



Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes¹

This standard is issued under the fixed designation A 213/A 213M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification² covers minimum-wall-thickness, seamless ferritic and austenitic steel, boiler and superheater tubes and austenitic steel heat-exchanger tubes, designated Grades T5, TP304, etc. These steels are listed in Tables 1-.

1.2 Grades S30432, TP304H, TP309H, TP309HCb, TP310H, TP310HCb, TP310HCbN, TP316H, TP321H, TP347H, TP347HFG (fine grained) 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.

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

1.4 Mechanical property requirements do not apply to tubing smaller than $\frac{1}{8}$ in. [3.2 mm] in inside diameter or 0.015 in. [0.4 mm] in thickness.

1.5 Optional supplementary requirements are provided and, when desired, shall be so stated in the order.

1.6 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. The inch-pound units shall apply unless the "M" designation of this specification is specified in the order.

2. Referenced Documents

2.1 ASTM Standards:

A 262 Practices for Detecting Susceptibility to Intergranu-

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.

lar Attack in Austenitic Stainless Steels³

A 450/A 450M Specification for General Requirements for

Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes⁴

E 112 Test Methods for Determining Average Grain Size⁵

E 527 Practice for Numbering Metals and Alloys (UNS)⁴

2.2 Other Standard:

SAE J1086 Practice for Numbering Metals and Alloys (UNS)⁶

3. Ordering Information

3.1 Orders for material under this specification should include the following, as required, to describe the desired material adequately:

3.1.1 Quantity (feet, metres, or number of lengths),

3.1.2 Name of material (seamless tubes),

3.1.3 Grade (Table 1 and Table 2),

3.1.4 Manufacture (hot finished or cold finished),

3.1.5 Controlled structural characteristics (see 6.2),

3.1.6 Size (outside diameter and minimum wall thickness),

3.1.7 Length (specific or random),

3.1.8 Hydrostatic Test or Nondestructive Electric Test (see 12.1),

3.1.9 Specification designation, and

3.1.10 Special requirements and any supplementary requirements selected.

4. General Requirements

4.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 450/A 450M, unless otherwise provided herein.

5. Materials and Manufacture

5.1 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.

5.2 Grain Size:

5.2.1 The grain size of Grades 304H, 316H, 321, 347H,

³ Annual Book of ASTM Standards, Vol 01.03.

⁴ Annual Book of ASTM Standards, Vol 01.01.

⁵ Annual Book of ASTM Standards, Vol 03.01.

⁶ Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

TABLE 1 Chemical Requirements for Ferritic Steel

| Grade | Composition, % | | | | | | | | | Other Elements |
|------------------|-------------------|-----------|-----------------|-------------|-----------|-------------|------------|--------------|---------------|--|
| | Carbon | Manganese | Phosphorus, max | Sulfur, max | Silicon | Chromium | Molybdenum | Titanium | Vanadium, min | |
| T2 ^A | 0.10–0.20 | 0.30–0.61 | 0.025 | 0.025 | 0.10–0.30 | 0.50–0.81 | 0.44–0.65 | ... | ... | |
| T5 | 0.15 max | 0.30–0.60 | 0.025 | 0.025 | 0.50 max | 4.00–6.00 | 0.45–0.65 | ... | ... | |
| T5b | 0.15 max | 0.30–0.60 | 0.025 | 0.025 | 1.00–2.00 | 4.00–6.00 | 0.45–0.65 | ... | ... | |
| T5c | 0.12 max | 0.30–0.60 | 0.025 | 0.025 | 0.50 max | 4.00–6.00 | 0.45–0.65 | ^B | ... | |
| T9 | 0.15 max | 0.30–0.60 | 0.025 | 0.025 | 0.25–1.00 | 8.00–10.00 | 0.90–1.10 | ... | ... | |
| T11 | 0.05 min–0.15 max | 0.30–0.60 | 0.025 | 0.025 | 0.50–1.00 | 1.00–1.50 | 0.44–0.65 | ... | ... | |
| T12 ^A | 0.05 min–0.15 max | 0.30–0.61 | 0.025 | 0.025 | 0.50 max | 0.80–1.25 | 0.44–0.65 | ... | ... | |
| T17 | 0.15–0.25 | 0.30–0.61 | 0.025 | 0.025 | 0.15–0.35 | 0.80–1.25 | ... | ... | 0.15 | |
| T21 | 0.05 min–0.15 max | 0.30–0.60 | 0.025 | 0.025 | 0.50 max | 2.65–3.35 | 0.80–1.06 | ... | ... | |
| T22 | 0.05 min–0.15 max | 0.30–0.60 | 0.025 | 0.025 | 0.50 max | 1.90–2.60 | 0.87–1.13 | ... | ... | |
| T23 | 0.04–0.10 | 0.10–0.60 | 0.030 | 0.010 | 0.50 max | 1.90–2.60 | 0.05–0.30 | ... | 0.20–0.30 | W 1.45–1.75 Cb 0.02–0.08 B 0.0005–0.006 N 0.030 max Al 0.030 max |
| T24 | 0.05–0.10 | 0.30–0.70 | 0.020 | 0.010 | 0.15–0.45 | 2.20–2.60 | 0.70–1.10 | 0.06–0.10 | 0.20–0.30 | B 0.0015–0.0020 N 0.012 max Al 0.020 max Cb 0.06–0.1 N 0.030–0.070 Ni 0.40 max Al 0.04 max W 1.5–2.00 Cb 0.04–0.09 B 0.001–0.006 N 0.03–0.07 Ni 0.40 max Al 0.04 max |
| T91 | 0.08–0.12 | 0.30–0.60 | 0.020 | 0.010 | 0.20–0.50 | 8.00–9.50 | 0.85–1.05 | ... | 0.18–0.25 | W 1.5–2.00 Cb 0.04–0.09 B 0.001–0.006 N 0.03–0.07 Ni 0.40 max Al 0.04 max W 1.5–2.00 Cu 0.30–1.70 Cb 0.04–0.10 B 0.0005–0.005 N 0.040–0.100 Ni 0.50 max Al 0.040 max Ni 0.40 max Cb 0.060–0.10 B 0.0003–0.006 N 0.04–0.09 Al 0.04 max W 0.90–1.10 N max 0.035 Ni + Cu max 1.00 |
| T92 | 0.07–0.13 | 0.30–0.60 | 0.020 | 0.010 | 0.50 max | 8.50–9.50 | 0.30–0.60 | ... | 0.15–0.25 | |
| T122 | 0.07–0.14 | 0.70 max | 0.020 | 0.010 | 0.50 max | 10.00–12.50 | 0.25–0.60 | ... | 0.15–0.30 | |
| T911 | 0.09–0.13 | 0.30–0.60 | 0.020 | 0.010 | 0.10–0.50 | 8.50–10.50 | 0.90–1.10 | ... | 0.18–0.25 | |
| 18Cr-2Mo | 0.025 max | 1.00 max | 0.040 | 0.030 | 1.00 max | 17.5–19.5 | 1.75–2.50 | ^C | ... | |

