

Standard Specification for Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service

1. Scope

1.1 This specification covers a number of grades of nominal-wall-thickness, stainless steel tubing for general corrosion-resisting and high-temperature service. Most of these grades are commonly known as the “straight-chromium” types and are characterized by being ferromagnetic. Two of these grades, TP410 and UNS S 41500 (Table 1), are amenable to hardening by heat treatment, and the high-chromium, ferritic alloys are sensitive to notch-brittleness on slow cooling to ordinary temperatures. These features should be recognized in the use of these materials. Grade TP439 is used primarily for hot-water tank service and does not require post-weld heat treatment to prevent attack of the heat affected zone.

1.2 An optional supplementary requirement is provided, and when desired, shall be so stated in the order.

1.3 The values stated in either inch-pound units 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. Combining values from the two systems may result in non-conformance with the standard. The inch-pound units shall apply unless the “M” designation of this specification is specified in the order.

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

A763 Practices for Detecting Susceptibility to Intergranular Attack in Ferritic Stainless Steels

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

E213 Practice for Ultrasonic Testing of Metal Pipe and Tubing

E273 Practice for Ultrasonic Testing of the Weld Zone of Welded Pipe and Tubing

3. Terminology

3.1 *Lot Definitions:*

3.1.1 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. If 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. If the final heat treatment is in a continuous furnace, 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 given in Table 2.

3.1.2 For tensile 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. If 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. If the final heat treatment is in a continuous furnace, 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.

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Such requirements may include, but are not limited to, the following:

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

4.1.2 Name of material (seamless or welded tubes),

4.1.3 Grade (Table 1),

4.1.4 Size (outside diameter and nominal wall thickness),

TABLE 1 Chemical Requirements

Grade	TP405	TP410	TP429	TP430	TP443	TP446-1	TP446-2 ⁴	...	TP409
UNS Designation	S40500	S41000	S42900	S43000	S44300	S44600	S44600	S40800	S40900
Element	Composition, %								
C, max	0.08	0.15	0.12	0.12	0.20	0.20	0.12	0.08	0.08
Mn, max	1.00	1.00	1.00	1.00	1.00	1.50	1.50	1.00	1.00
P, max	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.045	0.045
S, max	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.045	0.030
Si, max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ni	0.50 max	...	...	...	0.75 max	0.75 max	0.50 max	0.80 max	0.50 max
Cr	11.5–14.5	11.5–13.5	14.0–16.0	16.0–18.0	18.0–23.0	23.0–27.0	23.0–27.0	11.5–13.0	10.5–11.7
Mo	...	...	...	...	...	...	...	...	...
Al	0.10–0.30	...	...	...	...	...	...	...	...
Cu	...	...	...	...	0.90–1.25	...	...	...	...
N	...	...	...	...	...	0.25	0.25	...	...
Ti	...	...	...	...	...	...	...	12 × C min; 1.10 max	6 × C min; 0.75 max

