

ASTM - A249/A249M

Standard Specification for

Welded Austenitic Steel Boiler, Superheater, Heat- Exchanger, and Condenser Tubes

This specification covers nominal-wall-thickness welded tubes and heavily cold worked welded tubes made from the austenitic steels listed in Table 1, with various grades intended for such use as boiler, superheater, heat exchanger, or condenser tubes.

Grades TP304H, TP309H, TP309HCb, TP310H, TP310HCb, TP316H, TP321H, TP347H, and TP348H are modifications of Grades TP304, TP309S, TP309Cb, TP310S, TP310Cb, TP316, TP321, TP347, and TP348, and are intended for high-temperature service such as for superheaters and reheaters. The tubing sizes and thicknesses usually furnished to this specification are 1/8 in. [3.2 mm] in inside diameter to 12 in. [304.8 mm] in outside diameter and 0.015 to 0.320 in. [0.4 to 8.1 mm], inclusive, in wall thickness.

Tubing having other dimensions may be furnished, provided such tubes comply with all other requirements of this specification.

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

A. Heat Treatment :-

1. All material shall be furnished in the heat-treated condition in accordance with the requirements of Table 1.
2. A solution annealing temperature above 1950 °F [1065 °C] may impair the resistance to intergranular corrosion after subsequent exposure to sensitizing conditions in TP309HCb, TP310HCb, TP321, TP321H, TP347, TP347H, TP348, and TP348H.
3. When specified by the purchaser, a lower temperature stabilization or re-solution anneal shall be used subsequent to the initial high temperature solution anneal.
4. N08020 shall be supplied in the stabilization treatment condition.

Table 1

Grade	UNS Number	Solutioning Temperature, min or range	Quenching Method
All grades not individually listed below		1900 °F [1040 °C]	A
...	S30601	2010 to 2140 °F [1100 to 1170 °C]	B
...	S30815	1920 °F [1050 °C]	B

TP309HCb	S30941	1900 °F [1040 °C] ^C	B
TP310H	S31009	1900 °F [1040 °C]	B
TP310HCb	S31041	1900 °F [1040 °C] ^C	B
...	S31254	2100 °F [1150 °C]	B
...	S31266	2100 °F [1150 °C]	B
...	S31277	2050 °F [1120 °C]	B
TP316H	S31609	1900 °F [1040 °C]	B
...	S31727	1975 °F [1080 °C]–2155 °F [1180 °C]	B
...	S32053	1975 °F [1080 °C]–2155 °F [1180 °C]	B
TP321	S32100	1900 °F [1040 °C] ^C	B
TP321H	S32109	2000 °F [1100 °C] ^C	B
...	S32654	2100 °F [1150 °C]	B
...	S33228	2050 °F [1120 °C]	B
...	S34565	2050 °F [1120 °C]–2140 °F [1170 °C]	B
TP347	S34700	1900 °F [1040 °C] ^C	B
TP347H	S34709	2000 °F [1100 °C] ^C	B
TP348	S34800	1900 °F [1040 °C] ^C	B
TP348H	S34809	2000 °F [1100 °C] ^C	B
...	S35045	2000 °F [1100 °C]	D
...	S38815	1950 °F [1065 °C]	B
Alloy 20	N08020	1700–1850 °F [925–1010 °C] stabilization treatment	B
...	N08367	2025 °F [1110 °C]	B
800	N08800	1900 °F [1040 °C]	B
800H	N08810	2050 °F [1120 °C]	B
...	N08811	2100 °F [1150 °C]	B
...	N08904	2000 °F [1100 °C]	B
...	N08926	2010 °F [1105 °C]	B

^A Quenched in water or rapidly cooled by other methods, at a rate sufficient to prevent reprecipitation of chromium carbides, as demonstrated by the capability of passing Practices A262, Practice E. The manufacturer is not required to run the test unless it is specified on the purchase order.

