



Standard Specification for Welded Austenitic Steel Boiler, Superheater, Heat- Exchanger, and Condenser Tubes¹

This standard is issued under the fixed designation A249/A249M; 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 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.

1.2 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.

1.3 The tubing sizes and thicknesses usually furnished to this specification are $\frac{1}{8}$ 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.

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 one or more of these are desired, each 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~~ may not be exact equivalents; therefore, each system ~~must~~ shall be used independently of the other. Combining values from the two systems may result in non-conformance with the ~~specification~~ standard. The inch-pound units shall apply unless the "M" designation of this specification is specified in the order.

1.7 The following safety hazards caveat pertains only to the test method described in the Supplementary Requirements of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* A specific warning statement is given in Supplementary Requirement S7, Note S7.1.

<https://standards.iteh.ai/catalog/standards/sist/dfa474b2-a584-4572-b3bd-d26c611a5fc6/astm-a249-a249m-10>

2. Referenced Documents

2.1 ASTM Standards:³

A262 [Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels](#)

A480/A480M [Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip](#)

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](#)

E213 [Practice for Ultrasonic Testing of Metal Pipe and Tubing](#)

E273 [Practice for Ultrasonic Testing of the Weld Zone of Welded Pipe and Tubing](#)

E527 [Practice for Numbering Metals and Alloys in the Unified Numbering System \(UNS\)](#)

2.2 ASME Boiler and Pressure Vessel Code:

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-249 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.

*A Summary of Changes section appears at the end of this standard.

Section VIII ⁴

2.3 *Other Standard:*

SAE J1086 Practice for Numbering Metals and Alloys (UNS)⁵

3. Ordering Information

3.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Such requirements may include, but are not limited to, the following:

- 3.1.1 Quantity (feet, metres, or number of lengths),
- 3.1.2 Name of material welded tubes (WLD) or heavily cold worked tubes (HCW),
- 3.1.3 Grade (Table 1),
- 3.1.4 Size (outside diameter and nominal wall thickness),
- 3.1.5 Length (specific or random),
- 3.1.6 Optional requirements (13.6),
- 3.1.7 Test report required (see Certification Section of Specification A1016/A1016M),
- 3.1.8 Specification designation, and
- 3.1.9 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 A1016/A1016M, unless otherwise provided herein.

5. Manufacture

5.1 The welded (WLD) tubes shall be made from flat-rolled steel by an automatic welding process with no addition of filler metal.

5.1.1 Subsequent to welding and prior to final heat treatment, the tubes shall be cold worked either in both weld and base metal or in weld metal only. The method of cold working may be specified by the purchaser. When cold drawn, the purchaser may specify the minimum amount of reduction in cross-sectional area or wall thickness, or both.

5.1.2 Heavily cold worked (HCW) tubes shall be made by applying cold working of not less than 35 % reduction in both wall and weld to a welded tube prior to the final anneal. No filler metal shall be used in the making of the weld. Prior to cold working, the weld shall be 100 % radiographically inspected in accordance with the requirements of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, latest revision, Paragraph UW 51.

[ASTM A249/A249M-10](#)

<https://standards.iteh.ai/catalog/standards/sist/dfa474b2-a584-4572-b3bd-d26c611a5fc6/astm-a249-a249m-10>

⁴ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁵ Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.



TABLE 1 Chemical Requirements, %^A

| Grade | UNS Designation ^B | Composition, % | | | | | | | | | | |
|----------------------|------------------------------|----------------|-----------|-------------|--------|-----------|-----------|-----------|------------|-----------------------|--------|-----------------------------|
| | | Carbon | Manganese | Phosphorous | Sulfur | Silicon | Chromium | Nickel | Molybdenum | Nitrogen ^C | Copper | Other |
| TP 201 | S20100 | 0.15 | 5.50-7.5 | 0.060 | 0.030 | 1.00 | 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 | 1.00 | ... |
| TP 202 | S20200 | 0.15 | 7.5-10.0 | 0.060 | 0.030 | 1.00 | 17.0-19.0 | 4.0-6.0 | ... | 0.25 | ... | ... |
| TPXM-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 | ... | Cb 0.10-0.30 V 0.10-0.30 |
| TPXM-29 | S24000 | 0.08 | 11.5-14.5 | 0.060 | 0.030 | 1.00 | 17.0-19.0 | 2.3-3.7 | ... | 0.20-0.40 | ... | ... |
| TP304 | S30400 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 18.0-20.0 | 8.0-11.0 | ... | ... | ... | ... |
| TP304L ^D | S30403 | 0.030 | 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 | ... | ... | ... | ... |
| ... | S30415 | 0.04-0.06 | 0.80 | 0.045 | 0.030 | 1.00-2.00 | 18.0-19.0 | 9.0-10.0 | ... | 0.12-0.18 | ... | Ce 0.03-0.08 |
| 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 ^D | S30453 | 0.030 | 2.00 | 0.045 | 0.030 | 1.00 | 18.0-20.0 | 8.0-11.0 | ... | 0.10-0.16 | ... | ... |
| TP305 | S30500 | 0.12 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0-19.0 | 11.0-13.0 | ... | ... | ... | ... |
| ... | S30615 | 0.16-0.24 | 2.00 | 0.030 | 0.030 | 3.2-4.0 | 17.0-19.5 | 13.5-16.0 | ... | ... | ... | ... |
| ... | 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 | ... | ... | ... | ... |