TABLE 1 Continued

Grade	TP439	...	...	TP430 Ti	TP XM-27	TP XM-33 ^A	18Cr-2Mo	29-4	29-4-2	26-3-3	25-4-4	...	...	...	...	...	TP468
UNS Designation	S43035	S43932	S41500 ^B	S43036	S44627	S44626	S44400	S44700	S44800	S44660	S44635	S44735	S32803	S40977	S43940	S42035	S46800
Element	Composition, %																
C, max	0.07	0.030	0.05	0.10	0.01 ^A	0.06	0.025	0.010	0.010	0.030	0.025	0.030	0.015 ^C	0.03	0.03	0.08	0.030
Mn, max	1.00	1.00	0.5-1.0	1.00	0.40	0.75	1.00	0.30	0.30	1.00	1.00	1.00	0.5	1.50	1.00	1.00	1.00
P, max	0.040	0.040	0.03	0.040	0.02	0.040	0.040	0.025	0.025	0.040	0.040	0.040	0.020	0.040	0.040	0.045	0.040
S, max	0.030	0.030	0.03	0.030	0.02	0.020	0.030	0.020	0.020	0.030	0.030	0.030	0.005	0.015	0.015	0.030	0.030
Si, max	1.00	1.00	0.60	1.00	0.40	0.75	1.00	0.20	0.20	1.00	0.75	1.00	0.50	1.00	1.00	1.00	1.00
Ni	0.50 max	0.50	3.5-5.5	0.75 max	0.5 ^D max	0.50 max	1.00 max	0.15 max	2.0-2.5	1.0-3.50	3.5-4.5	1.00 max	3.0-4.0	0.30-1.00	...	1.0-2.5	0.50
Cr	17.00-19.00	17.0-19.0	11.5-14.0	16.00-19.50	25.0-27.5	25.0-27.0	17.5-19.5	28.0-30.0	28.0-30.0	25.0-28.0	24.5-26.0	28.00-30.00	28.0-29.00	0.50-12.50	7.50-18.50	13.5-15.5	8.00-20.00
Mo	...	...	0.5-1.0	...	0.75-1.50	0.75-1.50	1.75-2.50	3.5-4.2	3.5-4.2	3.0-4.0	3.5-4.5	3.60-4.20	1.8-2.5	...	...	0.2-1.2	...
Al, max	0.15	0.15	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cu, max	...	...	...	...	0.2	0.20	...	0.15	0.15	...	...	...	...	...	...	...	...
N, max	0.04	0.030 (Ti + Cb) {0.20 + 4 (C + N)} min.; 0.75 max	...	...	0.015	0.040	0.035	0.020 ^E	0.020 ^E	0.040	0.035	0.045	0.020	0.030	...	...	0.030
Ti	0.20 + 4 (C + N) min; 1.10 max	...	...	5 x C min; 0.75 max	...	7 x (C + N) but no less than 0.20 min; 1.00 max	(Ti + Cb) 0.20 + 4 (C + N) min; 0.80 max	...	...	(Ti + Cb) = 0.20-1.00 and 6 x (C + N) min	(Ti + Cb) = 0.20 + 4 (C + N) min to 0.80 max	(Ti + Cb) = 0.20-1.00 and 6 x (C + N) min	...	...	0.10-0.60	0.30-0.50	0.07-0.30
Cb	...	...	...	...	0.05-0.20	...	...	...	...	...	...	...	0.15-0.50 ^F	...	(3 x %C + 0.30) min	...	0.10-0.60 (Ti + Cb) = 0.20 + 4(C+N) min; 0.80 max

^A For small diameter or thin walls, or both, tubing, where many drawing passes are required, a carbon maximum of 0.015 % is necessary. Small outside diameter tubes are defined as those less than 0.500 in. [12.7 mm] in outside diameter and light wall tubes as those less than 0.049 in. [1.2 mm] in average wall thickness (0.040 in. [1 mm] in minimum wall thickness).

^B Plate version of CA6NM.

^C Carbon plus nitrogen = 0.30 max.

^D Nickel plus copper.

^E Carbon plus nitrogen = 0.025 % max.

^F Cb/(C + N) = 12 min.

- 4.1.5 Length (specific or random),
 4.1.6 Optional requirements (hydrostatic or nondestructive electric test, Section 16),
 4.1.7 Test report required (Certification Section of Specification A1016/A1016M),
 4.1.8 Specification designation,
 4.1.9 Intergranular corrosion test, and
 4.1.10 Special requirements.

TABLE 2 Number of Tubes in a Lot Heat Treated by the Continuous Process

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

5. General Requirements

5.1 Material furnished under this specification shall conform to the applicable requirements of Specification A1016/A1016M unless otherwise provided herein.

6. Manufacture

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

7. Heat Treatment

7.1 As a final heat treatment, tubes shall be reheated to a temperature of 1200 °F [650 °C] or higher and cooled (as appropriate for the grade) to meet the requirements of this specification.

7.2 The martensitic grade UNS S 41500 shall be reheated to a temperature of 950 °F [510 °C] or higher and cooled as appropriate to meet the requirements of this specification.

8. Chemical Composition

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

9. Product Analysis

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

9.2 The product analysis tolerance of the Chemical Requirements Table of 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.

9.3 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 the specification; otherwise all remaining

material in the heat or lot 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 which do not meet the requirements of the specification shall be rejected.