In the case of low-carbon types containing 3 % or more molybdenum, the applicability of the sensitizing treatment prior to testing shall be matter for negotiation between the seller and purchaser.

^B Quenched in water or rapidly cooled by other methods.

^C 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 re-solution anneal shall be used subsequent to the higher-temperature solution anneal prescribed in this table. ^D Cooled in still air, or faster.

B. Chemical Composition :-

The heat analysis shall conform to the requirements as to chemical composition given in Table 2.

Table 2

Grade	UNS Designation ^B	C	Mg	P	S	Si	Cr	Ni	Mo	N ^C	Other
TP 201	S20100	0.15	5.50–7.5	0.06	0.03	1	16.0–18.0	3.5–5.5	...	0.25	...
TP 201LN	S20153	0.03	6.4–7.5	0.045	0.015	0.75	16.0–17.5	4.0–5.0	...	0.10–0.25	Cu [1]
TP 202	S20200	0.15	7.5–10.0	0.06	0.03	1	17.0–19.0	4.0–6.0	...	0.25	...
TPXM-19	S20910	0.06	4.0–6.0	0.045	0.03	1	20.5–23.5	11.5–13.5	1.50–3.00	0.20–0.40	Cb [0.10–0.30], V [0.10–0.30]
TPXM-29	S24000	0.08	11.5–14.5	0.06	0.03	1	17.0–19.0	2.3–3.7	...	0.20–0.40	...
TP304	S30400	0.08	2	0.045	0.03	1	18.0–20.0	8.0–11.0	...	...	...
TP304L ^D	S30403	0.03	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	...	...	...
...	S30415	0.04–0.06	0.8	0.045	0.03	1.00–2.00	18.0–19.0	9.0–10.	...	0.12–0.18	Ce [0.03–0.08]
TP304N	S30451	0.08	2	0.045	0.03	1	18.0–20.0	8.0–11.0	...	0.10–0.16	...
TP304LN ^D	S30453	0.03	2	0.045	0.03	1	18.0–20.0	8.0–11.0	...	0.10–0.16	...

TP305	S30500	0.12	2	0.045	0.03	1	17.0–19.0	11.0– 13.0
...	S30615	0.16–0.24	2	0.03	0.03	3.2–4.0	17.0–19.5	13.5– 16.0

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				0.03							
...	S30815	0.05–0.10	0.8	0.04	0.03	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	0.045		1	22.0–24.0	12.0 ⁻
TP309H	S30909	0.04–0.10	2	0.045	0.03	1	22.0–24.0	15.0 12.0– 15.0	...	...	...
...	S30601	0.015	0.50–0.80	0.03	0.013	5.0–5.6	17.0–18.0	17.0– 18.0	0.2	0.05	Cu [0.35]
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]
TP310S	S31008	0.08	2	0.045	0.03	1	24.0–26.0	19.0– 22.0	...	...	...
TP310H	S31009	0.04–0.10	2	0.045	0.03	1	24.0–26.0	19.0– 22.0	...	...	...
TP310Cb	S31040	0.08	2	0.045	0.03	1	24.0–26.0	18.0– 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]
...	S31050	0.03	2	0.03	0.015	0.4	24.0–26.0	21.0– 23.0	2.00–3.00	0.10–0.16	...
...	S31254	0.02	1	0.03	0.01	0.8	19.5–20.5	17.5– 18.5	6.0–6.5	0.18–0.25	Cu [0.50–1.00]

