Designation: A 213/A 213M – 01a

An American National Standard
Used in USDOE-NE standards

Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes[1]

This standard is issued under the fixed designation A 213/A 213M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification[2] covers minimum-wall-thickness, seamless ferritic and austenitic steel, boiler and superheater tubes and austenitic steel heat-exchanger tubes, designated Grades T5, TP304, etc. These steels are listed in Table 1.

1.2 Grades S30432, TP304H, TP309H, TP309HCb, TP310H, TP310HCb, TP310HCbN, TP316H, TP321H, TP347H, TP347HFG (fine grained) and TP348H are modifications of Grades TP304, TP309S, TP309Cb, TP310S, TP310Cb, TP316, TP321, TP347, and TP348, and are intended for high-temperature service, such as for superheaters and reheaters.

1.3 The tubing sizes and thicknesses usually furnished to this specification are ⅛ in. [3.2 mm] in inside diameter to 5 in. [127 mm] in outside diameter and 0.015 to 0.500 in. [0.4 to 12.7 mm], inclusive, in minimum wall thickness. Tubing having other dimensions may be furnished, provided such tubes comply with all other requirements of this specification.

1.4 Mechanical property requirements do not apply to tubing smaller than ⅛ in. [3.2 mm] in inside diameter or 0.015 in. [0.4 mm] in thickness.

1.5 Optional supplementary requirements are provided and, when desired, shall be so stated in the order.

1.6 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 are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. 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:*

A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels[3]

A 450/A 450M Specification for General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes[4]

E 112 Test Methods for Determining Average Grain Size[5]

E 527 Practice for Numbering Metals and Alloys (UNS)[4]

2.2 *Other Standard:*

SAE J1086 Practice for Numbering Metals and Alloys (UNS)[6]

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, metres, or number of lengths),

3.1.2 Name of material (seamless tubes),

3.1.3 Grade (Table 1 and Table 2),

3.1.4 Manufacture (hot finished or cold finished),

3.1.5 Controlled structural characteristics (see 6.2),

3.1.6 Size (outside diameter and minimum wall thickness),

3.1.7 Length (specific or random),

3.1.8 Hydrostatic Test or Nondestructive Electric Test (see 12.1),

3.1.9 Specification designation, and

3.1.10 Special requirements and any supplementary requirements selected.

4. General Requirements

4.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 450/A 450M, unless otherwise provided herein.

5. Materials and Manufacture

5.1 Tubes shall be made by the seamless process and shall be either hot finished or cold finished, as specified. Grade TP347HFG shall be cold finished.

5.2 *Grain Size*:

[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-213 in Section II of that Code.

[3] *Annual Book of ASTM Standards*, Vol 01.03.

[4] *Annual Book of ASTM Standards*, Vol 01.01.

[5] *Annual Book of ASTM Standards*, Vol 03.01.

