



Designation: A789/A789M – 22

Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service¹

This standard is issued under the fixed designation A789/A789M; 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 specification² covers grades of average wall thickness, or, if specified on the order, minimum wall thickness, of stainless steel tubing for services requiring general corrosion resistance, with particular emphasis on resistance to stress corrosion cracking. These steels are susceptible to embrittlement if used for prolonged periods at elevated temperatures.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. Within the text, the SI units are shown in brackets. The inch-pound units shall apply unless the *M* designation of this specification is specified in the order.

1.3 *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:³

A480/A480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

A1016/A1016M Specification for General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel, and Stainless Steel Tubes

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 A01.10 on Stainless and Alloy Steel Tubular Products.

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² For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-789 in Section II of that Code.

³ 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.

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

2.2 SAE Standard:⁴

SAE J 1086 Practice for Numbering Metals and Alloys (UNS)

3. Ordering Information

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

3.1.1 Quantity (feet, metres, or number of lengths),

3.1.2 Name of product (seamless or welded tubes),

3.1.3 Grade (see **Table 1**),

3.1.4 Size (outside diameter and average wall thickness, unless minimum wall thickness is specified),

3.1.5 Length (specific or random),

3.1.6 Optional requirements (for product analysis, see Section 8; for hydrostatic or nondestructive electric test, see Section 10),

3.1.7 Test report required (see the Inspection section of Specification **A1016/A1016M**),

3.1.8 Specification designation, and

3.1.9 Special requirements.

4. General Requirements

4.1 Product furnished under this specification shall conform to the applicable requirements of Specification **A1016/A1016M**, unless otherwise provided herein.

5. Manufacture

5.1 The tubes shall be made by the seamless or welded process with no filler metal added.

6. Heat Treatment

6.1 All tubes shall be furnished in the heat-treated condition in accordance with the procedures shown in **Table 2**. For seamless tubes, as an alternate to final heat treatment in a continuous furnace or batch-type furnace, immediately following hot forming while the temperature of the tubes is not less