0.03

0.03

...	S31266	0.03	2.00–4.00	0.035	0.02	1	23.0–25.0	21.0–24.0	5.2–6.2	0.35–0.60	W [1.50–2.50], Cu [1.00–2.50]
...	S31277	0.02	3	0.03	0.01	0.5	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	0.045	0.03	1	16.0–18.0	10.0–14.0	2.00–3.00	...	...
TP316L ^D	S31603	0.03	2	0.045	0.03	1	16.0–18.0	10.0–14.0	2.00–3.00	...	...
TP316H	S31609	0.04–0.10	2	0.045	0.03	1	16.0–18.0	10.0–14.0	2.00–3.00	...	...
TP316N	S31651	0.08	2	0.045							
						1	16.0–18.0	10.0 ⁻ 13.0	2.00–3.00	0.10–0.16	...
TP316LN ^D	S31653	0.03	2	0.045							
						1	16.0–18.0	10.0 ⁻	2.00–3.00	0.10–0.16	...
S31655	0.03	2	0.045	0.015	1	19.5–21.5	8.0–9.5	0.50–1.50	0.14–0.25	1	...
TP317	S31700	0.08	2	0.045	0.03	1	18.0–20.0	11.0–15.0	3.0–4.0	...	...
TP317L	S31703	0.03	2	0.045	0.03	1	18.0–20.0	11.0–15.0	3.0–4.0	...	...

0.03

				0.03							
...	S31725	0.03	2	0.045	0.03	1	18.0–20.0	13.5–17.5	4.0–5.0	0.2	...
...	S31726	0.03	2	0.045	0.03	1	17.0–20.0	14.5–17.5	4.0–5.0	0.10–0.20	...
...	S31727	0.03	1	0.03	0.03	1	17.5–19.0	14.5–16.5	3.8–4.5	0.15–0.21	Cu [2.8-4.0]
...	S32050	0.03	1.5	0.035	0.02	1	22.0–24.0	20.0–23.0	6.0–6.8	0.21–0.32	Cu [0.4]
...	S32053	0.03	1	0.03	0.01	1	22.0–24.0	24.0–26.0	5.0–6.0	0.17–0.22	...
TP321	S32100	0.08	2	0.045	0.03	1	17.0–19.0	9.0–12.0	...	0.1	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	...	0.1	Ti [5(C+N)-0.70]
...	S32615	0.07	2	0.045	0.03	4.80–6.00	16.5–19.5	19.0–22.0	0.30–1.50	...	Cu [1.50–2.50]
...	S32654	0.02	2.0–4.0	0.03	0.005	0.5	24.0–25.0	21.0–23.0	7.0–8.0	0.45–0.55	Cu [0.30–0.60]
...	S33228	0.04–0.08	1	0.02	0.015	0.3	26.0–28.0	31.0–333.0	...	...	Cb [0.60–1.00], Ce [0.05–0.10], Al [0.025]
...	S34565	0.03	5.0–7.0	0.03	0.01	1	23.0–25.0	16.0–18.0	4.0–5.0	0.40–0.60	Cb [0.10]
TP347	S34700	0.08	2	0.045	0.03	1	17.0–19.0	9.0–12.0	...	...	Cb [10×C-1.10]

13.0

0.03

				0.03							
TP347H	S34709	0.04–0.10	2	0.045		1	17.0–19.0	9.0 – 12.0	...	...	Cb [8×C-1.10]
TP348	S34800	0.08	2	0.045		1	17.0–19.0	9.0– 12.0	...	...	(Cb+Ta) [10xC-1.10], Ta [0.10], Co [0.20]
TP348H	S34809	0.04–0.10	2	0.045	0.03	1	17.0–19.0	9.0– 12.0	...	...	(Cb+Ta) [8xC-1.10], Ta [0.10], Co [0.20]
...	S35045	0.06–0.10	1.5	0.045	0.015	1	25.0–29.0	32.0– 37.0	...	...	Al [0.15–0.60] Ti [0.15– 0.60], Cu [0.75]
TPXM-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	0.75–1.50	...	Al [0.30 max], Cu [0.75–1.50]
Alloy 20	N08020	0.07	2	0.045	0.035	1	19.0–21.0	32.0– 38.0	2.00–3.00	...	Nb [8 × C min. to 1.00 max] , Cu [3.00–4.00]
...	N08367	0.03	2	0.04	0.03	1	20.0–22.0	23.5– 25.5	6.0–7.0	0.18–0.25	Cu [0.75]
800	N08800	0.1	1.5	0.045	0.015	1	19.0–23.0	30.0– 35.0	...	...	Al [0.15–0.60], Ti [0.15–0.60], Cu [0.75] Fe ^E [39.5 min]
800H	N08810	0.05–0.10	1.5	0.045	0.015	1	19.0–23.0	30.0– 35.0	...	...	Al [0.15–0.60], Ti [0.15–0.60], Fe ^E [39.5 min], Cu [0.75]

