SPECIFICATION FOR SEAMLESS FERRITIC AND AUSTENITIC ALLOY-STEEL BOILER, SUPERHEATER, AND HEAT-EXCHANGER TUBES

SA-213/SA-213M (25)

(Identical with ASTM Specification A213/A213M-23 except for the additional H Grade requirements in para. 6.2 and Supplementary Requirement S5 made mandatory.)

ASME SA-213/SA-213 replaces para. 6.2.2 of ASTM A213/A213M with the following:

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. Other than for Grades S30815, S30942, S31272, S33228, S30432, and H grades, seamless tubing immediately following hot forming may be individually quenched in water or rapidly cooled by other means (direct quenched), provided that the temperature of the tubes after hot forming is not less than the minimum specified heat treatment temperatures. For H grades, as well as Grades S30815, S30942, S31272, S33228, and S30432, the tubes shall be reheated to the specified heat treatment temperature for the required time before quenching.

Designation: A213/A213M – 23

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

This standard is issued under the fixed designation A213/A213M; 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 U.S. 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 SI units or inch-pound 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.

1.5 *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]

A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

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

E112 Test Methods for Determining Average Grain Size

2.2 *AWS Specifications*[4]

A5.5/A5.5M Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding

A5.23/A5.23M Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding

A5.28/A5.28M Specification for Low-Alloy Steel Electrodes for Gas Shielded Arc Welding

A5.29/A5.29M Low-Alloy Steel Electrodes for Flux Cored Arc Welding

3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification, refer to Terminology A941.

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 Heat treatment type (Table 3).

4.1.6 Controlled structural characteristics (see 6.3),

[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.

[4] Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, http://www.aws.org.

***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[E]	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	0.40	1.90–2.60	0.05–0.30	0.20–0.30	0.0010–0.006	0.02–0.08	0.015	0.030	1.45–1.75	Ti 0.005–0.060 Ti/N ≥ 3.5[C]
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
T36	K21001	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
T91 Type 1	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	...	0.06–0.10	0.030–0.070	0.02	...	Ti 0.01 Zr 0.01
T91 Type 2	K90901															
Heat		0.08–0.12	0.30–0.50[D]	0.020[D]	0.005[D]	0.20–0.40[D]	0.20[D]	8.0–9.5[D]	0.85–1.05	0.18–0.25	0.001[D]	0.06–0.10	0.035–0.070[D]	0.020[D]	0.05[D]	Ti 0.01[D] Zr 0.01[D]
Product		0.07–0.13							0.80–1.05	0.16–0.27		0.05–0.11				Cu 0.10[D] Sb 0.003[D] Sn 0.010[D] As 0.010[D] N/Al 4.0 min
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	0.02	1.5–2.00	Ti 0.01 Zr 0.01
T93	K91350	0.05–0.10	0.20–0.70	0.020	0.008	0.05–0.50	0.20	8.50–9.50	...	0.15–0.30	0.007–0.015	[F]	0.005–0.015	0.030	2.5–3.5	Co 2.5–3.5 Nd 0.010–0.060 O 0.0050
T115	K91060															
Heat		0.08–0.13	0.20–0.50	0.020	0.005	0.15–0.45	0.25	10.0–11.0	0.40–0.60	0.18–0.25	0.001	0.02–0.06	0.030–0.070	0.02	...	Ti 0.01 Zr 0.01 Cu 0.10 As 0.010 Sn 0.010 Sb 0.003 W 0.05 N/Al 4.0 min CNB[G] 10.5 max

TABLE 1 *Continued*

Grade	UNS Designation	Composition, %														
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Vanadium	Boron	Niobium[E]	Nitrogen	Aluminum	Tungsten	Other Elements
Product		0.07–0.14	0.20–0.50	0.020	0.005	0.15–0.45	0.25	10.0–11.0	0.37–0.63	0.16–0.27	0.001	0.02–0.07	0.030–0.070	0.02	...	Ti 0.01 Zr 0.01 Cu 0.10 As 0.010 Sn 0.010 Sb 0.003 W 0.05
T122	K91271	0.07–0.14	0.70	0.020	0.010	0.50	0.50	10.0–11.5	0.25–0.60	0.15–0.30	0.0005–0.005	0.04–0.10	0.040–0.100	0.02	1.50–2.50	Cu 0.30–1.70 Ti 0.01 Zr 0.01
T128	K91421	0.12 – 0.17	0.30 – 0.80	0.02	0.01	0.20 – 0.60	0.10 – 0.40	10.50 – 12.00	0.20 – 0.60	0.15 – 0.30	0.008 – 0.015	0.02 – 0.06	0.002 – 0.020	0.02	1.50 – 2.20	Co 1.50 – 2.20 Cu 0.15
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	0.02	0.90–1.10	Ti 0.01 Zr 0.01
T921	K91201	0.08–0.12	0.5–0.7	0.03	0.02	1.6–2.2	0.8–1.4	8.0–9.5	0.8–1.1	...	...	...	0.02–0.05	0.04	...	Cu 0.8-1.4