^A It is permissible to order T2 and T12 with 0.045 max Sulfur.

^B Grade T5c shall have a titanium content of not less than four times the carbon content and not more than 0.70 %.

^C Grade 18Cr-2Mo shall have Ti + Cb = 0.20 + 4 (C + N) min, 0.80 max.

348H, and 310HCbN, as determined in accordance with Test Methods E 112, shall be No. 7 or coarser.

5.2.2 The grain size of cold-worked Grade TP321H, as determined in accordance with Test Methods E 112, shall be No. 7 or coarser.

5.2.3 The grain size of TP309H, TP309HCb, TP310H and TP310HCb, as determined in accordance with Test Methods E 112, shall be No. 6 or coarser.

5.2.4 The grain size of cold-worked Grade TP347HFG as determined in accordance with Test Methods E 112 shall be between No. 7 and No. 10.

6. Heat Treatment

6.1 All tubes of grades shown in Table 1, except T5c, T23, T24, T91, T92, T122, and T911, and in accordance with 6.1.1 shall be reheated and furnished in the full-annealed, isothermal

annealed, or normalized and tempered condition. If furnished in the normalized and tempered condition, the minimum tempering temperature for Grades T5, T5b, T9, T21, and T22 shall be 1250°F [675°C], and the minimum tempering temperature for Grades T11 and T17 shall be 1200°F [650°C].

6.1.1 Tubing of Grades T2 and T12 either hot-finished or cold-drawn, may be given a final heat treatment at 1200 to 1350°F [650 to 730°C] instead of heat treatments specified in 6.1 at the option of the manufacturer.

6.1.2 All tubing of Grade T5c shall be given a final heat treatment of approximately 1350°F [730°C] for a proper time, followed by air or furnace cooling.

6.1.3 Grade T24 shall be normalized at 1800°F [980°C] minimum and tempered at 1350°F [730°C] minimum as a final heat treatment.