⁴ Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

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

TABLE 1 Chemical Requirements^A

| UNS Designation ^B | C | Mn | P | S | Si | Ni | Cr | Mo | N | Cu | Others |
|------------------------------|-------|-----------|-------|-------|-----------|-----------|-----------|-----------|-----------|-----------|-------------|
| S31200 | 0.030 | 2.00 | 0.045 | 0.030 | 1.00 | 5.5–6.5 | 24.0–26.0 | 1.20–2.00 | 0.14–0.20 | ... | ... |
| S31260 | 0.030 | 1.00 | 0.030 | 0.030 | 0.75 | 5.5–7.5 | 24.0–26.0 | 2.5–3.5 | 0.10–0.30 | 0.20–0.80 | W 0.10–0.50 |
| S31500 | 0.030 | 1.20–2.00 | 0.030 | 0.030 | 1.40–2.00 | 4.3–5.2 | 18.0–19.0 | 2.50–3.00 | 0.05–0.1 | ... | ... |
| S31803 | 0.030 | 2.00 | 0.030 | 0.020 | 1.00 | 4.5–6.5 | 21.0–23.0 | 2.5–3.5 | 0.08–0.20 | ... | ... |
| S32001 | 0.030 | 4.00–6.00 | 0.040 | 0.030 | 1.00 | 1.0–3.0 | 19.5–21.5 | 0.60 | 0.05–0.17 | 1.00 | ... |
| S32003 | 0.030 | 2.00 | 0.030 | 0.020 | 1.00 | 3.0–4.0 | 19.5–22.5 | 1.50–2.00 | 0.14–0.20 | ... | ... |
| S32101 | 0.040 | 4.0–6.0 | 0.040 | 0.030 | 1.00 | 1.35–1.70 | 21.0–22.0 | 0.10–0.80 | 0.20–0.25 | 0.10–0.80 | ... |
| S32202 | 0.030 | 2.00 | 0.040 | 0.010 | 1.00 | 1.00–2.80 | 21.5–24.0 | 0.45 | 0.18–0.26 | ... | ... |
| S32205 | 0.030 | 2.00 | 0.030 | 0.020 | 1.00 | 4.5–6.5 | 22.0–23.0 | 3.0–3.5 | 0.14–0.20 | ... | ... |
| S32304 | 0.030 | 2.50 | 0.040 | 0.040 | 1.00 | 3.0–5.5 | 21.5–24.5 | 0.05–0.60 | 0.05–0.20 | 0.05–0.60 | ... |
| S32506 | 0.030 | 1.00 | 0.040 | 0.015 | 0.90 | 5.5–7.2 | 24.0–26.0 | 3.0–3.5 | 0.08–0.20 | ... | W 0.05–0.30 |
| S32520 | 0.030 | 1.50 | 0.035 | 0.020 | 0.80 | 5.5–8.0 | 23.0–25.0 | 3–5 | 0.20–0.35 | 0.50–3.00 | ... |
| S32550 | 0.04 | 1.50 | 0.040 | 0.030 | 1.00 | 4.5–6.5 | 24.0–27.0 | 2.9–3.9 | 0.10–0.25 | 1.50–2.50 | ... |
| S32707 | 0.030 | 1.50 | 0.035 | 0.010 | 0.50 | 5.5–9.5 | 26.0–29.0 | 4.0–5.0 | 0.30–0.50 | 1.0 max | Co 0.5–2.0 |
| S32750 ^C | 0.030 | 1.20 | 0.035 | 0.020 | 0.80 | 6.0–8.0 | 24.0–26.0 | 3.0–5.0 | 0.24–0.32 | 0.50 | ... |
| S32760 ^D | 0.030 | 1.00 | 0.030 | 0.010 | 1.00 | 6.0–8.0 | 24.0–26.0 | 3.0–4.0 | 0.20–0.30 | 0.50–1.00 | W 0.50–1.00 |
| S32808 | 0.030 | 1.10 | 0.030 | 0.010 | 0.50 | 7.0–8.2 | 27.0–27.9 | 0.80–1.20 | 0.30–0.40 | ... | W 2.10–2.50 |
| S32900 | 0.08 | 1.00 | 0.040 | 0.030 | 0.75 | 2.5–5.0 | 23.0–28.0 | 1.00–2.00 | ... | ... | ... |
| S32906 | 0.030 | 0.80–1.50 | 0.030 | 0.030 | 0.80 | 5.8–7.5 | 28.0–30.0 | 1.50–2.60 | 0.30–0.40 | 0.80 | ... |
| S32950 | 0.030 | 2.00 | 0.035 | 0.010 | 0.60 | 3.5–5.2 | 26.0–29.0 | 1.00–2.50 | 0.15–0.35 | ... | ... |
| S33207 | 0.030 | 1.50 | 0.035 | 0.010 | 0.80 | 6.0–9.0 | 29.0–33.0 | 3.0–5.0 | 0.40–0.60 | 1.0 | ... |
| S39274 | 0.030 | 1.00 | 0.030 | 0.020 | 0.80 | 6.0–8.0 | 24.0–26.0 | 2.5–3.5 | 0.24–0.32 | 0.20–0.80 | W 1.50–2.50 |
| S39277 | 0.025 | 0.80 | 0.025 | 0.002 | 0.80 | 6.5–8.0 | 24.0–26.0 | 3.00–4.00 | 0.23–0.33 | 1.20–2.00 | W 0.80–1.21 |
| S82011 | 0.030 | 2.0–3.0 | 0.040 | 0.020 | 1.00 | 1.00–2.00 | 20.5–23.5 | 0.10–1.00 | 0.15–0.27 | 0.50 | ... |
| S82031 | 0.05 | 2.50 | 0.040 | 0.005 | 0.80 | 2.0–4.0 | 19.0–22.0 | 0.60–1.40 | 0.14–0.24 | 1.00 | ... |
| S82441 | 0.030 | 2.50–4.00 | 0.035 | 0.005 | 0.70 | 3.0–4.5 | 23.0–25.0 | 1.00–2.00 | 0.20–0.30 | 0.10–0.80 | ... |
| S83071 | 0.030 | 0.50–1.50 | 0.030 | 0.020 | 0.50 | 6.0–8.0 | 29.0–31.0 | 3.0–4.0 | 0.28–0.40 | 0.80 | ... |

^A Maximum, unless a range or minimum is indicated. Where ellipses (...) appear in this table, there is no minimum and analysis for the element need not be determined or reported.