[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 16.3.
[C] Alternatively, in lieu of this ratio minimum, the material shall have a minimum hardness of 275 HV in the hardened condition, defined as after austenitizing and cooling to room temperature but prior to tempering. Hardness testing shall be performed at mid-thickness of the product. Hardness test frequency shall be two samples of product per heat treatment lot and the hardness testing results shall be reported on the material test report.
[D] Applies to both heat and product analyses.
[E] The terms Niobium (Nb) and Columbium (Cb) are alternate names for the same element.
[F] Grade T93 shall have a Nb + Ta content of 0.05–0.12 %.
[G] Chromium-Nickel Balance is defined as CNB = (Cr + 6Si + 4Mo +1.5W + 11V + 5Nb + 9Ti + 12Al) – (40C + 30N + 4Ni + 2Mn + 1Cu).

TABLE 2 Chemical Composition Limits, %[A] , for Austenitic and Ferritic Stainless Steel

Grade	UNS Designation	Composition											
		Carbon	Manga-nese	Phospho-rus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Nitrogen[B]	Niobium[N]	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	...	0.25	...	...	...
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
[C]	S30434	0.07–0.14	2.00	0.040	0.010	1.00	17.5–19.5	9.0–12.0	...	...	0.10–0.40[E]	0.10–0.25[E]	B 0.001–0.004 Cu 2.50–3.50
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	...	...	...	...	...
TP309LMoN	S30925	0.025	2.00	0.040	0.030	0.70	23.0–26.0	13.0–16.0	0.5–1.2	0.25–0.40	...	...	...
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	...	...
...	S30942	0.03–0.10	2.00	0.040	0.030	1.00	21.0–23.0	14.5–16.5		0.10–0.20	0.50–0.80		B=0.001–0.005
[C]	S31002	0.015	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	...	...	...	...	...
TP310MoCbN	S31025	0.10	1.50	0.030	0.030	1.00	19.5–23.0	23.0–26.0	1.0–2.0	0.10–0.25	0.10–0.40	0.20	B 0.002–0.010
	S31035	0.04–0.10	0.60	0.025	0.015	0.40	21.5–23.5	23.5–26.5	...	0.20–0.30	0.40–0.60	...	W 3.0–4.0 Co 1.0–2.0 Cu 2.5–3.5 B 0.002–0.008
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	...	...
[C]	S31043	0.04–0.10	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	...	0.15–0.35	0.20–0.50[O]	...	Ta 0.20 min[O]
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	0.18–0.25	...	...	Cu 0.50–1.00

TABLE 2 *Continued*

Grade	UNS Designation	Composition											
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Nitrogen[B]	Niobium[N]	Titanium	Other Elements
...	S31266	0.030	2.00–4.00	0.035	0.020	1.00	23.0–25.0	21.0–24.0	5.2–6.2	0.35–0.60	...	...	Cu 1.00–2.00 W 1.50–2.50
[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
[C]	S31277	0.020	3.00	0.030	0.010	0.50	20.5–23.0	26.0–28.0	6.5–8.0	0.30–0.40	...	...	Cu 0.50–1.50
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	...	...	...	...
TP316Ti	S31635	0.08	2.00	0.045	0.030	0.75	16.0–18.0	10.0–14.0	2.00–3.00	0.10	...	5X (C + N)–0.70	...
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]	S31730	0.030	2.00	0.040	0.010	1.00	17.0–19.0	15.0–16.5	3.0–4.0	0.045	...	...	Cu 4.0–5.0
[C]	S31740	0.005–0.020[P]	2.00	0.045	0.030	1.00	17.0–19.0	11.0–15.0	3.0–4.5	0.06–0.15	0.20–0.50[P]	...	...
[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	...
[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	0.30	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	...	...
TP347W	S34705	0.05	2.00	0.040	0.030	1.00	17.0–20.0	8.00–11.0	...	0.10–0.25	0.25–0.50	...	V 0.20–0.50 W 1.50–2.60
TP347H	S34709	0.04–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	8xC–1.10	...	...
TP347HFG	S34710	0.06–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	8xC–1.10	...	...
TP347LN	S34751	0.005–0.020	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	0.06–0.10	0.20–0.50[F]	...	...
[C]	S34752	0.005–0.020	2.00	0.035	0.010	0.60	17.0–19.0	10.0–13.0	0.20–1.20	0.06–0.12	0.20–0.50[F]	...	Cu 2.50–3.50 B 0.001–0.005
TP348	S34800	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	[G]	...	Co 0.20, Ta 0.10
TP348H	S34809	0.04–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	[H]	...	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
Alloy 20	N08020	0.070	2.00	0.045	0.035	1.00	19.0-21.0	32.0-38.0	2.00-3.00	...	[M]	...	Cu 3.00-4.00
	N08028	0.030	2.50	0.030	0.030	1.0	26.0-28.0	30.0-34.0	3.0-4.0				Cu 0.6-1.4
	N08029	0.020	2.0	0.025	0.015	0.6	26.0-28.0	30.0-34.0	4.0-5.0				Cu 0.6-1.4