TABLE 2 Chemical Requirements of Austenitic Steel

| Grade | TP201 | TP202 | TP304 | TP304H | ... | TP304N | TP304LN | TP304L | TP309Cb | TP309H | TP309Hcb | TP309S | ... | TP310Cb | TP310H | TP310Hcb | TP310HcbN | TP310S | TP31272 | TP316 | TP316H | |
|------------------------------|---------------|---------------|---------------|---------------|--|---------------|---------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-----------------|---------------|-------------------------------|-------------------------------|-----------------|-----------------|-----------------|----------------------|---------------|---------------|---------------|
| UNS Designation ^A | S20100 | S20200 | S30400 | S30409 | S30432 | S30451 | S30453 | S30403 | S30940 | S30909 | S30941 | S30908 | S31002 | S31040 | S31009 | S31041 | S31042 | S31008 | S31272 | S31600 | S31609 | |
| Carbon | 0.15 max | 0.15 max | 0.08 max | 0.04– 0.10 | 0.07– 0.13 | 0.08 max | 0.035 max ^B | 0.035 max ^B | 0.08 max | 0.04– 0.10 | 0.04– 0.10 | 0.08 max | 0.015 max | 0.08 max | 0.04– 0.10 | 0.04– 0.10 | 0.04– 0.10 | 0.08 max | 0.08– 0.12 | 0.08 max | 0.04– 0.10 | |
| Manganese, max | 5.50– 7.50 | 7.50– 10.0 | 2.00 | 2.00 | 0.50 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 1.5– 2.0 | 1.5– 2.0 | 2.00 | 2.00 | |
| Phosphorus, max | 0.060 | 0.060 | 0.040 | 0.040 | 0.045 | 0.040 | 0.040 | 0.045 | 0.045 | 0.045 | 0.045 | 0.045 | 0.020 | 0.045 | 0.040 | 0.045 | 0.030 | 0.030 | 0.030 | 0.040 | 0.040 | |
| Sulfur, max | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.015 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.015 | 0.030 | 0.030 | |
| Silicon | 1.00 max | 1.00 max | 0.75 max | 0.75 max | 0.30 max | 0.75 max | 0.75 max | 0.75 max | 0.75 max | 0.75 max | 0.75 max | 0.75 max | 0.15 max | 0.75 max | 0.75 max | 0.75 max | 0.75 max | 0.75 max | 0.3– 0.7 | 0.3– 0.7 | 0.75 max | 0.75 max |
| Nickel | 3.50– 5.50 | 4.00– 6.00 | 8.00– 11.0 | 8.00– 11.0 | 7.50– 10.50 | 8.00– 11.0 | 8.00– 13.0 | 12.00– 16.00 | 12.00– 16.00 | 12.00– 16.00 | 12.00– 16.00 | 12.00– 15.00 | 19.0– 22.0 | 19.0– 22.0 | 19.0– 22.00 | 19.0– 22.00 | 17.00– 23.00 | 19.00– 24.00 | 14.0– 16.0 | 14.0– 16.0 | 11.0– 14.0 | 11.0– 14.0 |
| Chromium | 16.0– 18.0 | 17.0– 19.0 | 18.0– 20.0 | 18.0– 20.0 | 18.0– 20.0 | 18.0– 20.0 | 18.0– 20.0 | 22.00– 24.00 | 22.00– 24.00 | 22.00– 24.00 | 22.00– 24.00 | 22.00– 24.00 | 24.0– 26.0 | 24.00– 26.00 | 24.00– 26.00 | 24.00– 26.00 | 24.00– 26.00 | 24.00– 26.00 | 14.0– 16.0 | 14.0– 16.0 | 16.0– 18.0 | 16.0– 18.0 |
| Molybdenum | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Titanium | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Columbium + tanta- lum | ... | ... | ... | ... | 0.20– 0.80 | ... | ... | 10 × C min, 1.10 max | 10 × C min, 1.10 max | 10 × C min, 1.10 max | 10 × C min, 1.10 max | ... | ... | 10 × C min, 1.10 max | 10 × C min, 1.10 max | 0.20– 0.60 | ... | ... | ... | ... | ... | ... |
| Tantalum, max | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Nitrogen ^C | 0.25 max | 0.25 max | ... | ... | 0.05– 0.12 | 0.10– 0.16 | ... | ... | ... | ... | ... | ... | 0.10 max | ... | ... | 0.15– 0.35 | ... | ... | ... | ... | ... | ... |
| Cerium | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Others | ... | ... | ... | ... | B 0.001– 0.010 Al 0.003– 0.030 Cu 2.5– 3.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | B 0.004– 0.008 | ... | ... | ... |

TABLE 2 Chemical Requirements of Austenitic Steel (continued)