[6] Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

TABLE 1 Chemical Requirements for Ferritic Steel

Grade	Composition, %									Other Elements
	Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon	Chromium	Molybdenum	Titanium	Vanadium, min	
T2[A]	0.10–0.20	0.30–0.61	0.025	0.025	0.10–0.30	0.50–0.81	0.44–0.65	...	...	
T5	0.15 max	0.30–0.60	0.025	0.025	0.50 max	4.00–6.00	0.45–0.65	...	...	
T5b	0.15 max	0.30–0.60	0.025	0.025	1.00–2.00	4.00–6.00	0.45–0.65	...	...	
T5c	0.12 max	0.30–0.60	0.025	0.025	0.50 max	4.00–6.00	0.45–0.65	[B]	...	
T9	0.15 max	0.30–0.60	0.025	0.025	0.25–1.00	8.00–10.00	0.90–1.10	...	...	
T11	0.05 min–0.15 max	0.30–0.60	0.025	0.025	0.50–1.00	1.00–1.50	0.44–0.65	...	...	
T12[A]	0.05 min–0.15 max	0.30–0.61	0.025	0.025	0.50 max	0.80–1.25	0.44–0.65	...	...	
T17	0.15–0.25	0.30–0.61	0.025	0.025	0.15–0.35	0.80–1.25	...	...	0.15	
T21	0.05 min–0.15 max	0.30–0.60	0.025	0.025	0.50 max	2.65–3.35	0.80–1.06	...	...	
T22	0.05 min–0.15 max	0.30–0.60	0.025	0.025	0.50 max	1.90–2.60	0.87–1.13	...	...	
T23	0.04-0.10	0.10–0.60	0.030	0.010	0.50 max	1.90-2.60	0.05-0.30	...	0.20-0.30	W 1.45-1.75 Cb 0.02-0.08 B 0.0005-0.006 N 0.030 max Al 0.030 max
T24	0.05–0.10	0.30–0.70	0.020	0.010	0.15–0.45	2.20–2.60	0.70–1.10	0.06–0.10	0.20–0.30	B 0.0015–0.0020 N 0.012 max Al 0.020 max
T91	0.08–0.12	0.30–0.60	0.020	0.010	0.20–0.50	8.00–9.50	0.85–1.05	...	0.18–0.25	Cb 0.06–0.1 N 0.030–0.070 Ni 0.40 max Al 0.04 max
T92	0.07–0.13	0.30–0.60	0.020	0.010	0.50 max	8.50–9.50	0.30–0.60	. . .	0.15–0.25	W 1.5–2.00 Cb 0.04–0.09 B 0.001–0.006 N 0.03–0.07 Ni 0.40 max Al 0.04 max
T122	0.07-0.14	0.70 max	0.020	0.010	0.50 max	10.00-12.50	0.25-0.60	...	0.15-0.30	W 1.50-2.50 Cu 0.30-1.70 Cb 0.04-0.10 B 0.0005-0.005 N 0.040-0.100 Ni 0.50 max Al 0.040 max
T911	0.09–0.13	0.30–0.60	0.020	0.010	0.10–0.50	8.50–10.50	0.90–1.10	...	0.18–0.25	Ni 0.40 max Cb 0.060–0.10 B 0.0003–0.006 N 0.04–0.09 Al 0.04 max W 0.90–1.10
18Cr-2Mo	0.025 max	1.00 max	0.040	0.030	1.00 max	17.5–19.5	1.75–2.50	[C]	...	N max 0.035 Ni + Cu max 1.00

[A] It is permissible to order T2 and T12 with 0.045 max Sulfur.
[B] Grade T5c shall have a titanium content of not less than four times the carbon content and not more than 0.70 %.
[C] Grade 18Cr-2Mo shall have Ti + Cb = 0.20 + 4 (C + N) min, 0.80 max.

5.2.1 The grain size of Grades 304H, 316H, 321H, 347H, 348H, and 310HCbN, as determined in accordance with Test Methods E 112, shall be No. 7 or coarser.

5.2.2 The grain size of cold-worked Grade TP321H, as determined in accordance with Test Methods E 112, shall be No. 7 or coarser.

5.2.3 The grain size of TP309H, TP309HCb, TP310H and TP310HCb, as determined in accordance with Test Methods E 112, shall be No. 6 or coarser.

5.2.4 The grain size or cold-worked Grade TP347HFG as determined in accordance with Test Methods E 112 shall be between No. 7 and No. 10.

6. Heat Treatment

6.1 All tubes of grades shown in Table 1, except T5c, T23, T24, T91, T92, T122, and T911, and in accordance with 6.1.1 shall be reheated and furnished in the full-annealed, isothermal annealed, or normalized and tempered condition. If furnished in the normalized and tempered condition, the minimum tempering temperature for Grades T5, T5b, T9, T21, and T22 shall be 1250°F [675°C], and the minimum tempering temperature for Grades T11 and T17 shall be 1200°F [650°C].

6.1.1 Tubing of Grades T2 and T12 either hot-finished or cold-drawn, may be given a final heat treatment at 1200 to 1350°F [650 to 730°C] instead of heat treatments specified in 6.1 at the option of the manufacturer.

6.1.2 All tubing of Grade T5c shall be given a final heat treatment of approximately 1350°F [730°C] for a proper time, followed by air or furnace cooling.

6.1.3 Grade T24 shall be normalized at 1800°F [980°C]

minimum and tempered at 1350°F [730°C] minimum as a final heat treatment.

6.1.4 Grades T23, T91, T92, T122, and T911 shall be normalized at 1900°F [1040°C] minimum and tempered at 1350°F [730°C] minimum as a final heat treatment.

NOTE 1—Isothermal annealing as applied to tubular products, may involve austenitizing a ferrous alloy and then cooling to and holding within the range of temperature at which austenite transforms to a relatively soft ferrite-carbide aggregate.

6.2 If any controlled structural characteristics are required these shall be so specified as to be a guide as to the most suitable heat treatment.

6.3 All austenitic tubes shall be furnished in the heat-treated condition. The heat-treatment procedure, except for the H grades and S30815, shall consist of heating the material to a minimum temperature of 1900°F [1040°C] and quenching in water or rapidly cooling by other means. Alternatively, immediately following hot forming, while the temperature of the tubes is not less than the specified minimum solution treatment temperature, tubes may be individually quenched in water or rapidly cooled by other means.

6.4 All H, S30815, S33228, and S31272 grades shall be furnished in the solution-treated condition. If cold working is involved in processing, the minimum solution treating temperature for Grades TP321H, TP347H and TP348H shall be 2000°F [1100°C] and for Grades TP304H, and TP316H, 1900°F [1040°C]. If the H grade is hot-rolled, the minimum solution treatment for Grades TP321H, TP347H, and TP348H shall be 1925°F [1050°C], and for Grades TP304H, and TP316H, 1900°F [1040°C]. The minimum solution treating temperature for S30815 and S31272 shall be 1920°F [1050°C]. The minimum solution treating temperature for S33228 shall be 2050°F [1120°C]. The minimum solution treating temperature for TP309H, TP309HCb, TP310H, and TP310HCb shall be 1900°F [1037°C]. The minimum solution treating temperature for TP310HCbN shall be 2000°F (1100°C) and sufficient to produce a grain size of No. 7 or coarser. The minimum solution treating temperature for S30432 shall be 2000°F [1100°C].

6.5 The heat treatment of cold-worked TP347HFG comprises a softening heat treatment prior to cold-working, and a solution heat treatment after final cold-working. The softening temperature shall be at least 90°F [50°C] higher than the solution heat treatment temperature which shall be at 2150°F [1180°C] minimum.

6.6 Tubing of Grade 18Cr-2Mo shall be given a final heat treatment of 1400°F [760°C] or higher, and cooled in such a manner as to meet the requirements of this specification.

6.7 The minimum solution treating temperature for grade UNS S21500 shall be 1920°F [1050°C]. A maximum solution treating temperature of 2100°F [1150°C] is recommended.

6.8 S34565 shall be heat treated in the temperature range from 2050°F [1120°C] minimum to 2140°F [1170°C] maximum, followed by quenching in water or rapidly cooling by other means.

6.9 S32050 shall be heat treated to a minimum temperature of 2100°F [1150°C] followed by quenching in water or rapidly cooling by other means.

6.10 A solution annealing temperature above 1950°F [1065°C] may impair resistance to intergranular corrosion after subsequent exposure to sensitizing conditions in TP309HCb, TP310HCb, TP310HCbN, TP321, TP321H, TP347, TP347H, TP348, and TP348H. When specified by the purchaser, a lower temperature stabilization or resolution anneal shall be used subsequent to the initial high-temperature solution anneal (see Supplementary Requirement S2).

