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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 seamless ferritic and austenitic steel boiler, superheater, and heat-exchanger tubes, designated Grades T5, TP304, etc. These steels are listed in Tables 1 and 2.

1.2 Grades containing the letter, H, in their designation, have requirements different from those of similar grades not containing the letter, H. These different requirements provide higher creep-rupture strength than normally achievable in similar grades without these different requirements.

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 or, if specified in the order, average wall thickness. Tubing having other diameters may be furnished, provided such tubes comply with all other requirements of this specification.

1.4 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:* [3]

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

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys and Ferroalloys

A 1016/A 1016M Specification for General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel, and Stainless Steel Tubes

E 112 Test Methods for Determining Average Grain Size

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology A 941.

4. Ordering Information

4.1 It shall be the responsibility of the purchaser to specify all requirements that are necessary for products under this specification. Such requirements to be considered 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 tubes),

4.1.3 Grade (Tables 1 and 2),

4.1.4 Condition (hot finished or cold finished),

4.1.5 Controlled structural characteristics (see 6.3),

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

4.1.7 Length (specific or random),

4.1.8 Hydrostatic Test or Nondestructive Electric Test (see 10.1),

4.1.9 Specification designation and year of issue,

4.1.10 Increased sulfur (for machinability, see Note B, Table 1, and 15.3), and

4.1.11 Special requirements and any supplementary requirements selected.

5. General Requirements

5.1 Product furnished to this specification shall conform to the requirements of Specification A 1016/A 1016M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A 1016/A 1016M constitutes nonconformance with this specification. In case of conflict between

[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] 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.

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

TABLE 1 Chemical Composition Limits, %[A], for Low Alloy Steel

Grade	UNS Designation	Composition, %														
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Vanadium	Boron	Niobium	Nitrogen	Aluminum	Tungsten	Other Elements
T2	K11547	0.10–0.20	0.30–0.61	0.025	0.025[B]	0.10–0.30	...	0.50–0.81	0.44–0.65	...	...	...	...	...	...	...
T5	K41545	0.15	0.30–0.60	0.025	0.025	0.50	...	4.00–6.00	0.45–0.65	...	...	...	...	...	...	...
T5b	K51545	0.15	0.30–0.60	0.025	0.025	1.00–2.00	...	4.00–6.00	0.45–0.65	...	...	...	...	...	...	...
T5c	K41245	0.12	0.30–0.60	0.025	0.025	0.50	...	4.00–6.00	0.45–0.65	...	...	...	...	...	...	Ti 4xC–0.70
T9	K90941	0.15	0.30–0.60	0.025	0.025	0.25–1.00	...	8.00–10.00	0.90–1.10	...	...	...	...	...	...	...
T11	K11597	0.05–0.15	0.30–0.60	0.025	0.025	0.50–1.00	...	1.00–1.50	0.44–0.65	...	...	...	...	...	...	...
T12	K11562	0.05–0.15	0.30–0.61	0.025	0.025[B]	0.50	...	0.80–1.25	0.44–0.65	...	...	...	...	...	...	...
T17	K12047	0.15–0.25	0.30–0.61	0.025	0.025	0.15–0.35	...	0.80–1.25	...	0.15	...	...	...	...	...	...
T21	K31545	0.05–0.15	0.30–0.60	0.025	0.025	0.50–1.00	...	2.65–3.35	0.80–1.06	...	...	...	...	...	...	...
T22	K21590	0.05–0.15	0.30–0.60	0.025	0.025	0.50	...	1.90–2.60	0.87–1.13	...	...	...	...	...	...	...
T23	K40712	0.04–0.10	0.10–0.60	0.030	0.010	0.50	...	1.90–2.60	0.05–0.30	0.20–0.30	0.0005–0.006	0.02–0.08	0.03	0.030	1.45–1.75	...
T24	K30736	0.05–0.10	0.30–0.70	0.020	0.010	0.15–0.45	...	2.20–2.60	0.90–1.10	0.20–0.30	0.0015–0.007	...	0.012	0.02	...	Ti 0.06–0.10
T91	K90901	0.07–0.14	0.30–0.60	0.020	0.010	0.20–0.50	0.40	8.0–9.5	0.85–1.05	0.18–0.25	...	0.06–0.1	0.030–0.070	0.04	...	...
T92	K92460	0.07–0.13	0.30–0.60	0.020	0.010	0.50	0.40	8.5–9.5	0.30–0.60	0.15–0.25	0.001–0.006	0.04–0.09	0.030–0.070	0.04	1.5–2.00	...
T122	K91271	0.07–0.14	0.70	0.020	0.010	0.50	0.50	10.0–12.5	0.25–0.60	0.15–0.30	0.0005–0.005	0.04–0.10	0.040–0.100	0.04	1.50–2.50	Cu 0.30–1.70
T911	K91061	0.09–0.13	0.30–0.60	0.020	0.010	0.10–0.50	0.40	8.5–9.5	0.90–1.10	0.18–0.25	0.0003–0.006	0.06–0.10	0.040–0.090	0.04	0.90–1.10	...
T ZZ	KXXXXX	0.10–0.17	0.80–1.20	0.030	0.025	0.25–0.50	1.00–1.30	0.30	0.25–0.50	0.02	...	0.015–0.045	0.02	0.050	...	Cu 0.50–0.80