0.03

				0.03							
...	N08811	0.05–0.10	1.5	0.045	0.015	1	19.0–23.0	30.0–35.0	...	...	Al [0.25–0.60 ^F] Ti [0.25–0.60 ^F] Fe ^E [39.5 min], Cu [0.75]
...	N08926	0.02	2	0.03	0.01	0.5	19.0–21.0	24.0–26.0	6.0–7.0	0.15–0.25	Cu [0.50–1.50]
...	N08904	0.02	2	0.04	0.03	1	19.0–23.0	23.0–28.0	4.0–5.0	0.1	Cu [1.00–2.00]

^A Maximum, unless otherwise indicated.

^B New designation established in accordance with Practice E527 and SAE J1086.

^C The method of analysis for nitrogen shall be a matter of agreement between the purchaser and manufacturer.

^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 TP 304L and TP 316L. Small outside diameter tubes are defined as those less than 0.500 in. [12.7 mm] in outside diameter and light wall are those less than 0.049 in. [1.2 mm] in minimum wall thickness.

^E Iron shall be determined arithmetically by difference of 100 minus the sum of the other specified elements. ^F (Al + Ti) = 0.85 to 1.20.

C. Tensile Requirements :-

The material shall conform to the tensile properties prescribed in Table 3.

D. Hardness Requirements :-

The tubes shall have a Rockwell hardness number not exceeding the values specified in Table 3.

Table 3^A

Grade	UNS Designation	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa]	Elongation in 2 in. or 50 mm, min, %	Rockwell Hardness Number,max
TP201	S20100	95 [655]	38 [260]	35	B95
TP201LN	S20153	95 [655]	45 [310]	45	B100
TP202	S20200	90 [620]	38 [260]	35	B95
TPXM-19	S20910	100 [690]	55 [380]	35	C25
TPXM-29	S24000	100 [690]	55 [380]	35	B100
TP304	S30400	75 [515]	30 [205]	35	B90
TP304L	S30403	70 [485]	25 [170]	35	B90
TP304H	S30409	75 [515]	30 [205]	35	B90
...	S30415	87 [600]	42 [290]	35	B96
TP304N	S30451	80 [550]	35 [240]	35	B90
TP304LN	S30453	75 [515]	30 [205]	35	B90
TP305	S30500	75 [515]	30 [205]	35	B90
...	S30601	78 [540]	37 [255]	30	B100
...	S32615	80 [550]	32 [220]	25	B100
...	S30615	90 [620]	40 [275]	35	B95
...	S30815	87 [600]	45 [310]	35	B95
TP309S	S30908	75 [515]	30 [205]	35	B90
TP309H	S30909	75 [515]	30 [205]	35	B90
TP309Cb	S30940	75 [515]	30 [205]	35	B90