| Grade | TP316L/TP316N | TP 316LN | TP317 | TP317L | TP321 | TP 321H | TP347 | TP 347H | TP 347LN | TP 347HFC | TP 348H | XM-15 | | | | | | | | XM-19 | ... | | |
|------------------------------|------------------------------------|--------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------------|-----------------------|-----------------------|------------------------|------------------------|------------------------|----------------|-------------------|-------------------|-------------------|-------------------|-----------------------|-----------------------|--------------------------|----------------------------------|
| UNS Designation ^A | S31603 | S31653 | S31700 | S31703 | S32100 | S32109 | S34700 | S34709 | S34751 | S34800 | S34809 | S38100 | S33081 | S33082 | S33228 | S33229 | S33230 | S33231 | S33232 | S20910 | ... | ... | |
| Carbon | 0.035 max ^B 2.00 | 0.035 max ^B 2.00 | 0.08 max 2.00 | 0.035 max 2.00 | 0.08 max 2.00 | 0.04-0.10 2.00 | 0.08 max 2.00 | 0.04-0.10 2.00 | 0.005-0.020 2.00 | 0.06-0.10 2.00 | 0.08 max 2.00 | 0.08 max 2.00 | 0.016-0.24 2.00 | 0.05-0.10 0.80 | 0.025 7.0 | 0.06-0.15 5.50 | 0.03 max 2.00 | 0.03 max 2.00 | 0.03 max 2.00 | 0.06 max 4.00-6.00 | 0.02 max 2.0 | 0.030 max 1.50 | |
| Manganese, max | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.040 | 0.030 | 0.030 | 0.030 | 0.020 | 0.040 | 0.040 | 0.040 | 0.040 | 0.04 | 0.025 | 0.035 | |
| Phosphorus, max | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.015 | 0.030 | 0.030 | 0.030 | 0.030 | 0.03 | 0.010 | 0.020 | |
| Sulfur, max | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.015 | 0.030 | 0.030 | 0.030 | 0.030 | 0.03 | 0.010 | 0.020 | |
| Silicon | 0.75 max ^C 10.0-11.0 | 0.75 max 11.0-14.0 | 0.75 max 11.0-14.0 | 0.75 max 11.0-14.0 | 0.75 max 9.00-11.0 | 0.75 max 9.00-11.0 | 0.75 max 9.00-11.0 | 0.75 max 9.00-11.0 | 0.75 max 9.0-13.0 | 0.75 max 9.00-13.0 | 0.75 max 9.00-13.0 | 1.50-2.50 17.5-18.5 | 1.50-2.50 17.5-18.5 | 1.50-2.50 17.5-18.5 | 0.2-1.0 0.4 | 0.2-1.0 0.4 | 0.75 13.5-17.5 | 0.75 13.5-17.5 | 0.75 13.5-17.5 | 0.75 13.5-17.5 | 1.00 max 11.5-22.0 | 6.5-8.0 max 22.0-20.0 | 1.00 max 8.0 max 20.0-22.0 |
| Nickel | 10.0-14.0 | 14.0 | 14.0 | 14.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.0 | 13.5-17.5 | 13.5-17.5 | 10.0-12.0 | 20.5-23.5 | 9.00-11.0 | 17.5-19.0 | 17.5-19.0 | 17.5-19.0 | 11.5-13.5 | 22.0-25.0 | 22.0-25.0 | |
| Chromium | 16.0-18.0 | 16.0-18.0 | 18.0-20.0 | 17.0-20.0 | 17.0-20.0 | 17.0-20.0 | 17.0-20.0 | 17.0-20.0 | 17.0-20.0 | 17.0-20.0 | 17.0-20.0 | 17.0-20.0 | 17.0-20.0 | 17.0-20.0 | 16.0-26.0 | 14.0-18.0 | 17.0-20.0 | 17.0-20.0 | 16.5-26.0 | 20.5-23.5 | 8.0-11.0 | 22.0-24.0 | |
| Molybdenum | 2.00-3.00 | 2.00-3.00 | 3.00-4.00 | 3.00-4.00 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1.6-2.6 | 1.6-2.6 | 0.8-1.20 | 4.0-5.00 | 4.0-5.00 | 4.0-5.00 | 1.50-3.00 | 0.50 max 6.8 max | 6.0-6.8 max | |
| Titanium | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| Columbium + tantalum | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| Tantalum, max | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| Nitrogen ^F | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| Cerium | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| Others | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | |

^A New designation established in accordance with Practice E 527 and SAE J1086.
^B 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 and TP316L. Small outside diameter tubes are defined as those less than 0.500 in. [12.7 mm] in outside diameter and light wall tubes are those less than 0.049 in. [1.2 mm] in average wall thickness (0.044 in. [1.1 mm] in minimum wall thickness).
^C For seamless TP316L tubes, the silicon maximum shall be 1.00 %.
^D Grade TP321 shall have a titanium content of not less than five times the carbon content and not more than 0.60 %.
^E Grade TP321H shall have a titanium content of not less than four times the carbon content and not more than 0.60 %.
^F Grades TP347 and TP348 shall have a columbium plus tantalum content of not less than ten times the carbon content and not more than 1.00 %.
^G Grades TP347H and TP348H shall have a columbium plus tantalum content of not less than eight times the carbon content and not more than 1.0 %.
^H Grade TP347LN shall have a columbium (niobium) plus tantalum content of not less than 15 times the carbon content.
^I The method of analysis for nitrogen shall be a matter of agreement between the purchaser and manufacturer.