[A] Maximum, unless range or minimum is indicated. Where ellipses (...) appear in this table, there is no requirement, and analysis for the element need not be determined or reported.
[B] It is permissible to order T2 and T12 with a sulfur content of 0.045 max. See 15.3.

the requirements of this specification and Specification A 1016/A 1016M, this specification shall prevail.

6. Materials and Manufacture

6.1 *Manufacture and Condition*—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.

6.2 *Heat Treatment*:

6.2.1 *Ferritic Alloy and Ferritic Stainless Steels*—The ferritic alloy and ferritic stainless steels shall be reheated for heat treatment in accordance with the requirements of Table 3. Heat treatment shall be carried out separately and in addition to heating for hot forming.

6.2.2 *Austenitic Stainless Steels*—All austenitic tubes shall be furnished in the heat-treated condition, and shall be heat treated in accordance with the requirements of Table 3. Alternatively, immediately after hot forming, while the temperature of the tubes is not less than the minimum solution treatment temperature specified in Table 3, tubes may be individually quenched in water or rapidly cooled by other means (direct quenched).

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

TABLE 2 Chemical Composition Limits, %^{A}, for Austenitic and Ferritic Stainless Steel

Grade	UNS Designation	Composition											
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Nitrogen^{B}	Niobium	Titanium	Other Elements
TP201	S20100	0.15	5.5–7.5	0.060	0.030	1.00	16.0–18.0	3.5–5.5	...	0.25	...	...	...
TP202	S20200	0.15	7.5–10.0	0.060	0.030	1.00	17.0–19.0	4.0–6.0	...	.025	...	...	...
XM-19	S20910	0.06	4.0–6.0	0.045	0.030	1.00	20.5–23.5	11.5–13.5	1.50–3.00	0.20–0.40	0.10–0.30	...	V 0.10–0.30
^{C}	S21500	0.06–0.15	5.5–7.0	0.045	0.030	0.20–1.00	14.0–16.0	9.0–11.0	0.80–1.20	...	0.75–1.25	...	B 0.003–0.009, V 0.15–0.40
^{C}	S25700	0.02	2.00	0.025	0.010	6.5–8.0	8.0–11.5	22.0–25.0	0.50	...	...	...	...
TP304	S30400	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	...	...	...	...	...
TP304L	S30403	0.035^{D}	2.00	0.045	0.030	1.00	18.0–20.0	8.0–12.0	...	...	...	...	...
TP304H	S30409	0.04–0.10	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	...	...	...	...	...
^{C}	S30432	0.07–0.13	1.00	0.040	0.010	0.30	17.0–19.0	7.5–10.5	...	0.05–0.12	0.30–0.60	...	Al 0.003–0.030, B 0.001–0.010, Cu 2.5–3.5
TP304N	S30451	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	...	0.10–0.16	...	...	...
TP304LN	S30453	0.035^{D}	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	...	0.10–0.16	...	...	...
^{C}	S30615	0.016–0.24	2.00	0.030	0.030	3.2–4.0	17.0–19.5	13.5–16.0	...	...	...	...	Al 0.8–1.5
^{C}	S30815	0.05–0.10	0.80	0.040	0.030	1.40–2.00	20.0–22.0	10.0–12.0	...	0.14–0.20	...	...	Ce 0.03–0.08
TP309S	S30908	0.08	2.00	0.045	0.030	1.00	22.0–24.0	12.0–15.0	...	...	...	...	...
TP309H	S30909	0.04–0.10	2.00	0.045	0.030	1.00	22.0–24.0	12.0–15.0	...	...	...	...	...
TP309Cb	S30940	0.08	2.00	0.045	0.030	1.00	22.0–24.0	12.0–16.0	...	...	10xC–1.10	...	...
TP309HCb	S30941	0.04–0.10	2.00	0.045	0.030	1.00	22.0–24.0	12.0–16.0	...	...	10xC-1.10	...	...
^{C}	S31002	0.02	2.00	0.020	0.015	0.15	24.0–26.0	19.0–22.0	0.10	0.10	...	...	...
TP310S	S31008	0.08	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	...	...	...	...	...
TP310H	S31009	0.04–0.10	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	...	...	...	...	...
TP310Cb	S31040	0.08	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	...	...	10xC-1.10	...	...
TP310HCb	S31041	0.04–0.10	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	...	...	10xC-1.10	...	...
TP310HCbN	S31042	0.04–0.10	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	...	0.15–0.35	0.20–0.60	...	...
TP310MoLN	S31050	0.025	2.00	0.020	0.030	0.40	24.0–26.0	21.0–23.0	2.00–3.00	0.10–0.16	...	...	...
^{C}	S31060	0.05–0.10	1.00	0.040	0.030	0.50	22.0–24.0	10.0–12.5	...	0.18–0.25	...	...	Ce + La 0.025–0.070 B 0.001–0.010
^{C}	S31254	0.020	1.00	0.030	0.010	0.80	19.5–20.5	17.5–18.5	6.0–6.5	0.18–.022	...	...	Cu 0.50–1.00
^{C}	S31272	0.08–0.12	1.50–2.00	0.030	0.015	0.30–0.70	14.0–16.0	14.0–16.0	1.00–1.40	...	...	0.30–0.60	B 0.004–0.008
TP316	S31600	0.08	2.00	0.045	0.030	1.00	16.0–18.0	10.0–14.0	2.00–3.00	...	...	...	...
TP316L	S31603	0.035^{D}	2.00	0.045	0.030	1.00	16.0–18.0	10.0–14.0	2.00–3.00	...	...	...	...
TP316H	S31609	0.04–0.10	2.00	0.045	0.030	1.00	16.0–18.0	11.0–14.0	2.00–3.00	...	...	...	...
TP316N	S31651	0.08	2.00	0.045	0.030	1.00	16.0–18.0	10.0–13.0	2.00–3.00	0.10–0.16	...	...	...
TP316LN	S31653	0.035^{D}	2.00	0.045	0.030	1.00	16.0–18.0	10.0–13.0	2.00–3.00	0.10–0.16	...	...	...
TP317	S31700	0.08	2.00	0.045	0.030	1.00	18.0–20.0	11.0–15.0	3.0–4.0	...	...	...	...
TP317L	S31703	0.035	2.00	0.045	0.030	1.00	18.0–20.0	11.0–15.0	3.0–4.0	...	...	...	...
TP317LM	S31725	0.03	2.00	0.045	0.030	1.00	18.0–20.0	13.5–17.5	4.0–5.0	0.20	...	...	Cu 0.75
TP317LMN	S31726	0.03	2.00	0.045	0.030	1.00	17.0–20.0	13.5–17.5	4.0–5.0	0.10–0.20	...	...	Cu 0.75
^{C}	S32050	0.030	1.50	0.035	0.020	1.00	22.0–24.0	20.0–23.0	6.0–6.8	0.21–0.32	...	...	Cu 0.40
TP321	S32100	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	...	...	5(C + N)–0.70	...
TP321H	S32109	0.04–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	...	...	4(C + N)–0.70	...