^B Designation established in accordance with Practice E527 and SAE J1086.

^C % Cr + 3.3 × % Mo + 16 × % N ≥ 41.

^D % Cr + 3.3 × (% Mo + 1/2 %W) + 16 × % N ≥ 41.

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than the specified minimum solution treatment temperature, tubes may be individually quenched in water or rapidly cooled by other means.

7. Chemical Composition

7.1 The steel shall conform to the chemical requirements prescribed in **Table 1**.

8. Product Analysis

8.1 An analysis of either one billet or one length of flat-rolled stock or one tube shall be made from each heat. The chemical composition thus determined shall conform to the requirements specified.

8.2 A product analysis tolerance (see the annex table on Chemical Requirements (Product Analysis Tolerances) in Specification **A480/A480M**) shall apply. The product analysis tolerance is not applicable to the carbon content for material with a specified maximum carbon of 0.04 % or less.

8.3 If the original test for product analysis fails, retests of two additional billets, lengths of flat-rolled stock, or tubes shall be made. Both retests for the elements in question shall meet the requirements of this specification; otherwise, all remaining material in the heat shall be rejected or, at the option of the producer, each billet or tube may be individually tested for acceptance. Billets, lengths of flat-rolled stock, or tubes that do not meet the requirements of this specification shall be rejected.

NOTE 1—For flange and flaring requirements, the term *lot* applies to all

tubes prior to cutting of the same nominal size and wall thickness that are produced from the same heat of steel. When final heat treatment is in a batch-type furnace, a lot shall include only those tubes of the same size and from the same heat that are heat treated in the same furnace charge. When the final heat treatment is in a continuous furnace, or when heat treated condition is obtained directly by quenching after hot forming, the number of tubes of the same size and from the same heat in a lot shall be determined from the size of the tubes as prescribed in **Table 3**.

NOTE 2—For tension and hardness test requirements, the term *lot* applies to all tubes prior to cutting, of the same nominal diameter and wall thickness that are produced from the same heat of steel. When final heat treatment is in a batch-type furnace, a lot shall include only those tubes of the same size and the same heat that are heat treated in the same furnace charge. When the final heat treatment is in a continuous furnace, or when heat treated condition is obtained directly by quenching after hot forming, a lot shall include all tubes of the same size and heat, heat treated in the same furnace at the same temperature, time at heat, and furnace speed, or all tubes of the same size and heat, hot formed and quenched in the same production run.

9. Mechanical Tests Required

9.1 *Tension Tests*—One tension test shall be made on a specimen for lots of not more than 50 tubes. Tension tests shall be made on specimens from two tubes for lots of more than 50 tubes (see **Note 2**).

9.2 *Flaring Test (for Seamless Tubes)*—One test shall be made on specimens from one end of one tube from each lot (see **Note 1**) of finished tubes. The minimum expansion of the inside diameter shall be 10 %.

9.3 *Flange Test (for Welded Tubes)*—One test shall be made on specimens from one end of one tube from each lot (see **Note 1**) of finished tubes.