10. Tensile Requirements

10.1 The material shall conform to the tensile properties prescribed in Tables 3 and 4.

11. Hardness Requirements

11.1 The tubes shall have a hardness number not to exceed those prescribed in Table 5.

TABLE 3 Tensile Requirements

Grade and UNS Designation	Tensile strength,	Yield strength,	Elongation ^A in 2 in. or 50 mm, min, %
	min, ksi [MPa]	min, ksi [MPa]	
TP405	60 [415]	30 [205]	20
S40500	55 [380]	30 [205]	20
S40800	60 [415]	30 [205]	20
TP410	60 [415]	30 [205]	20
S41000	60 [415]	30 [205]	20
TP429, TP430, and TP430 Ti	60 [415]	35 [240]	20
S429000, S 43000, and S 43036	70 [485]	40 [275]	20
TP443	70 [485]	40 [275]	18
S44300	65 [450]	40 [275]	20
TP446-1	65 [450]	40 [275]	20
S44600	55 [380]	25 [170]	20
TP446-2	60 [415]	30 [205]	20
S44600	60 [415]	30 [205]	20
TP409	115 [795]	90 [620]	15
S40900	60 [415]	30 [205]	20
TP439	60 [415]	30 [205]	20
S43035	60 [415]	30 [205]	20
S43932	60 [415]	30 [205]	20
S41500	115 [795]	90 [620]	15
TPXM-27	65 [450]	40 [275]	20
S44627	68 [470]	45 [310]	20
TPXM-33	60 [415]	40 [275]	20
S44626	60 [415]	40 [275]	20
18Cr-2Mo	60 [415]	40 [275]	20
S44400	80 [550]	60 [415]	20
29-4 and 29-4-2	80 [550]	60 [415]	20
S44700 and S44800	85 [585]	65 [450]	20
26-3-3	85 [585]	65 [450]	20
S44660	90 [620]	75 [515]	20
25-4-4	90 [620]	75 [515]	20
S44635	75 [515]	60 [415]	18
S44735	87 [600]	72 [500]	16
28-2-3.5	65 [450]	41 [280]	18
S32803	62 [430]	36 [250]	18
S40977	80 [550]	55 [380]	16
S43940	60 [415]	30 [205]	22
S42035	60 [415]	30 [205]	22
TP468	60 [415]	30 [205]	22
S46800	60 [415]	30 [205]	22

^A For tubing smaller than ½ in. [12.7 mm] in outside diameter, the elongation values given for strip specimens in Table 2 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].

^B For longitudinal strip tests a deduction of 0.90 % for TP446-1 and S44735 and 1.00 % for all other grades shall be made from the basic minimum elongation for each ½ in. [0.8 mm] decrease in wall thickness below ⅝ in. [8 mm]. The following table gives the computed minimum values:

TABLE 4 Minimum Elongation Values

Wall Thickness		Elongation ^A in 2 in. or 50 mm, min, %		
in.	mm	TP446-1 and S44735		All Other Grades
		S44735	S41500	
3/16 [0.312]	8	18	15	20
5/32 [0.281]	7.2	17	14	19
1/4 [0.250]	6.4	16	14	18
7/32 [0.219]	5.6	15	13	17
3/16 [0.188]	4.8	14	12	16
5/32 [0.156]	4	13	11	15
1/8 [0.125]	3.2	13	11	14
3/32 [0.094]	2.4	12	10	13
1/16 [0.062]	1.6	11	9	12
0.062–0.035, excl	1.6–0.9	10	8	12
0.035–0.022, excl	0.9–0.6	10	8	11
0.022–0.015, incl	0.6–0.4	10	8	11

^ACalculated elongation requirements shall be rounded to the nearest whole number.

Note—The above table gives the computed minimum 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
TP446-1 and S44735	$E = 28.8t + 9.00$ [$E = 1.13t + 9.00$]
S41500	$E = 24t + 7.5$
All other grades	$E = 32t + 10.00$ [$E = 1.25t + 10.00$]

where:

E = elongation in 2 in. or 50 mm, %.

t = actual thickness of specimen, in. [mm].

TABLE 5 Hardness Requirements.

Grade	UNS Designation	Brinell Hardness, max	Rockwell Hardness, B Scale, max
TP405	S40500	207	95
...	S40800	207	95
TP410	S41000	207	95
TP429, TP430, and TP430 TI	S42900, S 43000, and S 43036	190	90
TP443	S44300	207	95
TP446-1 and TP446-2	S44600	207	95
TP409	S40900	207	95
TP439	S43035 ^A	190	90
...	S43932	190	90
...	S41500	295 ^B	32
TPXM-33 and TPXM-27	S44626 and S44627	241	100
18CR-2Mo	S44400	217	95
29-4 and 29-4-2	S44700 and S44800	207	100
26-3-3	S44660	265	25 ^B
25-4-4	S44635	270	27 ^B
...	S44735	...	100
28-2-3.5	S32803	240	100
...	S40977	180	88
...	S43940	180	88
...	S42035	180	88

^A Editorially corrected October 2000.