TABLE 2 *Continued*

Grade	UNS Designation	Composition											
		Carbon	Manga-nese	Phospho-rus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Nitrogen[B]	Niobium[N]	Titanium	Other Elements
[C]	N08367	0.030	2.00	0.040	0.030	1.00	20.0-22.0	23.5-25.5	6.00-7.00	0.18-0.25	...	...	Cu 0.75
800	N08800	0.10	1.50	0.045	0.015	1.00	19.0–23.0	30.0–35.0	...	...			Cu 0.75 Al 0.15–0.60 Ti 0.15–0.60 Fe[I] 39.5 min
800H	N08810	0.05–0.10	1.50	0.045	0.015	1.00	19.0–23.0	30.0–35.0	...	...			Cu 0.75 Al 0.15–0.60 Ti 0.15–0.60 Fe[I] 39.5 min
...	N08811	0.06–0.10	1.50	0.045	0.015	1.00	19.0–23.0	30.0–35.0	...	...			Cu 0.75 Al 0.15–0.60[J] Ti 0.15–0.60[J] Fe[I] 39.5 min
	N08904	0.020	2.00	0.040	0.030	1.00	19.0–23.0	23.0–28.0	4.0–5.0	0.10			Cu 1.00–2.00
...	N08925	0.020	1.00	0.045	0.030	0.50	19.0–21.0	24.0–26.0	6.0–7.0	0.10–0.20	...	...	Cu 0.80–1.50
...	N08926	0.020	2.00	0.030	0.010	0.50	19.0–21.0	24.0–26.0	6.0–7.0	0.15–0.25	...	...	Cu 0.50–1.50
TP444	S44400	0.03	1.00	0.040	0.030	1.00	17.5–19.5	[K]	1.75–2.50	0.035	...	[L]	...
[C]	S35030	0.05–0.10	1.50	0.030	0.015	0.50–2.0	18.5–22.5	22.5–27.5	...	0.05–0.15	0.25–0.75	...	Cu: 2.5–3.5

[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 S30434 shall have (Ti + ½ Nb) of not less than 2 times and not more than 4 times the carbon content.
[F] Grade TP347LN and S34752 shall have an Nb content of not less than 15 times the carbon content.
[G] Grade TP348 shall have an Nb + Ta content of not less than 10 times the carbon content and not more than 1.10 %.
[H] Grade TP348H shall have an Nb + Ta content of not less than 8 times the carbon content and not more than 1.10 %.
[I] Iron shall be determined arithmetically by difference of 100 minus the sum of the other specified elements.
[J] Al + Ti shall be 0.85 % min; 1.20 % max.
[K] Grade TP444 shall have Ni + Cu = 1.00 max.
[L] Grade TP444 shall have Ti + Nb content not less than 0.20 + 4(C+N) and not more than 0.80 %.
[M] N08020 shall have an Nb + Ta content of not less than 8 times the carbon content and not more than 1.00%.
[N] The terms Niobium (Nb) and Columbium (Cb) are alternative names for the same element.
[O] UNS S31043 shall have a Nb + 1/2Ta content of 0.30 to 0.60 %.
[P] UNS designation S31740 steel shall have a niobium content of not less than 15 times the carbon content.

TABLE 3 Heat Treatment and Grain Size Requirements[A]

Grade	UNS Number	Heat Treat Type	Austenitizing/ Solutioning/ Stabilizing Temperature, min or range °F [°C]	Cooling Media	Subcritical Annealing or Tempering Temperature, min or range °F [°C]	ASTM Grain Size No.[B]
			Ferritic Alloy Steels			
T2	K11547	full or isothermal anneal; or	...	...	...	...
		normalize and temper; or	...	...	...	...
		subcritical anneal	...	...	1200 to 1350 [650 to 730]	...
T5	K41545	full or isothermal anneal; or	...	...	...	...
		normalize and temper	...	...	1250 [675]	...
T5b	K51545	full or isothermal anneal; or	...	...	...	...
		normalize and temper	...	...	1250 [675]	...
T5c	K41245	subcritical anneal	...	air or furnace	1350 [730][C]	...
T9	K90941	full or isothermal anneal; or	...	...	...	...
		normalize and temper	...	...	1250 [675]	...
T11	K11597	full or isothermal anneal; or	...	...	...	...
		normalize and temper	...	...	1200 [650]	...
T12	K11562	full or isothermal anneal; or	...	...	...	...
		normalize and temper; or	...	...	...	...
		subcritical anneal	...	...	1200 to 1350 [650 to 730]	...
T17	K12047	full or isothermal anneal; or	...	...	...	...
		normalize and temper	...	...	1200 [650]	...
T21	K31545	full or isothermal anneal; or	...	...	...	...
		normalize and temper	...	...	1250 [675]	...
T22	K21590	full or isothermal anneal; or	...	...	...	...
		normalize and temper	...	...	1250 [675]	...
T23	K40712	normalize and temper	1900–1975 [1040–1080]	...	1350–1470 [730–800]	...
T24	K30736	normalize and temper	1800–1870 [980–1020]	[D]	1350–1420 [730–770]	...
T36	K21001	normalize and temper	1650 [900]	[E]	1100 [595]	...
T91 Types 1 and 2	K90901	normalize and temper	1900–1975 [1040–1080]	...	1350–1470 [730–800]	...
T92	K92460	normalize and temper	1900–1975 [1040–1080]	...	1350–1470 [730–800]	...
T93	K91350	normalize and temper	1960–2140 [1070–1170]	...	1380–1455 [750–790]	...
T115	K91060	normalize and temper	1920–2010 [1050–1100]	...	1380–1455 [750–790]	...
T122	K91261	normalize and temper	1900–1975 [1040–1080]	...	1350–1470 [730–800]	...
T128	K91421	normalize and temper	1975–2140 [1080–1170]	air	1400–1470 [760–800]	...
T911	K91061	normalize and temper	1900–1975 [1040–1080]	[D]	1365–1435 [740–780]	...
T921	K91201	normalize and temper	1670–1740 [910–950]	air	1350–1420 [730-770]	...
			Austenitic Stainless Steels			
TP201	S20100	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP202	S20200	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
XM-19	S20910	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S21500	solution treatment	1900 [1040][F,G]	water or other rapid cool	...	...
	S25700	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP304	S30400	solution treatment	1900 [1040][F]	water or other rapid cool	...	...