TABLE 2 *Continued*

Grade	UNS Designation	Composition											
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Nitrogen[B]	Niobium	Titanium	Other Elements
[C]	S32615	0.07	2.00	0.045	0.030	4.8–6.0	16.5–19.5	19.0–22.0	0.30–1.50	...	...	...	Cu 1.50–2.50
[C]	S33228	0.04–0.08	1.00	0.020	0.015	0.03	26.0–28.0	31.0–33.0	...	...	0.60–1.00	...	Ce 0.05–0.10, Al 0.025
[C]	S34565	0.030	5.0–7.0	0.030	0.010	1.00	23.0–25.0	16.0–18.0	4.0–5.0	0.40–0.60	0.10	...	...
TP347	S34700	0.08	2.00	0.045	0.030	1.00	17.0–20.0	9.0–13.0	...	...	10xC–1.10	...	...
TP347H	S34709	0.04–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	...	8xC–1.10	...	...
TP347HFG	S34710	0.06–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	...	8xC–1.10	...	...
TP347LN	S34751	0.005–0.020	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	0.06–0.10	0.20–0.50[E]	...	...
TP348	S34800	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	...	[F]	...	Co 0.20, Ta 0.10
TP348H	S34809	0.04–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	...	[G]	...	Co 0.20, Ta 0.10
...	S35045	0.06–0.10	1.50	0.045	0.015	1.00	25.0–29.0	32.0–37.0	...	...	...	0.15–0.60	Al 0.15–0.60 Cu 0.75
XM-15	S38100	0.08	2.00	0.030	0.030	1.50–2.50	17.0–19.0	17.5–18.5	...	...	...	...	...
...	S38815	0.030	2.00	0.040	0.020	5.5–6.5	13.0–15.0	15.0–17.0	0.75–1.50	...	...	...	Cu 0.75–1.50 Al 0.30
TP444	S44400	0.03	1.00	0.040	0.030	1.00	17.5–19.5	[H]	1.75–2.50	0.035	...	[I]	...

