



# Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes<sup>1</sup>

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 ( $\epsilon$ ) 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<sup>2</sup> 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  $\frac{1}{8}$  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.*

<sup>1</sup> 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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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-213 in Section II of that Code.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

**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<sup>4</sup>

**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**),

<sup>3</sup> 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.

<sup>4</sup> 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, %<sup>A</sup>, for Low Alloy Steel

Grade	UNS Designation	Composition, %											Tungsten	Other Elements			
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Nickel	Chromium	Molybdenum	Vanadium	Boron	Niobium <sup>F</sup>			Nitrogen	Aluminum	
T2	K11547	0.10-0.20	0.30-0.61	0.025	0.025 <sup>B</sup>	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 <sup>B</sup>	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	0.015	0.030	1.45-1.75	Ti 0.005-0.060 Ti/N $\geq$ 3.5 <sup>C</sup> Ti		
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	...	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	0.02	...	Ti 0.01 Zr 0.01		
T91 Type 2	K90901	0.08-0.12	0.30-0.50 <sup>D</sup>	0.020 <sup>D</sup>	0.005 <sup>D</sup>	0.20-0.40 <sup>D</sup>	0.20 <sup>D</sup>	8.0-9.5 <sup>D</sup>	0.85-1.05	0.18-0.25	0.001 <sup>D</sup>	0.06-0.10	0.020 <sup>D</sup>	0.05 <sup>D</sup>	Ti 0.01 <sup>D</sup> Zr 0.01 <sup>D</sup> Cu 0.10 <sup>D</sup> Sb 0.003 <sup>D</sup> Sn 0.010 <sup>D</sup> As 0.010 <sup>D</sup> N/Al 4.0 min		
Product		0.07-0.13						0.80-1.05	0.16-0.27			0.05-0.11					
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	0.02	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	0.08-0.13	0.20-0.50	0.020	0.010	0.15-0.45	0.25	10.0-11.5	0.40-0.60	0.18-0.25	0.001	0.02-0.06	0.02	...	Ti 0.01 Zr 0.01		
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	0.02	1.50-2.50	Cu 0.30-1.70 Ti 0.01		
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	0.02	0.90-1.10	Zr 0.01 Ti 0.01 Zr 0.01		

<sup>A</sup> 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.

<sup>B</sup> It is permissible to order T2 and T12 with a sulfur content of 0.045 max. See 16.3.

<sup>C</sup> 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.

<sup>D</sup> Applies to both heat and product analyses.

<sup>E</sup> The terms Niobium (Nb) and Columbian (Cb) are alternate names for the same element.

<sup>F</sup> Grade T93 shall have a Nb + Ta content of 0.05-0.12 %.



TABLE 2 Chemical Composition Limits, %<sup>A</sup>, for Austenitic and Ferritic Stainless Steel

Grade	UNS Designation	Composition											Other Elements
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Nitrogen <sup>B</sup>	Niobium <sup>N</sup>	Titanium	
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
<sup>C</sup>	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
<sup>C</sup>	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 <sup>D</sup>	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	...	...	...	...	...
<sup>C</sup>	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
<sup>C</sup>	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 <sup>F</sup>	0.10-0.25 <sup>F</sup>	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 <sup>D</sup>	2.00	0.045	0.030	1.00	18.0-20.0	8.0-11.0	...	0.10-0.16	...	...	...
<sup>C</sup>	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
<sup>C</sup>	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
<sup>C</sup>	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	...	...	...	...	...
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 W 3.0-4.0 Co 1.0-2.0 Cu 2.5-3.5 B 0.002-0.008
...	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	...	...
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	...	...	...
<sup>C</sup>	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
<sup>C</sup>	S31254	0.020	1.00	0.030	0.010	0.80	19.5-20.5	17.5-18.5	6.0-6.5	0.18-0.22	...	...	Cu 0.50-1.00
...	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



TABLE 2 Continued

Grade	UNS Designation	Composition											Other Elements
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Nitrogen <sup>P</sup>	Niobium <sup>M</sup>	Titanium	
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 Cu 0.50-1.50
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	...	...	...
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 <sup>D</sup>	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 <sup>D</sup>	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	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 <sup>F</sup>	...	...
TP348	S34800	0.08	2.00	0.045	0.030	1.00	17.0-19.0	9.0-13.0	...	...	<sup>G</sup>	...	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	...	...	<sup>H</sup>	...	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	...	<sup>M</sup>	...	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
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/39.5 min



TABLE 2 Continued

Grade	UNS Designation	Composition										Other Elements			
		Carbon	Manga- nese	Phospho- rus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Nitrogen <sup>B</sup>	Niobium <sup>N</sup>		Titanium		
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/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 <sup>J</sup> Ti 0.15-0.60 <sup>J</sup> Fe/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	κ	1.75-2.50	0.035	...	...	...	...	...

<sup>A</sup>Maximum, unless a range or minimum is indicated. Where ellipses (...) appear in this table, there is no minimum and analysis for the element need not be determined or reported.

<sup>B</sup>The method of analysis for Nitrogen shall be a matter of agreement between the purchaser and the producer.

<sup>C</sup>For these alloys, there is no common grade designation. The UNS number uniquely identifies these alloys.

<sup>D</sup>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.

<sup>E</sup>Grade S30434 shall have (Ti + 1/2 Nb) of not less than 2 times and not more than 4 times the carbon content.

<sup>F</sup>Grade TP347LN shall have an Nb content of not less than 15 times the carbon content.

<sup>G</sup>Grade TP348 shall have an Nb + Ta content of not less than 10 times the carbon content and not more than 1.10 %.

<sup>H</sup>Grade TP348H shall have an Nb + Ta content of not less than 8 times the carbon content and not more than 1.10 %.

<sup>I</sup>Iron shall be determined arithmetically by difference of 100 minus the sum of the other specified elements.

<sup>J</sup>Al + Ti shall be 0.85 % min; 1.20 % max.

<sup>K</sup>Grade TP444 shall have Ni + Cu = 1.00 max.

<sup>L</sup>Grade TP444 shall have Ti + Nb content not less than 0.20 + 4(C+N) and not more than 0.80 %.

<sup>M</sup>N08020 shall have an Nb + Ta content of not less than 8 times the carbon content and not more than 1.00%.

<sup>N</sup>The terms Niobium (Nb) and Columblum (Cb) are alternate names for the same element.



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### TABLE 3 Heat Treatment and Grain Size Requirements<sup>A</sup>

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. <sup>B</sup>
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] <sup>C</sup>	...
T9	S50400	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]	<i>D</i>	1350–1420 [730–770]	...
T36	K21001	normalize and temper	1650 [900]	<i>E</i>	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]	...
T911	K91061	normalize and temper	1900–1975 [1040–1080]	<i>D</i>	1365–1435 [740–780]	...
Austenitic Stainless Steels						
TP201	S20100	solution treatment	1900 [1040] <sup>F</sup>	water or other rapid cool	...	...
TP202	S20200	solution treatment	1900 [1040] <sup>F</sup>	water or other rapid cool	...	...
XM-19	S20910	solution treatment	1900 [1040] <sup>F</sup>	water or other rapid cool	...	...
	S21500	solution treatment	1900 [1040] <sup>F,G</sup>	water or other rapid cool	...	...
TP304	S25700	solution treatment	1900 [1040] <sup>F</sup>	water or other rapid cool	...	...
	S30400	solution treatment	1900 [1040] <sup>F</sup>	water or other rapid cool	...	...
TP304L	S30403	solution treatment	1900 [1040] <sup>F</sup>	water or other rapid cool	...	...
TP304H	S30409	solution treatment	1900 [1040]	water or other rapid cool	...	7
	S30432	solution treatment	2000 [1100] <sup>F</sup>	water or other rapid cool	...	...
	S30434	solution treatment	2120 [1160]	water or other rapid cool	...	...