TABLE 3 *Continued*

Grade	UNS Number	Heat Treat Type	Austenitizing/ Solutioning/ Stabilizing Temperature, min or range °F [°C]	Cooling Media	Subcritical Annealing or Tempering Temperature, min or range °F [°C]	ASTM Grain Size No.[B]
TP304L	S30403	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP304H	S30409	solution treatment	1900 [1040]	water or other rapid cool	...	7
	S30432	solution treatment	2000 [1100][F]	water or other rapid cool	...	...
	S30434	solution treatment	2120 [1160]	water or other rapid cool	...	...
TP304N	S30451	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP304LN	S30453	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S30615	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S30815	solution treatment	1920 [1050]	water or other rapid cool	...	...
TP309S	S30908	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP309H	S30909	solution treatment	1900 [1040]	water or other rapid cool	...	7
TP309LMoN	S30925	solution treatment	1920 [1050]	water or other rapid cool	...	7
TP309Cb	S30940	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP309HCb	S30941	solution treatment	1900 [1040][H]	water or other rapid cool	...	7
	S30942	solution treatment	2120 [1160]	water or other rapid cool		6
	S31002	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP310S	S31008	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP310H	S31009	solution treatment	1900 [1040]	water or other rapid cool	...	7
TP310MoCbN	S31025	solution treatment	2100 [1150]	water or other rapid cool	...	7
	S31035	solution treatment	2160–2280 [1180–1250]	water or other rapid cool	...	...
TP310Cb	S31040	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP310HCb	S31041	solution treatment	1900 [1040][H]	water or other rapid cool	...	7
TP310HCbN	S31042	solution treatment	1900 [1040][F,H]	water or other rapid cool	...	7
...	S31043	solution treatment	1900 [1040][F,H]	water or other rapid cool	...	7
TP310MoLN	S31050	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S31060	solution treatment	1975–2160 [1080–1180][F]	water or other rapid cool	...	7
	S31254	solution treatment	2100 [1150]	water or other rapid cool	...	...
	S31266	solution treatment	2100 [1150]	water or other rapid cool	...	...
	S31272	solution treatment	1920 [1050]	water or other rapid cool	...	...
	S31277	solution treatment	2050 [1120][F]	water or other rapid cool	...	...
TP316	S31600	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP316L	S31603	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP316H	S31609	solution treatment	1900 [1040]	water or other rapid cool	...	7
TP316Ti	S31635	solution treatment	1900 [1040]	water or other rapid cool	...	...
TP316N	S31651	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP316LN	S31653	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP317	S31700	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP317L	S31703	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S31725	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S31730	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S31740	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S32050	solution treatment	2100 [1150][F]	water or other rapid cool	...	...
TP321	S32100	solution treatment	1900 [1040][F,H]	water or other rapid cool	...	...
TP321H	S32109	solution treatment	cold worked: 2000 [1090] hot rolled: 1925 [1050][H]	water or other rapid cool	...	7
	S32615	solution treatment	1900 [1040][F]	water or other rapid cool	...	3 or finer
	S32716	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S33228	solution treatment	2050 [1120]	water or other rapid cool	...	...
	S34565	solution treatment	2050–2140 [1120–1170]	water or other rapid cool	...	...
TP347	S34700	solution treatment	1900 [1040][F,H]	water or other rapid cool	...	...
TP347W	S34705	solution treatment	2000 [1100]	water or other rapid cool	...	7-10
TP347H	S34709	solution treatment	cold worked: 2000 [1100] hot rolled: 1925 [1050][H]	water or other rapid cool	...	7
TP347HFG	S34710	solution treatment,[I]	2150 [1175][F]	water or other rapid cool	...	7-10
TP347LN	S34751	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S34752	solution treatment	1940-2138 [1060-1170]	Water or other rapid cool	...	...
TP348	S34800	solution treatment	1900 [1040][F,H]	water or other rapid cool	...	...
TP348H	S34809	solution treatment	cold worked: 2000 [1100] hot rolled: 1925 [1050][H]	water or other rapid cool	...	7
	S35045	solution treatment	2000 [1100][F]	still air cool or faster	...	...
XM-15	S38100	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
	S38815	solution treatment	1950 [1065][F]	water or other rapid cool	...	...

TABLE 3 *Continued*

Grade	UNS Number	Heat Treat Type	Austenitizing/ Solutioning/ Stabilizing Temperature, min or range °F [°C]	Cooling Media	Subcritical Annealing or Tempering Temperature, min or range °F [°C]	ASTM Grain Size No.[B]
Alloy 20	N08020	stabilization treatment	1700-1850 [925-1010][F]	water or other rapid cool	...	...
	N08028	solution treatment	2000 [1100][F]	water or other rapid cool	...	...
	N08029	solution treatment	2000 [1100][F]	water or other rapid cool	...	...
	N08367	solution treatment	2025 [1105][F]	water or other rapid cool	...	...
800	N08800	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
800H	N08810	solution treatment	2050 [1120][F]	water or other rapid cool	...	5
	N08811	solution treatment	2100 [1150][F]	water or other rapid cool	...	5
	N08904	solution treatment	2000 [1100][F]	water or other rapid cool	...	...
	N08925	solution treatment	2010–2100 [1100–1150]	water or other rapid cool	...	...
	N08926	solution treatment	2010–2100 [1100–1150]	water or other rapid cool	...	...
	S35030	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
			Ferritic Stainless Steels			
TP444	S44400	subcritical anneal	...	...	1400 [760]	...

[A] Where ellipses (...) appear in this table there is no requirement.
[B] ASTM Grain Size No. listed, or coarser, unless otherwise indicated.
[C] Approximately, to achieve properties.
[D] Accelerated cooling from the normalizing temperature shall be permitted for section thicknesses greater than 3 in. [75 mm].
[E] Accelerated air cooling or liquid quenching shall be permitted for Class 2.
[F] Quenched in water or rapidly cooled by other means, at a rate sufficient to prevent re-precipitation of carbides, as demonstrable by the capability of tubes, heat treated by either separate solution annealing or by direct quenching, passing Practices A262, Practice E. The manufacturer is not required to run the test unless it is specified on the purchase order (see Supplementary Requirement S4). Note that Practices A262 requires the test to be performed on sensitized specimens in the low-carbon and stabilized types and on specimens representative of the as-shipped condition for other types. In the case of low-carbon types containing 3 % or more molybdenum, the applicability of the sensitizing treatment prior to testing shall be a matter for negotiation between the seller and the purchaser.
[G] A maximum solution treating temperature of 2100 °F [1150 °C] is recommended for UNS S21500.
[H] A solution treating temperature above 1950 °F [1065 °C] may impair resistance to intergranular corrosion after subsequent exposure to sensitizing conditions in the indicated grades. When specified by the purchaser, a lower temperature stabilization or resolution anneal shall be used subsequent to the higher-temperature solution anneal prescribed in this table.
[I] Solution treatment shall be preceded by a softening heat treatment prior to 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.

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

4.1.8 Length (specific or random),

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

4.1.10 Specification designation and year of issue,

4.1.11 Increased sulfur (for machinability, see Note B, Table 1, and 16.3), and

4.1.12 Special requirements and any supplementary requirements selected.

5. General Requirements

5.1 Product furnished to this specification shall conform to the requirements of Specification A1016/A1016M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A1016/A1016M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A1016/A1016M, 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 or stabilization 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.

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 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 E112.

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 15.1.

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, T115, T122, T128, T911, T921, and S44400: $E = 32t + 10.00$ [$E = 1.25t + 10.00$]. For Grade T36: $E = 32t + 5.0$ [$E = 1.25t + 5.0$]. For grade T93: $E = 32t + 9.00$ [$E = 1.25t + 9.00$]. 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 15.2.

9.2 *Hardness Requirements:*

9.2.1 The material shall conform to the hardness requirements given in Table 4. See 15.2.

9.2.2 Brinell, Vickers, or Rockwell hardness tests shall be made on specimens from two tubes from each lot. See 15.2.

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 15.1.

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 15.1.

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. Repair by Welding

12.1 Repair welding shall be performed in conformance with Specification A1016/A1016M.

12.2 All repair welds in T91 shall be made with one of the following welding processes and consumables: SMAW, A5.5/A5.5M E90XX-B9; SAW, A5.23/A5.23M EB9 + neutral flux; GTAW, A5.28/A5.28M ER90S-B9; and FCAW A5.29/A5.29M E91T1-B9. In addition, the sum of the Ni+Mn content of all welding consumables used to weld repair T91 Types 1 and 2 shall not exceed 1.0 %.

12.3 All repair welds in T92, T93, T911, and T122, shall be made using welding consumables meeting the chemical requirements for the grade in Table 1.

13. Permissible Variations from the Specified Wall Thickness

13.1 Permissible variations from the specified minimum wall thickness shall be in accordance with Specification A1016/A1016M.

13.2 Permissible variations from the specified average wall thickness shall be ± 10 % of the specified average wall thickness for cold formed tubes and, unless otherwise specified by the purchaser, shall be in accordance with Table 6 for hot formed tubes.

14. Surface Condition

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

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

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

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

15. Sampling

15.1 For flattening, flaring, and grain size requirements, the term lot applies to all tubes, prior to cutting, of the same size (see 4.1.7) that are produced from the same heat of steel. When

TABLE 4 Tensile and Hardness Requirements

Grade	UNS Designation	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa]	Elongation in 2 in. or 50 mm, min, %[B,C]	Hardness[A]	
					Brinell/Vickers	Rockwell
Low Alloy Steels:						
T5b	K51545	60 [415]	30 [205]	30	179 HBW/ 190HV	89 HRB
T9	K90941	60 [415]	30 [205]	30	179 HBW/ 190HV	89 HRB
T12	K11562	60 [415]	32 [220]	30	163 HBW/ 170 HV	85 HRB
T23	K40712	74 [510]	58 [400]	20	220 HBW/ 230 HV	97 HRB
T24	K30736	85 [585]	60 [415]	20	250 HBW/ 265 HV	25 HRC
T36 Class 1	K21001	90 [620]	64 [440]	15	250 HBW/ 265 HV	25 HRC
T36 Class 2	K21001	95.5 [660]	66.5 [460]	15	250 HBW/ 265 HV	25 HRC
T91 Types 1 and 2	K90901	85 [585]	60 [415]	20	190 to 250 HBW/ 196 to 265 HV	90 HRB to 25 HRC
T92	K92460	90 [620]	64 [440]	20	250 HBW/ 265 HV	25 HRC
T93	K91350	90 [620]	64 [440]	19	250 HBW/ 265 HV	25 HRC
T115	K91060	90 [620]	65 [450]	20	190 to 250 HWB/ 196 to 265 HV	90 HRB to 25 HRC
T122	K91271	90 [620]	58 [400]	20	250 HBW/ 265 HV	25 HRC
T128	K91421	94 [650]	71 [490]	20	265HBW/280HV	27HRC
T911	K91061	90 [620]	64 [440]	20	250 HBW/ 265 HV	25 HRC
T921	K91201	109 [750]	84 [580]	20	276 HBW/ 290 HV	26 HRC
All other low alloy grades		60 [415]	30 [205]	30	163 HBW/ 170 HV	85 HRB
Austenitic Stainless Steels:						
TP201	S20100	95 [655]	38 [260]	35	219 HBW/ 230 HV	95 HRB
TP202	S20200	90 [620]	45 [310]	35	219 HBW/ 230 HV	95 HRB
XM-19	S20910	100 [690]	55 [380]	35	250 HBW/ 265 HV	25 HRC
...	S21500	78 [540]	33 [230]	35	192 HBW/ 200 HV	90 HRB
...	S25700	78 [540]	35 [240]	50	217 HBW	95 HRB
TP304	S30400	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP304L	S30403	70 [485]	25 [170]	35	192 HBW/ 200 HV	90 HRB
TP304H	S30409	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
...	S30432	86 [590]	34 [235]	35	219 HBW/ 230 HV	95 HRB
...	S30434	73 [500]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP304N	S30451	80 [550]	35 [240]	35	192 HBW/ 200 HV	90 HRB
TP304LN	S30453	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
...	S30615	90 [620]	40 [275]	35	192 HBW/ 200 HV	90 HRB
...	S30815	87 [600]	45 [310]	40	217 HBW	95 HRB
TP309S	S30908	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP309H	S30909	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP309LMoN	S30925	93 [640]	38 [260]	30	256 HBW/270 HV	100 HRB
TP309Cb	S30940	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP309HCb	S30941	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB

TABLE 4 *Continued*

Grade	UNS Designation	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa]	Elongation in 2 in. or 50 mm, min, %[B,C]	Hardness[A]	
					Brinell/Vickers	Rockwell
...	S30942	86 [590]	34 [235]	35	219 HBW/ 230 HV	95 HRB
...	S31002	73 [500]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP310S	S31008	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP310H	S31009	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP310MoCbN	S31025	93 [640]	39 [270]	30	256 HBW/ 270 HV	100 HRB
	S31035	95 [655]	45 [310]	40	220 HBW/ 230 HV	96 HRB
TP310Cb	S31040	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP310HCb	S31041	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP310HCbN	S31042	95 [655]	43 [295]	30	256 HBW	100 HRB
...	S31043	95 [655]	43 [295]	30	256 HBW	100 HRB
TP310MoLN	S31050					
$T \leq 0.25$ in. [6 mm]		84 [580]	39 [270]	25	217 HBW	95 HRB
$t > 0.25$ in. [6 mm]		78 [540]	37 [255]	25	217 HBW	95 HRB
...	S31060	87 [600]	41 [280]	40	217 HBW	95 HRB
...	S31254					
$T \leq 0.187$ in. [5 mm]		98 [675]	45 [310]	35	220 HBW/ 230 HV	96 HRB
$T > 0.187$ in. [5 mm]		95 [655]	45 [310]	35	220 HBW/ 230 HV	96 HRB
...	S31266	109 [750]	61 [420]	35	...	B100
...	S31272	65 [450]	29 [200]	35	217 HBW	95 HRB
...	S31277	112 [770]	52 [360]	40	241 HBW	100 HRB
TP316	S31600	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP316L	S31603	70 [485]	25 [170]	35	192 HBW/ 200 HV	90 HRB
TP316H	S31609	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP316Ti	S31635	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP316N	S31651	80 [550]	35 [240]	35	192 HBW/ 200 HV	90 HRB
TP317	S31700	75 [515]	30 [205]	34	192 HBW/ 200 HV	90 HRB
TP317L	S31703	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
...	S31725	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
...	S31730	70 [480]	25 [175]	35	...	90 HRB
	S31740	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
...	S32050	98 [675]	48 [330]	40	256 HBW	100 HRB
TP321	S32100	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP321H	S32109	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
...	S32615	80 [550]	32 [220]	25	192 HBW/ 200 HV	90 HRB
...	S32716	80 [550]	35 [240]	35	192 HBW/ 200 HV	90 HRB
...	S33228	73 [500]	27 [185]	30	192 HBW/ 200 HV	90 HRB
...	S34565	115 [790]	60 [415]	35	241 HBW	100 HRB
TP347	S34700	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP347W	S34705	90 [620]	38 [260]	30	219 HBW/ 230 HV	95 HRB
TP347H	S34709	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP347HFG	S34710	80 [550]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP347LN	S34751	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB

TABLE 4 *Continued*

Grade	UNS Designation	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa]	Elongation in 2 in. or 50 mm, min, %[B,C]	Hardness[A]	
					Brinell/Vickers	Rockwell
...	S34752	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP348	S34800	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
TP348H	S34809	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
...	S35045	70 [485]	25 [170]	35	192 HBW/ 200 HV	90 HRB
XM-15	S38100	75 [515]	30 [205]	35	192 HBW/ 200 HV	90 HRB
...	S38815	78 [540]	37 [255]	30	256 HBW	100 HRB
Alloy 20	N08020	80 [550]	35 [240]	30	217 HBW	95 HRB
	N08028	73 [500]	31 [214]	40	...	...
	N08029	73 [500]	31 [214]	40	...	...
...	N08367	...	...	...	...	...
...	≤3/16 in. wall	100 [690]	45 [310]	30	...	100 HRB
...	>3/16 in. wall	95 [655]	45 [310]	30	241 HBW	...
800	N08800					
...	cold-worked annealed	75 [515]	30 [205]	30	192 HBW/ 200 HV	90 HRB
...	hot-finished annealed	65 [450]	25 [170]	30	192 HBW/ 200 HV	90 HRB
800H	N08810	65 [450]	25 [170]	30	192 HBW/ 200 HV	90 HRB
...	N08811	65 [450]	25 [170]	30	192 HBW/ 200 HV	90 HRB
	N08904	71 [490]	31 [215]	35	192 HBW/ 200 HV	90 HRB
...	N08925	87 [600]	43 [295]	40	217 HBW	95 HRB
...	N08926	94 [650]	43 [295]	35	256 HBW	100 HRB
...	S35030	80 [550]	34 [235]	30	192HBW/ 200HV	90 HRB
Ferritic Stainless Steels:						
TP444	S44400	60[415]	40[275]	20	217 HBW/ 230 HV	96 HRB

[A] Max, unless a range or a minimum is specified.
[B] When standard round 2 in. or 50 mm gauge length or smaller proportionally sized specimens with gauge length equal to 4 *D* (4 times the diameter) is used, the minimum elongation shall be 22 % for all low alloy grades except T23, T24, T91, T92, T93, T115, T122, T128, and T911; and except for TP444.
[C] For longitudinal strip tests, a deduction from the basic minimum elongation values of 1.00 % for TP444, T23, T24, T91, T92, T93, T115, T122, T128, and T911, and of 1.50 % for all other low alloy grades for each 1/32-in. [0.8-mm] decrease in wall thickness below 5/16 in. [8 mm] shall be made.

TABLE 5 Computed Minimum Values[A]

Wall Thickness		Elongation in 2 in. or 50 mm, min, %			
in.	mm	S44400, T23, T24, T91 Types 1 and 2, T92, T921, T115, T122, T128, and T911	T93	T 36	All Other Ferritic Grades
5/16 [0.312]	8	20	19	15	30
9/32 [0.281]	7.2	19	18	14	29
1/4 [0.250]	6.4	18	17	13	27
7/32 [0.219]	5.6	17	16	12	26
3/16 [0.188]	4.8	16	15	11	24
5/32 [0.156]	4	15	14	10	23
1/8 [0.125]	3.2	14	13	9	21
3/32 [0.094]	2.4	13	12	8	20
1/16 [0.062]	1.6	12	11	7	18
0.062 to 0.035, excl	1.6 to 0.9	12	11	7	17
0.035 to 0.022, excl	0.9 to 0.6	11	10	6	17
0.022 to 0.015 incl	0.6 to 0.4	11	10	6	16

[A] Calculated elongation requirements shall be rounded to the nearest whole number.

TABLE 6 Permitted Variations in Average Wall Thickness for Hot Formed Tubes

Specified Outside Diameter, in. [mm]	Tolerance in %, from specified Over	Under
0.405 to 2.875 [10.3 to 73.0] incl, all t/D ratios[A]	20	12.5
Above 2.875 [73.0], t/D ≤ 5 %[A]	22.5	12.5
Above 2.875 [73.0], t/D > 5 %[A]	15	12.5

[A] t = specified wall thickness D = specified outside diameter

TABLE 7 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
2 in. [50.8 mm] and over in outside diameter and under 0.200 in. [5.1 mm] in wall thickness	not more than 75 tubes
Less than 2 in. [50.8 mm] but over 1 in. [25.4 mm] in outside diameter	not more than 75 tubes
1 in. [25.4 mm] or less in outside diameter	not more than 125 tubes

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 7.

15.2 For tensile and hardness test requirements, the term lot applies to all tubes prior to cutting, of the same size (see 4.1.7) 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 the 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, except as prescribed in 9.1.3.

16. Product Marking

16.1 In addition to the marking prescribed in Specification A1016/A1016M, the marking shall include: the condition, hot finished or cold finished; and the wall designation, minimum wall or average wall.

16.2 For the austenitic stainless steels having a grain size requirement (see Table 3) the marking shall also include the heat number and heat-treatment lot identification.

16.3 When either T2 or T12 are ordered with higher sulfur contents as permitted by Note B of Table 1, the marking shall include the letter, S, following the grade designation: T2S or T12S.

16.4 For T91, the marking shall also include the type.

17. Keywords

17.1 alloy steel tubes; austenitic stainless steel; boiler tubes; ferritic stainless steel; heat exchanger tubes; high-temperature applications; seamless steel tubes; steel tubes; superheater tubes; temperature service applications-high

SUPPLEMENTARY REQUIREMENTS

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

S1. Stress-Relieved Annealed Tubes

S1.1 For use in certain corrosives, particularly chlorides where stress corrosion may occur, tubes in Grades TP304L, TP316L, TP321, TP347, and TP348 may be specified in the stress-relieved annealed condition.

S1.2 When stress-relieved tubes are specified, tubes shall be given a heat treatment at 1500 to 1650 °F [815 to 900 °C] after roll straightening. Cooling from this temperature range may be either in air or by slow cooling. No mechanical straightening is permitted after the stress-relief treatment.

S1.3 Straightness of the tubes shall be a matter of negotiation between the purchaser and supplier.

S2. Stabilizing Heat Treatment

S2.1 Subsequent to the solution anneal required in Section 6, Grades TP309HCb, TP310HCb, TP310HCbN, TP321, TP321H, TP347, TP347H, TP348, and TP348H shall be given a stabilization heat treatment at a temperature lower than that used for the initial solution annealing heat treatment. The temperature of stabilization heat treatment shall be at a temperature as agreed upon between the purchaser and vendor.

S3. Unstraightened Tubes

S3.1 When the purchaser specifies tubes unstraightened after final heat treatment (such as coils), the minimum yield strength of Table 4 shall be reduced by 5 ksi [35 MPa].

S3.2 On the certification, and wherever the grade designation for unstraightened tubing appears, it shall be identified with the suffix letter "U" (for example, 304-U, 321-U, etc.).

S4. Intergranular Corrosion Test

S4.1 When specified, material shall pass intergranular corrosion tests conducted by the manufacturer in accordance with Practices A262, Practice E.

NOTE S4.1—Practice E requires testing on the sensitized condition for low carbon or stabilized grades, and on the as-shipped condition for other grades.

S4.2 A stabilization heat treatment in accordance with Supplementary Requirement S2 may be necessary and is permitted in order to meet this requirement for the grades containing titanium or columbium, particularly in their H versions.

S5. Minimum Cooling Rate for Grade T91 Type 2

S5.1 For Grade T91 Type 2 material, the heat treatment shall ensure that following austenitizing the rate of cooling from 1650 °F to 900 °F [900 °C to 480 °C] is no slower than 9 °F/min [5 °C/ min].

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A213/A213M – 22a) that may impact the use of this standard. (Approved May 1, 2023.)

(1) Added Supplementary Requirement S5.
(2) Corrected UNS number for Grade T9 in Table 3.
(3) Revised outside diameter column in Table 6.

Committee A01 has identified the location of selected changes to this standard since the last issue (A213/A213M – 22) that may impact the use of this standard. (Approved Nov. 1, 2022.)

(1) Added Alloy UNS S35030 to Table 2, Table 3, and Table 4.

Committee A01 has identified the location of selected changes to this standard since the last issue (A213/A213M – 21b) that may impact the use of this standard. (Approved May 1, 2022.)

(1) Revised carbon maximum for UNS S31002 in Table 2.
(2) Revised nitrogen from 0.18–0.22 to 0.18–0.25 for UNS S31254 in Table 2.

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