TABLE 2 Heat Treatment

| UNS Designation | Temperature °F [°C] | Quench |
|-----------------|--------------------------|---|
| S31200 | 1920–2010 [1050–1100] | rapid cooling in water |
| S31260 | 1870–2010 [1020–1100] | rapid cooling in water or by other means |
| S31500 | 1800–1900 [980–1040] | rapid cooling in water or by other means |
| S31803 | 1870–2010 [1020–1100] | rapid cooling in water or by other means |
| S32001 | 1800–1950 [982–1066] | rapid cooling in water or by other means |
| S32003 | 1850–2050 [1010–1120] | rapid cooling in water or by other means |
| S32101 | 1870 [1020] min | rapid cooling in water or by other means |
| S32202 | 1870–1975 [1020–1080] | rapid cooling in water or by other means |
| S32205 | 1870–2010 [1020–1100] | rapid cooling in water or by other means |
| S32304 | 1700–1920 [925–1050] | rapid cooling in water or by other means |
| S32506 | 1870–2050 [1020–1120] | rapid cooling in water or by other means |
| S32520 | 1975–2050 [1080–1120] | rapid cooling in water or by other means |
| S32550 | 1900 [1040] min | rapid cooling in water or by other means |
| S32707 | 1975–2050 [1080–1120] | rapid cooling in water or by other means |
| S32750 | 1880–2060 [1025–1125] | rapid cooling in water or by other means |
| S32760 | 1960–2085 [1070–1140] | rapid cooling in water or by other means |
| S32808 | 1920–2100 [1050–1150] | rapid cooling in water or by other means |
| S32900 | 1700–1750 [925–955] | rapid cooling in water or by other means |
| S32906 | 1870–2100 [1020–1150] | rapid cooling in water or by other means |
| S32950 | 1820–1880 [990–1025] | air cool |
| S33207 | 1905–2085 [1040–1140] | rapid cooling in water or by other means |
| S39274 | 1920–2060 [1050–1125] | rapid cooling in water or by other means |
| S39277 | 1975–2155 [1080–1180] | rapid cooling in water or by other means |
| S82011 | 1850–2050 [1010–1120] | rapid cooling in water or by other means |
| S82031 | 1830 [1000] min | rapid cooling in water or by other means |
| S82441 | 1830 [1000] min | rapid cooling in water or by other means |
| S83071 | 1830–2100 [1000–1150] | rapid cooling in water or by other means |

TABLE 3 Number of Tubes in a Lot Heat Treated by the Continuous Process or by Direct Quench after Hot Forming

| Size of Tube | Size of Lot |
|---|-------------------------|
| 2 in. [50.8 mm] and over in outside diameter and 0.200 in. [5.1 mm] and over in wall thickness | not more than 50 tubes |
| Less than 2 in. [50.8 mm] but over 1 in. [25.4 mm] in outside diameter or over 1 in. [25.4 mm] in outside diameter and under 0.200 in. [5.1 mm] in wall thickness | not more than 75 tubes |
| 1 in. [25.4 mm] or less in outside diameter | not more than 125 tubes |

9.4 Hardness Test:

9.4.1 Brinell or Rockwell hardness tests shall be made on specimens from two tubes from each lot (see Note 2).

9.4.2 For tubing less than 0.354 in. [9.00 mm] in inside diameter and for tubing less than 0.065 in. [1.65 mm] in wall thickness, it is permissible to use the Vickers hardness test in lieu of the Brinell or Rockwell methods.

9.5 When more than one heat is involved, the tension, flaring, flanging, and hardness test requirements shall apply to each heat.

9.6 *Reverse Flattening Test*—For welded tubes, one reverse flattening test shall be made on a specimen from each 1500 ft [450 m] of finished tubing.

10. Hydrostatic or Nondestructive Electric Test

10.1 Each tube shall be subjected to the nondestructive electric test or the hydrostatic test. The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in the purchase order.

10.2 The hydrostatic test shall be in accordance with Specification A1016/A1016M, except that in the calculation of the hydrostatic test pressure 64000(441.2) shall be substituted for 32000(220.6).

11. Tensile and Hardness Properties

11.1 The material shall conform to the tensile and hardness properties prescribed in Table 4.

12. Permissible Variations in Dimensions

12.1 Variations in outside diameter, wall thickness, and length from those specified shall not exceed the amounts prescribed in Table 5.

12.2 The permissible variations in outside diameter given in Table 5 are not sufficient to provide for ovality in thin-walled tubes, as defined in the table. In such tubes, the maximum and minimum diameters at any cross section shall deviate from the nominal diameter by no more than twice the permissible variation in outside diameter given in Table 5; however, the mean diameter at that cross section must still be within the given permissible variation.

13. Surface Condition

13.1 All tubes shall be free of excessive mill scale, suitable for inspection. A slight amount of oxidation will not be considered as scale. Any special finish requirements shall be subject to agreement between the manufacturer and the purchaser.

14. Product Marking

14.1 In addition to the marking prescribed in Specification A1016/A1016M, the marking shall indicate whether the tubing is seamless or welded and the wall designation (average wall or minimum wall).

15. Keywords

15.1 duplex stainless steel; ferritic/austenitic stainless steel; seamless steel tube; stainless steel tube; steel tube; welded steel tube