^B Rockwell hardness, C scale.

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 6.

12.2 The permissible variations in outside diameter given in Table 6 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 6; however, the mean diameter at that cross section must still be within the given permissible variation.

12.3 When the specified wall is 2 % or less of the specified outside diameter, the method of measurement is in accordance with the agreement between the purchaser and the manufacturer (see Note 1).

NOTE 1—Very thin wall tubing may not be stiff enough for the outside diameter to be accurately measured with a point contact test method, such as with the use of a micrometer or caliper. When very thin walls are specified, “go”–“no go” ring gages are commonly used to measure diameters of 1 1/2 in. [38.1 mm] or less. A0.002-in. [0.05-mm] additional tolerance is usually added on the “go” ring gage to allow clearance for sliding. On larger diameters, measurement is commonly performed with a pi tape. Other test methods such as optical test methods may also be considered.

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. Mechanical Tests Required

14.1 *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.

14.2 *Flaring Test (for Seamless Tubes)*—One test shall be made on specimens from one end of one tube from each lot of finished tubes. The minimum expansion of the inside diameter shall be 10 %. For tubes over 8 in. [203.2 mm] in outside diameter, or tubes with wall thickness 3/8 in. [9.52 mm] and over, the flattening test may be performed instead of the flaring test unless the flaring test is specified in the purchase order.

14.3 *Flange Test (for Welded Tubes)*—One test shall be made on specimens from one end of one tube from each lot of finished tubes. For tubes over 8 in. [203.2 mm] in outside diameter, or tubes with wall thickness 3/8 in. [9.52 mm] and over, the flattening test may be performed instead of the flange test unless the flange test is specified in the purchase order.

14.4 *Hardness Test*—Brinell or Rockwell hardness tests shall be made on specimens from two tubes from each lot.

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

14.6 *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.

15. Intergranular Corrosion Test

15.1 If intergranular corrosion testing is specified in the purchase order, the test shall be made in accordance with

TABLE 6 Permissible Variations in Dimensions

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

^AWhen tubes as ordered require wall thicknesses ¼ 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 wall thickness of 12.5 % over or under will be permitted.

For tubes less than ½ in. [12.7 mm] in inside diameter which cannot be successfully drawn over a mandrel, the wall thickness may vary ±15 % from that specified.

^BThese 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 lesser.

^COvality provisions of 12.2 apply.

Practices A763, using samples prepared as agreed upon between the seller and the purchaser.

16. Hydrostatic or Nondestructive Electric Test

16.1 Each tube, seamless or welded, 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.

17. Product Marking

17.1 In addition to the marking described in Specification A1016/A1016M, the marking shall indicate whether the tubing is seamless or welded.

18. Keywords

18.1 ferritic stainless steel; seamless steel tube; stainless steel tube; steel tube; welded steel tube

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements 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 under water or pneumatic leak test) in accordance with Specification A1016/A1016M.

S2. Additional Testing of Welded Tubing for 100 % Joint Efficiency in Certain ASME Applications (see Note S2.1)

NOTE S2.1—When specified, the special testing in this supplement is intended for special ASME applications. It is not mandatory for all ASME applications.

S2.1 Where this supplement is specified in the purchase order, in certain ASME applications it is permissible to use 100 % joint efficiency for the longitudinal weld, provided the following additional requirements are met:

S2.1.1 Each tube shall be subjected to an ultrasonic inspection employing Practices E273 or E213 with the rejection criteria referenced in Specification A1016/A1016M.

S2.1.2 If Practice E273 is employed, a 100 % volumetric inspection of the entire length of each tube shall also be performed using one of the non-destructive electric tests permitted by Specification A1016/A1016M.

S2.1.3 The test methods described in the supplement may not be capable of inspecting the end portions of tubes. This condition is referred to as end effect. This portion, as determined by the manufacturer, shall be removed and discarded.

S2.1.4 In addition to the marking prescribed in Specification A1016/A1016M, “S2” shall be added after the grade designation.