49.56              | [73.7]               | 1100          | [7.6]  | 1200    | [8.3]  |
|             |                                       | 0.438              | [11.13]              | 57.59              | [86.7]               | 1200          | [8.3]  | 1400    | [9.7]  |
|             |                                       | 0.500              | [12.70]              | 65.42              | [97.3]               | 1400          | [9.7]  | 1600    | [11.0] |
|             |                                       | 0.562 <sup>A</sup> | [14.27] <sup>A</sup> | 73.15 <sup>A</sup> | [108.8] <sup>A</sup> | 1600          | [11.0] | 1900    | [13.1] |

<sup>A</sup> Designates weights heavier than extra-strong.

## 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 ¼ ± ⅓₂ 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: