ASTM - A213/A213M
Standard Specification for
Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes

This specification covers seamless ferritic and austenitic steel boiler, superheater, and heat-exchanger tubes.

The tubing sizes and thicknesses usually furnished to this specification are 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.

A. <u>Manufacture :-</u>

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

B. <u>Heat Treatment :-</u>

1. Ferritic Alloy and Ferritic Stainless Steels :-
   - i. The ferritic alloy and ferritic stainless steels shall be reheated for heat treatment in accordance with the requirements of Table 1.
2. Austenitic Stainless Steels :-
   - i. All austenitic tubes shall be furnished in the heat-treated condition, and shall be heat treated in accordance with the requirements of Table 3.
   - ii. Other than for Grades S30815, S30942, S31272, S33228, and H Grades, seamless tubing immediately following hot forming may be individually quenched in the water or rapidly cooled by other means, provided that the temperature of the tubes after hot forming is not less than the minimum specified solution temperature.
   - iii. For H grades, as well as Grades S30815, S30942, S31272, S33228, and S30432, the tubes shall be reheated to the specified solution treatment temperature for the required time before quenching.

Table 1[A]

Grade	UNS Number	Heat Treat Type	Austenitizing/ Solutioning Temperature, min or range °F [°C]	Cooling Media	Subcritical Annealing or Tempering	ASTM Grain Size No.[B]
					Temperature, min or range °F [°C]	
Ferritic Alloy Steels						
T2	K11547	full or isothermal anneal	...	...	...	...
		normalize and temper	...	...	...	...
		subcritical anneal	...	...	1200 to 1350 [650 to 730]	
T5	K41545	full or isothermal anneal	...	...	...	...
		normalize and temper	...	...	1250 [675]	...
T5b	K51545	full or isothermal anneal	...	...	...	...
		normalize and temper	...	...	1250 [675]	...
T5c	K41245	subcritical anneal	...	air or furnace	1350 [730][C]	...

...

T9	K90941	full or isothermal anneal	...	...	...	...
		normalize and temper	...	...	1250 [675]	...
T11	K11597	full or isothermal anneal	...	...	...	...
		normalize and temper	...	...	1200 [650]	...
T12	K11562	full or isothermal anneal	...	...	...	...
		normalize and temper	...	...	...	...
		subcritical anneal	...	...	1200 to 1350 [650 to 730]	
T17	K12047	full or isothermal anneal	...	...	...	...
		normalize and temper	...	...	1200 [650]	...
T21	K31545	full or isothermal anneal	...	...	...	...
		normalize and temper	...	...	1250 [675]	...
T22	K21590	full or isothermal anneal	...	...	...	...
		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	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]	...
T122	K91271	normalize and temper	1900–1975 [1040–1080]	...	1350–1470 [730–800]	...
T911	K91061	normalize and temper	1900–1975 [1040–1080]	[D]	1365–1435 [740–780]	...
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	...	...

						...
			1900 [1040]	water or other rapid cool	...	...
	S21500	solution treatment	[F,G]			
	S25700	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP310MoLN	S31050	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP304	S30400	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP304L	S30403	solution treatment	1900 [1040][F]	water or other rapid cool	...	...
TP304H	S30409	solution treatment	1900 [1040][F]	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	...	

...

1900 [1040] 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] [F]	water or other rapid cool	...	7
TP310Cb	S31040	solution treatment				
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
	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	...	...

						...
			1900 [1040]	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]	water or other rapid cool	...	7
			hot rolled: 1925 [1050][H]		...	...
	S32615	solution treatment	1900 [1040][F]	water or other rapid cool	...	3 or finer
	S32716	solution treatment	[F]			
	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	...	7.0-10.0
TP347H	S34709	solution treatment	cold worked: 2000 [1100]	water or other rapid cool	...	7
			hot rolled: 1925 [1050][H]		...	...
TP347HFG	S34710	solution treatment,[I]	2150 [1175][F]	water or other rapid cool	...	7.0-10.0
TP347LN	S34751	solution treatment	1900 [1040][F]	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]	water or other rapid cool	...	7

...

1900 [1040] water or other rapid cool ...

			hot rolled: 1925 [1050][H]		...	...
	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	...	...
Alloy 20	N08020	stabilization treatment	1700-1850[F] [925-1010]	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	...	...
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. 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.

C. <u>Chemical Composition :-</u>

1. The alloy steels shall conform to the chemical requirements given in Table 2.
2. The stainless steels shall conform to the chemical requirements given in Table 3.

Table 2[A]

Grade	UNS	C	Mn	P	S	Si	Cr	Ni	Mo	Other

...

	Designation									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	0.5	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	0.5	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]	0.5	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	...	...	V [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	0.5	1.90–2.60	...	0.87–1.13	
T23	K40712	0.04–0.10	0.10–0.60	0.03	0.01	0.5	1.90–2.60	0.4	0.05–0.30	V [0.20–0.30], B [0.001–0.006], Cb [0.02–0.08], N [0.015],Al [0.03], W [1.45–1.75], Ti [0.005–0.060], Ti/N ≥3.5[C]
T24	K30736	0.05–0.10	0.30–0.70	0.02	0.01	0.15–0.45	2.20–2.60	...	0.90–1.10	V [0.20–0.30], B [0.0015–0.007], N [0.012], Al [0.02], Ti [0.06–0.10]
T36	K21001	0.10–0.17	0.80–1.20	0.03	0.025	0.25–0.50	0.3	1.00–1.30	0.25–0.50	V [0.02], Cb [0.015–0.045], N [0.02], Al [0.05], Cu [0.50–0.80]
T91	K90901	0.07–0.14	0.30–0.60	0.02	0.01	0.20–0.50	8.0–9.5	0.4	0.85–1.05	V [0.18–0.25], Cb [0.06–0.10], N [0.030–0.070], Al [0.02], Ti [0.01], Zr [0.01]
T92	K92460	0.07–0.13	0.30–0.60	0.02	0.01	0.5	8.5–9.5	0.4	0.30–0.60	V [0.15–0.25], B [0.001–0.006], Cb [0.04–0.09], N [0.030–0.070], Al [0.02], W [1.5-2.0], Ti [0.01], Zr [0.01]
T122	K91271	0.07–0.14	0.7	0.02	0.01	0.5	10.0–11.5	0.5	0.25–0.60	V [0.15–0.30], B [0.0005–0.005], Cb [0.04–0.10], N [0.040–0.100], Al [0.02], W [1.5-2.5], Ti [0.01], Zr [0.01], Cu [0.3-1.7]
T911	K91061	0.09–0.13	0.30–0.60	0.02	0.01	0.10–0.50	8.5–9.5	0.4	0.90–1.10	V [0.18–0.25], B [0.0003–0.006], Cb [0.06–0.10], N [0.040–0.090], Al [0.02], W [0.9-1.1], Ti [0.01], Zr [0.01]

[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.*

...

[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.*

Table 3[A]

Grade	UNS Designation	C	Mn	P	S	Si	Cr	Ni	N[B]	Other Elements

TP201	S20100	0.15	5.5–7.5	0.06	0.03	1	16.0–18.0	3.5–5.5	0.25	
TP202	S20200	0.15	7.5–10.0	0.06	0.03	1	17.0–19.0	4.0–6.0	0.025	
XM-19	S20910	0.06	4.0–6.0	0.045	0.03	1	20.5–23.5	11.5–13.5	0.20–0.40	Mo [1.50–3.00], Cb [0.1-0.3], V [0.10–0.30]
C	S21500	0.06–0.15	5.5–7.0	0.045	0.03	0.20–1.00	14.0–16.0	9.0–11.0	...	Mo [0.80–1.20], Cb [0.75-1.25], B [0.003–0.009],V [0.15–0.40]
C	S25700	0.02	2	0.025	0.01	6.5–8.0	8.0–11.5	22.0–25.0	...	Mo [0.50]
TP304	S30400	0.08	2	0.045	0.03	1	18.0–20.0	8.0–11.0	...	
TP304L	S30403	0.035[D]	2	0.045	0.03	1	18.0–20.0	8.0–12.0	...	
TP304H	S30409	0.04–0.10	2	0.045	0.03	1	18.0–20.0	8.0–11.0	...	
C	S30432	0.07–0.13	1	0.04	0.01	0.3	17.0–19.0	7.5–10.5	0.05–0.12	Cb [0.3-0.6], Al [0.003–0.030], B [0.001–0.010], Cu [2.5–3.5]
C	S30434	0.07–0.14	2	0.04	0.01	1	17.5–19.5	9.0–12.0	...	Cb [0.1-0.4[E]], Ti [0.1-0.25[E]], B [0.001–0.004], Cu [2.50–3.50]
TP304N	S30451	0.08	2	0.045	0.03	1	18.0–20.0	8.0–11.0	0.10–0.16	
TP304LN	S30453	0.035D	2	0.045	0.03	1	18.0–20.0	8.0–11.0	0.10–0.16	
C	S30615	0.016–0.24	2	0.03	0.03	3.2–4.0	17.0–19.5	13.5–16.0	...	Al [0.8–1.5]
C	S30815	0.05–0.10	0.8	0.04	0.03	1.40–2.0	20.0–22.0	10.0–12.0	0.14–0.20	Ce [0.03–0.08]
TP309S	S30908	0.08	2	0.045	0.03	1	22.0–24.0	12.0–15.0	...	
TP309H	S30909	0.04–0.10	2	0.045	0.03	1	22.0–24.0	12.0–15.0	...	
TP309LMoN	S30925	0.025	2	0.04	0.03	0.7	23.0–26.0	13.0–16.0	0.25–0.40	Mo [0.5-1.2]
TP309Cb	S30940	0.08	2	0.045	0.03	1	22.0–24.0	12.0–16.0	...	Cb [10*C-1.10]
TP309HCb	S30941	0.04–0.10	2	0.045	0.03	1	22.0–24.0	12.0–16.0	...	Cb [10*C-1.10]
...	S30942	0.03–0.10	2	0.04	0.03	1	21.0–23.0	14.5–16.5	0.10–0.20	Cb [0.5-0.8], B [0.001–0.005]
C	S31002	0.02	2	0.02	0.015	0.15	23.0–26.0	19.0–22.0	0.1	Mo [0.1]
TP310S	S31008	0.08	2	0.045	0.03	1	23.0–26.0	19.0–22.0		
TP310H	S31009	0.04–0.10	2	0.045	0.03	1	23.0–26.0	19.0–22.0		

TP310MoCbN	S31025	0.1	1.5	0.03	0.03	1	19.5–23.0	23.0–26.0	0.10–0.25	Mo [0.10-0.20], Cb [0.1-0.4], Ti [0.2], B [0.002–0.010]
	S31035	0.04–0.10	0.6	0.025	0.015	0.4	21.5–23.5	23.5–26.5	0.20–0.30	Cb [0.4-0.6], 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	0.045	0.03	1	24.0–26.0	19.0–22.0	...	Cb [10*C-1.10]
TP310HCb	S31041	0.04–0.10	2	0.045	0.03	1	24.0–26.0	19.0–22.0	...	Cb [10*C-1.10]
TP310HCbN	S31042	0.04–0.10	2	0.045	0.03	1	24.0–26.0	19.0–22.0	0.15–0.35	Cb [0.2-0.6]
TP310MoLN	S31050	0.025	2	0.02	0.03	0.4	24.0–26.0	21.0–23.0	0.10–0.16	Mo [2.0-3.0]
C	S31060	0.05–0.10	1	0.04	0.03	0.5	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	0.02	1	0.03	0.01	0.8	19.5–20.5	17.5–18.5	0.18–0.22	Mo [6.0-6.5], Cu [0.50–1.00]
...	S31266	0.03	2.00–4.00	0.035	0.02	1	23.0–25.0	21.0–24.0	0.35–0.60	Mo [5.2-6.2], Cu [1.00–2.00], W [1.50–2.50]
C	S31272	0.08-0.12	1.50–2.00	0.03	0.015	0.30–0.70	14.0–16.0	14.0–16.0	...	Mo [1.00–1.40], Ti [0.30–0.60], B [0.004–0.008]
C	S31277	0.02	3	0.03	0.01	0.5	20.5–23.0	26.0–28.0	0.30–0.40	Mo [6.5–8.0], Cu [0.50–1.50]
TP316	S31600	0.08	2	0.045	0.03	1	16.0–18.0	10.0–14.0	...	Mo [2.00–3.00]
TP316L	S31603	0.035[D]	2	0.045	0.03	1	16.0–18.0	10.0–14.0	...	Mo [2.00–3.00]
TP316H	S31609	0.04–0.10	2	0.045	0.03	1	16.0–18.0	10.0–14.0	...	Mo [2.00–3.00]
TP316Ti	S31635	0.08	2	0.045	0.03	0.75	16.0–18.0	10.0–14.0	0.1	Mo [2.00–3.00], Ti [5*(C + N)–0.70]
TP316N	S31651	0.08	2	0.045	0.03	1	16.0–18.0	10.0–13.0	0.10–0.16	Mo [2.00–3.00]
TP316LN	S31653	0.035[D]	2	0.045	0.03	1	16.0–18.0	10.0–13.0	0.10–0.16	Mo [2.00–3.00]
TP317	S31700	0.08	2	0.045	0.03	1	18.0–20.0	11.0–15.0	...	Mo [3.0–4.0]
TP317L	S31703	0.035	2	0.045	0.03	1	18.0–20.0	11.0–15.0	...	Mo [3.0–4.0]
TP317LM	S31725	0.03	2	0.045	0.03	1	18.0–20.0	13.5–17.5	0.2	Mo [4.0–5.0], Cu [0.75]
TP317LMN	S31726	0.03	2	0.045	0.03	1	17.0–20.0	13.5–17.5	0.10–0.20	Mo [4.0–5.0], Cu [0.75]

C	S32050	0.03	1.5	0.035	0.02	1	22.0–24.0	20.0–23.0	0.21–0.32	Mo [6.0–6.8], Cu [0.40]

TP321	S32100	0.08	2	0.045	0.03	1	17.0–19.0	9.0–12.0	...	Ti [5*(C + N)–0.70]

TP321H	S32109	0.04–0.10	2	0.045	0.03	1	17.0–19.0	9.0–12.0	...	Ti [4*(C + N)–0.70]

C	S32615	0.07	2	0.045	0.03	4.8–6.0	16.5–19.5	19.0–22.0	...	Mo [0.30–1.50], Cu [1.50–2.50]

C	S33228	0.04–0.08	1	0.02	0.015	0.3	26.0–28.0	31.0–33.0	...	Cb [0.60–1.00], Ce [0.05–0.10], Al [0.025]
C	S34565	0.03	5.0–7.0	0.03	0.01	1	23.0–25.0	16.0–18.0	0.40–0.60	Mo [4.0–5.0], Nb [0.1]
TP347	S34700	0.08	2	0.045	0.03	1	17.0–20.0	9.0–13.0	...	Nb [10*C-1.1]
TP347W	S34705	0.05	2	0.04	0.03	1	17.0–20.0	8.00–11.0	0.10–0.25	Nb [0.25–0.50], V [0.20–0.50], W [1.50–2.60]
TP347H	S34709	0.04–0.10	2	0.045	0.03	1	17.0–19.0	9.0–13.0	...	Nb [8*C-1.1]
TP347HFG	S34710	0.06–0.10	2	0.045	0.03	1	17.0–19.0	9.0–13.0	...	Nb [8*C-1.1]
TP347LN	S34751	0.005–0.020	2	0.045	0.03	1	17.0–19.0	9.0–13.0	0.06–0.10	Nb [0.25–0.50F]
TP348	S34800	0.08	2	0.045	0.03	1	17.0–19.0	9.0–13.0	...	[G], Co [0.20], Ta [0.10]
TP348H	S34809	0.04–0.10	2	0.045	0.03	1	17.0–19.0	9.0–13.0	...	[H], Co [0.20], Ta [0.10]
…	S35045	0.06–0.10	1.5	0.045	0.015	1	25.0–29.0	32.0–37.0	...	Ti [0.15–0.60], Al [0.15–0.60], Cu [0.75]
XM-15	S38100	0.08	2	0.03	0.03	1.50–2.50	17.0–19.0	17.5–18.5	...	
...	S38815	0.03	2	0.04	0.02	5.5–6.5	13.0–15.0	15.0–17.0	...	Mo [0.75–1.50], Cu [0.75–1.50], Al [0.30]
Alloy 20	N08020	0.07	2	0.045	0.035	1	19.0-21.0	32.0-38.0	...	Mo [2.00-3.00], [M], Cu [3.00-4.00]
C	N08367	0.03	2	0.04	0.03	1	20.0-22.0	23.5-25.5	0.18-0.25	Mo [6.00-7.00], Cu [0.75]
800	N08800	0.1	1.5	0.045	0.015	1	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	1.5	0.045	0.015	1	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	1.5	0.045	0.015	1	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	0.02	2	0.04	0.03	1	19.0–23.0	23.0–28.0	0.1	Mo [4.0–5.0], Cu [1.00–2.00]

...	N08925	0.02	1	0.045	0.03	0.5	19.0–21.0	24.0–26.0	0.10–0.20	Mo [6.0–7.0], Cu [0.80–1.50]
...	N08926	0.02	2	0.03	0.01	0.5	19.0–21.0	24.0–26.0	0.15–0.25	Mo [6.0–7.0], Cu [0.50–1.50]
TP444	S44400	0.03	1	0.04	0.03	1	17.5–19.5	[K]	0.035	Mo [1.75–2.50], [L]

[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 + 1/2 Nb) of not less than 2 times and not more than 4 times the carbon content.* [F] *Grade TP347LN 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) 0.85–1.20.*

[K] *Grade TP444 shall have Ni + Cu = 1.00 max.*

[L] *Grade TP444 shall have Ti + Nb = 0.20 + 4(C + N)–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%.*

D. <u>Grain Size :-</u>

1. Grain size shall be as given in Table 1, as determined in accordance with Test Methods E112.

E. <u>Mechanical Properties :-</u> 1.

Tensile Requirements :-

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

ii. Table 5 gives the computed minimum elongation values for each 1⁄32-in. [0.8-mm] decrease in wall thickness.

iii. 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 T36: $E = 32t + 5.0$ [$E = 1.25t + 5.0$].

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].

2. Hardness Requirements :- The material shall conform to the hardness requirements given in Table 4. 3. Flattening Test :-

4. Flaring Test :-

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.

Table 4

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	K90901	85 [585]	60 [415]	20	190 to 250 HBW/ 196 to 265 HV	90 HRB to 25HRC
T92	K92460	90 [620]	64 [440]	20	250 HBW/265 HV	25 HRC
T122	K91271	90 [620]	58 [400]	20	250 HBW/265 HV	25 HRC
T911	K91061	90 [620]	64 [440]	20	250 HBW/265 HV	25 HRC
All other low alloy grades		60 [415]	30 [205]	30	163 HB/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 90 HRB	80 [550]	35 [240]	35	192 HBW/200 HV	
TP304LN	S30453 90 HRB	75 [515]	30 [205]	35	192 HBW/200 HV	
...	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
...	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

TP310Cb	S31035	95 [655]	45 [310]	40 35	220 HBW/230 HV	96 HRB
	S31040	75 [515]	30 [205]		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
TP310MoLN	S31050					
	T ≤ 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 ≤ 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 35	192 HBW/200 HV	90 HRB
TP316N	S31651	80 [550]	35 [240]		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
TP317LM	S31725	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

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
...	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
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 4D (4 times the diameter) is used, the minimum elongation shall be 22 % for all low alloy grades except T23, T24, T91, T92, T122, 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, T122, 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

Wall Thickness		Elongation in 2 in. or 50 mm, min, % [A]		
in.	mm	S44400,T23, T24, T91,T92, T122, and T911	T 36	All Other Ferritic Grades

5⁄16 (0.312)	8	20	15	30
1⁄16 (0.062)	1.6	12	7	18
0.062 to 0.035, excl	1.6 to 0.9	12	7	17
0.035 to 0.022 , excl	0.9 to 0.6	11	6	17
0.022 to 0.015, excl	0.6 to 0.4	11	6	16
9⁄32 (0.281)	7.2	19	14	29
1⁄4 (0.250)	6.4	18	13	27
7⁄32 (0.219)	5.6	17	12	26
3⁄16 (0.188)	4.8	16	11	24
5⁄32 (0.156)	4	15	10	23
1⁄8 (0.125)	3.2	14	9	21
3⁄32 (0.094)	2.4	13	8	20

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

F. <u>Hydrostatic or Non-destructive Electric Test :-</u>

1. Each tube shall be subjected to the non-destructive 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.

G. Permissible Variations from the Specified Wall Thickness

1. 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.

Table 6

Above 2½ [65], t/D ≤ 5 %[A]	22.5	12.5
Above 2½ [65], t/D > 5 %[A]	15	12.5
NPS [DN] Designator	**Tolerance in %, from specified**	
	Over	**Under**
⅛ to 2½ [6 to 65] incl, all t/D ratios[A]	20	12.5

[A] *t = specified wall thickness, D = specified outside diameter.*

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