

# SPECIFICATION FOR SEAMLESS AND WELDED FERRITIC/AUSTENITIC STAINLESS STEEL TUBING FOR GENERAL SERVICE



SA-789/SA-789M



(Identical with ASTM Specification A789/A789M-18.)

# Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service

## 1. Scope

1.1 This specification 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:

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

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

### 2.2 SAE Standard:

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

TABLE 1 Chemical Requirements<sup>A</sup>

UNS Designation <sup>B</sup>	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 <sup>C</sup>	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 <sup>D</sup>	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	...

<sup>A</sup>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.

<sup>B</sup>Designation established in accordance with Practice E527 and SAE J1086.

<sup>C</sup>% Cr + 3.3 × % Mo + 16 × % N ≥ 41.

<sup>D</sup>% Cr + 3.3 × % Mo + 16 × % N ≥ 40.

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

TABLE 4 Tensile and Hardness Requirements<sup>A</sup>

UNS Designation	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa]	Elongation in 2 in. or 50 mm, min, %	Hardness, max		
				Brinell HBW	Rockwell HRC	Vickers <sup>C</sup> HV
S31200	100 [690]	65 [450]	25	280	29	280
S31260	100 [690]	65 [450]	25	290	30	290
S31500	92 [630]	64 [440]	30	290	30	290
S31803	90 [620]	65 [450]	25	290	30	290
S32001	90 [620]	65 [450]	25	290	30	290
S32003 <sup>B</sup>						290
Wall 0.187 in. [5.00 mm] and under	100 [690]	70 [485]	25	290	30	290
Wall above 0.187 in. [5.00 mm]	95 [655]	65 [450]	25	290	30	290
S32101						
Wall 0.187 in. [5.00 mm] and under	101 [700]	77 [530]	30	290	30	290
Wall above 0.187 in. [5.00 mm]	94 [650]	65 [450]	30	290	30	290
S32202	94 [650]	65 [450]	30	290	30	290
S32205	95 [655]	70 [485]	25	290	30	290
S32304						
OD 1 in. [25 mm] and under	100 [690]	65 [450]	25	...	...	290
OD above 1 in. [25 mm]	87 [600]	58 [400]	25	290	30	290
S32506	90 [620]	65 [450]	18	302	32	300
S32520	112 [770]	80 [550]	25	310	32	310
S32550	110 [760]	80 [550]	15	297	31	295
S32707	133 [920]	101 [700]	25	318	34	315
S32750	116 [800]	80 [550]	15	300	32	300
S32760	109 [750]	80 [550]	25	310	32	310
S32808	116 [800]	80 [550]	15	310	32	310
S32900	90 [620]	70 [485]	20	271	28	275
S32906						
Wall under 0.40 in. [10 mm]	116 [800]	94 [650]	25	300	32	300
Wall 0.40 in. [10 mm] and above	109 [750]	80 [550]	25	300	32	300
S32950	100 [690]	70 [480]	20	290	30	290
S33207						
Wall under 0.157 in. [4 mm]	138 [950]	112 [770]	15	336	36	330
Wall 0.157 in. [4 mm] and above	123 [850]	101 [700]	15	336	36	330
S39274	116 [800]	80 [550]	15	310	32	310
S39277	120 [825]	90 [620]	25	290	30	290
S82011						
Wall 0.187 in. [5.00 mm] and under	101 [700]	75 [515]	30	293	31	295
Wall above 0.187 in. [5.00 mm]	95 [655]	65 [450]	30	293	31	295
S82031						
Wall 0.187 in. [5.00 mm] and under	102 [700]	73 [500]	35	293	31	295
Wall above 0.187 in. [5.00 mm]	94 [650]	58 [400]	35	290	30	290
S82441						
Wall under 0.40 in. [10 mm]	107 [740]	78 [540]	25	290	30	290
Wall 0.40 in. [10 mm] and above	99 [680]	70 [480]	25	290	30	290
S83071	120 [830]	98 [680]	25	300	32	300

<sup>A</sup> For tubing smaller than ½ in. [12.7 mm] in outside diameter, the elongation values given for strip specimens in Table 4 shall apply. Mechanical property requirements do not apply to tubing smaller than ⅛ in. [3.2 mm] in outside diameter or with walls thinner than 0.015 in. [0.4 mm].

<sup>B</sup> Prior to A789/A789M-04, the values for S32003 were 90 ksi tensile strength and 65 ksi yield strength.

<sup>C</sup> See 9.4.2 for when Vickers hardness testing is permitted.

TABLE 5 Permissible Variations in Dimensions

Group	Size, Outside Diameter, in. [mm]	Permissible Variations in Outside Diameter, in. [mm]	Average Wall <sup>D</sup> Permissible Variations in Wall Thickness, <sup>A</sup> %	Minimum Wall <sup>E</sup> Permissible Variations in Wall Thickness, <sup>A</sup> %		Permissible Variations in Cut Length, in. <sup>B</sup> [mm]		Thin Walled Tubes <sup>C</sup>
				Over	Under	Over	Under	
1	Up to ½ [12.7], excl	±0.005 [0.13]	±15	30	0	⅛ [3]	0	...
2	½ to 1½ [12.7 to 38.1], excl	±0.005 [0.13]	±10	20	0	⅛ [3]	0	less than 0.065 in. [1.6 mm] specified
3	1½ to 3½ [38.1 to 88.9], excl	±0.010 [0.25]	±10	20	0	⅜ [5]	0	less than 0.095 in. [2.4 mm] specified
4	3½ to 5½ [88.9 to 139.7], excl	±0.015 [0.38]	±10	20	0	⅜ [5]	0	less than 0.150 in. [3.8 mm] specified
5	5½ to 8 [139.7 to 203.2], incl	±0.030 [0.76]	±10	20	0	⅜ [5]	0	less than 0.150 in. [3.8 mm] specified

<sup>A</sup> When tubes as ordered require wall thicknesses ¾ in. [19 mm] or over, or an inside diameter 60 % or less of the outside diameter, a wider variation in wall thickness is required. On such sizes a variation in average wall thickness of 12.5 % over or under, or a variation in minimum wall thickness of 25.0 % over and 0 % under, shall be permitted.

For tubes less than ½ in. [12.7 mm] in inside diameter that cannot be successfully drawn over a mandrel, the average wall thickness may vary ±15 % from that specified or the minimum wall thickness may vary by +30 %, -0 % from that specified.

<sup>B</sup> These tolerances apply to cut lengths up to and including 24 ft [7.3 m]. For lengths greater than 24 ft [7.3 m], the above over-tolerances shall be increased by ⅛ in. [3 mm] for each 10 ft [3 m] or fraction thereof over 24 ft or ½ in. [13 mm], whichever is the lesser.

<sup>C</sup> Ovality provisions of 12.2 apply.

<sup>D</sup> Applicable to tubing specified as average wall (see 3.1.4).

<sup>E</sup> Applicable to tubing specified as minimum wall (see 3.1.4).

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirement shall apply only when specified by the purchaser in the inquiry, contract, or order.

### S1. Pneumatic Test

S1.1 The tubing shall be examined by a pneumatic test (either air underwater or pneumatic leak test) in accordance with Specification A1016/A1016M.