TABLE 2 Chemical Requirements of Austentic Steel

Grade	TP201	TP202	TP304	TP 304H	. . .	TP 304N	TP 304LN	TP 304L	TP 309Cb	TP 309H	TP 309HCb	TP 309S	. . .	TP 310Cb	TP 310H	TP 310HCb	TP 310HCbN	TP 310S		TP316	TP 316H
UNS Designation[A]	S20100	S20200	S30400	S30409	S30432	S30451	S30453	S30403	S30940	S30909	S30941	S30908	S31002	S31040	S31009	S31041	S31042	S31008	S31272	S31600	S31609
Carbon	0.15 max	0.15 max	0.08 max	0.04–0.10	0.07–0.13	0.08 max	0.035 max[B]	0.035 max[B]	0.08 max	0.04–0.10	0.04–0.10	0.08 max	0.015 max	0.08 max	0.04–0.10	0.04–0.10	0.04–0.10	0.08 max	0.08–0.12	0.08 max	0.04–0.10
Manganese, max	5.50–7.50	7.50–10.0	2.00	2.00	0.50	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.5–2.0	2.00	2.00
Phosphorus, max	0.060	0.060	0.040	0.040	0.045	0.040	0.040	0.040	0.045	0.045	0.045	0.045	0.020	0.045	0.040	0.045	0.030	0.045	0.030	0.040	0.040
Sulfur, max	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.015	0.030	0.030	0.030	0.030	0.030	0.015	0.030	0.030
Silicon	1.00 max	1.00 max	0.75 max	0.75 max	0.30 max	0.75 max	0.75 max	0.75 max	0.75 max	0.75 max	0.75 max	0.75 max	0.15 max	0.75 max	0.75 max	0.75 max	0.75 max	0.75 max	0.3–0.7	0.75 max	0.75 max
Nickel	3.50–5.50	4.00–6.00	8.00–11.0	8.00–11.0	7.50–10.50	8.00–11.0	8.00–11.0	8.00–13.0	12.00–16.00	12.00–15.00	12.00–16.00	12.00–15.00	19.0–22.0	19.00–22.00	19.0–22.00	19.0–22.00	17.00–23.00	19.00–22.00	14.0–16.0	11.0–14.0	11.0–14.0
Chromium	16.0–18.0	17.0–19.0	18.0–20.0	18.0–20.0	17.00–19.00	18.0–20.0	18.0–20.0	18.0–20.0	22.00–24.00	22.00–24.00	22.00–24.00	22.00–24.00	24.0–26.0	24.00–26.00	24.00–26.00	24.00–26.00	24.00–26.00	24.00–26.00	14.0–16.0	16.0–18.0	16.0–18.0
Molybdenum	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.75 max	0.75 max	0.75 max	0.75 max	0.10 max	0.75 max	. . .	0.75 max	. . .	0.75 max	1.0–1.4	2.00–3.00	2.00–3.00
Titanium		. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.3–0.6	. . .	. . .
Columbium + tantalum	. . .	. . .	. . .	. . .	0.20–0.80	. . .	. . .	. . .	10× C min, 1.10 max	. . .	10 × C min, 1.10 max	. . .	. . .	10× C min, 1.10 max	. . .	10 × C min, 1.10 max	0.20–0.60	. . .	. . .	. . .	. . .
Tantalum, max	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Nitrogen[C]	0.25 max	0.25 max	. . .	. . .	0.05–0.12	0.10–0.16	0.10–0.16	. . .	. . .	. . .	. . .	. . .	0.10 max	. . .	. . .	. . .	0.15–0.35	. . .	. . .	. . .	. . .
Cerium	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Others	. . .	. . .	. . .	. . .	B 0.001–0.010 Al 0.003–0.030 Cu 2.5–3.5	. . .	. . .	. . .		. . .			. . .		. . .		. . .		B 0.004–0.008	. . .	