TP309HCb	S30941	75 [515]	30 [205]	35	B90
TP310S	S31008	75 [515]	30 [205]	35	B90
TP310H	S31009	75 [515]	30 [205]	35	B90
TP310Cb	S31040	75 [515]	30 [205]	35	B90
TP310HCb	S31041	75 [515]	30 [205]	35	B90
...	S31050:				
	t ≤ 0.25 in.	84 [580]	39 [270]	25	B95
	t > 0.25 in.	78 [540]	37 [255]	25	B95
...	S31254:				
	t ≤ 0.187 in. [5.00 mm]	98 [675]	45 [310]	35	B100
	t > 0.187 in. [5.00 mm]	95 [655]	45 [300]	35	B100
...	S31266	109 [750]	61 [420]	35	B100
...	S31277	112 [770]	52 [360]	40	B100
TP316	S31600	75 [515]	30 [205]	35	B90
TP316L	S31603	70 [485]	25 [170]	35	B90
TP316H	S31609	75 [515]	30 [205]	35	B90
TP316N	S31651	80 [550]	35 [240]	35	B90
TP316LN	S31653	75 [515]	30 [205]	35	B90
	S31655	92 [635]	45 [310]	35	B100
TP317	S31700	75 [515]	30 [205]	35	B90
TP317L	S31703	75 [515]	30 [205]	35	B90
...	S31725	75 [515]	30 [205]	35	B90
...	S31726	80 [550]	35 [240]	35	B90
...	S31727	80 [550]	36 [245]	35	B96
...	S32050	98 [675]	48 [330]	40	
...	S32053	93 [640]	43 [295]	40	B96

TP321	S32100	75 [515]	30 [205]	35	B90
TP321H	S32109	75 [515]	30 [205]	35	B90
...	S32654	109 [750]	62 [430]	35	B100
...	S33228	73 [500]	27 [185]	30	B90
...	S34565	115 [795]	60 [415]	35	B100
TP347	S34700	75 [515]	30 [205]	35	B90
TP347H	S34709	75 [515]	30 [205]	35	B90
TP348	S34800	75 [515]	30 [205]	35	B90
TP348H	S34809	75 [515]	30 [205]	35	B90
...	S35045	70 [485]	25 [170]	35	B90
TPXM-15	S38100	75 [515]	30 [205]	35	B90
...	S38815	78 [540]	37 [255]	30	B100
Alloy 20	N08020	80 [550]	35 [240]	30	B95
...	N08367				
	$t \leq 0.187$	100 [690]	45 [310]	30	B100
	$t > 0.187$	95 [655]	45 [310]	30	B100
800	N08800	75 [515]	30 [205]	30	90
800H	N08810	65 [450]	25 [170]	30	90
...	N08811	65 [450]	25 [170]	30	90
.	N08904	71 [490]	31 [215]	35	B90
.	N08926	94 [650]	43 [295]	35	B100

^A Not applicable to tubes less than 1/8 in. [3.2 mm] in outside diameter or having wall thickness below 0.015 in. [0.4 mm], or both. The tensile properties of such small diameter or thin wall tubes shall be a matter of agreement between the manufacturer and the purchaser.

E. Grain Size Requirement:-

	Grain Size	Test Methods
Grades - TP309H, TP309HCb, TP310H and TP310HCb	6 or coarser.	E112
Grades - TP304H, TP316H, TP321H, TP347H and TP348H	7 or coarser.	E112
UNS S32615	3 or finer	E112
UNS N08810 and N08811	5 or coarser	E112

F. Mechanical Tests:-

1. Tension Test.
2. Flattening Test.
3. Flange Test.
4. Reverse-Bend Test.
5. Hardness Test.
6. Hydrostatic or Non-destructive Electric Test.

G. Supplementary Requirements :-

1. Pneumatic Test.
2. Intergranular Corrosion Test.
3. Weld Decay Test:-
This test is not applicable to alloys with a nickel content $\geq 19.0\%$ or a molybdenum content $\geq 4.00\%$, or both.
Heavily cold worked tubes (HCW) shall be capable of passing the weld decay test with a weld metal to base metal loss ratio of 0.90 to 1.10.
4. Stress-Relieved Annealed Tubes:-
When stress-relieved tubes are specified, tubes shall be given a heat treatment at 1550 to 1650 °F [845 to 900 °C] after roll straightening.
Cooling from this temperature range may be either in air or by slow cooling.

Keyword

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