[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] The method of analysis for Nitrogen shall be a matter of agreement between the purchaser and the producer.
[C] For these alloys, there is no common grade designation. The UNS number uniquely identifies these alloys.
[D] For small diameter or thin walls, or both, where many drawing passes are required, a carbon maximum of 0.040% is necessary in Grades TP304L, TP304LN, TP316L, and TP316LN.
[E] Grade TP347LN shall have an Nb content of not less than 15 times the carbon content.
[F] Grade TP348 shall have an Nb + Ta content of not less than 10 times the carbon content and not more than 1.10%.
[G] Grade TP348H shall have an Nb + Ta content of not less than 8 times the carbon content and not more than 1.10%.
[H] Grade TP444 shall have Ni + Cu = 1.00 max.
[I] Grade TP444 shall have Ti + Nb = 0.20 + 4(C + N)–0.80.

7. Chemical Composition

7.1 *Composition Requirements*:

7.1.1 The alloy steels shall conform to the chemical requirements given in Table 1.

7.1.2 The stainless steels shall conform to the chemical requirements given in Table 2.

7.2 *Product Analysis*:

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

7.2.2 If the original test for product analysis fails, retests of two additional billets 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 (as described in Section 14) shall be rejected or, at the option of the producer, each billet or tube may be individually tested for acceptance. Billets or tubes that do not meet the requirements of the specification shall be rejected.

8. Grain Size

8.1 Grain size shall be as given in Table 3, as determined in accordance with Test Methods E 112.

8.2 Grain size determinations, to demonstrate compliance with 8.1, shall be made on one end of one finished tube from each lot. See 14.1.

9. Mechanical Properties

9.1 *Tensile Requirements*:

9.1.1 The material shall conform to the requirements as to tensile properties given in Table 4.

9.1.2 Table 5 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 in Table 5, the minimum elongation value shall be determined by the following equations. For Grades T23, T24, T91, T92, T122, T911, and S44400: $E = 32t + 10.00$ [$E = 1.25t + 10.00$]. For Grade T ZZ: $E = 32t + 5.0$ [$E = 1.25t + 5.0$]. For all other ferritic alloy grades: $E = 48t + 15.00$ [$E = 1.87t + 15.00$].

where:

E = elongation in 2 in. [50 mm], %, and

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

9.1.3 One tension test shall be made on a specimen from one tube 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 14.2.

9.2 *Hardness Requirements*:

9.2.1 The material shall conform to the hardness requirements given in Table 4. See 14.2.

9.2.2 Brinell, Vickers, or Rockwell hardness tests shall be made on specimens from two tubes from each lot. See 14.2.

9.3 *Flattening Test*—One flattening test shall be made on specimens from each end of one finished tube, not the one used for the flaring test, from each lot. See 14.1.

9.4 *Flaring Test*—One flaring test shall be made on specimens from each end of one finished tube, not the one used for the flattening test, from each lot. See 14.1.

9.5 Mechanical property requirements do not apply to tubing smaller than 1/8 in. [3.2 mm] in inside diameter or thinner than 0.015 in. [0.4 mm] in thickness.

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.

11. Forming Operations

11.1 Tubes, when inserted in a boiler or tube sheet, shall stand expanding and beading without showing cracks or flaws. Superheater tubes when properly manipulated shall stand all forging, welding, and bending operations necessary for application without developing defects. See Note 1.

NOTE 1—Certain of the ferritic steels covered by this specification will harden if cooled rapidly from above their critical temperature. Some will air harden, that is, become hardened to an undesirable degree when cooled in air from high temperatures, particularly chromium-containing steels with chromium of 4 % and higher. Therefore, operations that involve heating such steels above their critical temperatures, such as welding, flanging, and hot bending, should be followed by suitable heat treatment.

12. Permissible Variations from the Specified Wall Thickness

12.1 Permissible variations from the specified minimum wall thickness shall be in accordance with Specification A 1016/A 1016M.

12.2 Permissible variations from the specified average wall thickness are ± 10 % of the specified average wall thickness.

13. Surface Condition

13.1 Ferritic alloy cold-finished steel tubes shall be free of scale and suitable for inspection. A slight amount of oxidation is not considered scale.

13.2 Ferritic alloy hot-finished steel tubes shall be free of loose scale and suitable for inspection.

13.3 Stainless steel tubes shall be pickled free of scale. When bright annealing is used, pickling is not necessary.

13.4 Any special finish requirement shall be subject to agreement between the supplier and the purchaser.

14. Sampling

14.1 For flattening, flaring, and grain size requirements, the term lot applies to all tubes, prior to cutting, of the same size (see 4.1.6) 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 the 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 6.

14.2 For tensile and hardness test requirements, the term lot applies to all tubes prior to cutting, of the same size (see 4.1.6) that are produced from the same heat of steel. When final heat treatment is in a batch-type furnace, a lot shall include only