TABLE 1 Continued

| Grade | UNS Designation ^F | Composition, % | | | | | | | | | | |
|----------------------|------------------------------|----------------|-----------|-------------|--------|---------|-----------|-----------|------------|-----------------------|-----------|--------|
| | | Carbon | Manganese | Phosphorous | Sulfur | Silicon | Chromium | Nickel | Molybdenum | Nitrogen ^C | Copper | Other |
| TP309Cb | S30940 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 22.0–24.0 | 12.0–16.0 | ... | ... | ... | Cb 10x |
| TP309Hcb | S30941 | 0.04–0.10 | 2.00 | 0.045 | 0.030 | 1.00 | 22.0–24.0 | 12.0–16.0 | ... | ... | ... | Cb 10x |
| 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 | ... | ... | ... | ... |
| TP310Cb | S31040 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 14.0–26.0 | 18.0–22.0 | ... | ... | ... | ... |
| TP310Hcb | S31041 | 0.04–0.10 | 2.00 | 0.045 | 0.030 | 1.00 | 24.0–26.0 | 19.0–22.0 | ... | ... | ... | Cb 10x |
| ... | S31050 | 0.030 | 2.00 | 0.030 | 0.015 | 0.40 | 24.0–26.0 | 21.0–23.0 | 2.00–3.00 | 0.10–0.16 | ... | ... |
| ... | 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 | ... | ... |
| ... | 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 | 0.50–1.00 | ... |
| 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 ^D | S31603 | 0.030 | 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 | 10.0–14.0 | 2.00–3.00 | ... | ... | ... |
| 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 ^P | S31653 | 0.030 | 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 | 0.030 | 2.00 | 0.045 | 0.030 | 1.00 | 18.0–20.0 | 11.0–15.0 | 3.0–4.0 | ... | ... | ... |



TABLE 1 Continued

| Grade | UNS Designation ^a | Composition, % | | | | | | | | | | Other |
|---------|------------------------------|----------------|-----------|-------------|--------|-----------|-----------|------------|------------|-----------------------|-----------|---|
| | | Carbon | Manganese | Phosphorous | Sulfur | Silicon | Chromium | Nickel | Molybdenum | Nitrogen ^c | Copper | |
| ... | S31725 | 0.030 | 2.00 | 0.045 | 0.030 | 1.00 | 18.0-20.0 | 13.5-17.5 | 4.0-5.0 | 0.20 | ... | ... |
| ... | S31726 | 0.030 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0-20.0 | 14.5-17.5 | 4.0-5.0 | 0.10-0.20 | ... | ... |
| ... | S31727 | 0.030 | 1.00 | 0.030 | 0.030 | 1.00 | 17.5-19.0 | 14.5-16.5 | 3.8-4.5 | 0.15-0.21 | ... | ... |
| ... | 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 | 0.40 | ... |
| ... | S32053 | 0.030 | 1.00 | 0.030 | 0.010 | 1.00 | 22.0-24.0 | 24.0-26.0 | 5.0-6.0 | 0.17-0.22 | ... | ... |
| TP321 | S32100 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0-19.0 | 9.0-12.0 | ... | 0.10 | ... | Ti 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 | ... | 0.10 | ... | Ti 5(C+N)-0.70 |
| ... | S32654 | 0.020 | 2.0-4.0 | 0.030 | 0.005 | 0.50 | 24.0-25.0 | 21.0-23.0 | 7.0-8.0 | 0.45-0.55 | 0.30-0.60 | ... |
| ... | S33228 | 0.04-0.08 | 1.00 | 0.020 | 0.015 | 0.30 | 26.0-28.0 | 31.0-333.0 | ... | ... | ... | Cb 0.60-1.00 |
| ... | 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 | ... | Ce 0.05-0.10 |
| TP347 | S34700 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0-19.0 | 9.0-12.0 | ... | ... | ... | AlO.025 Cb 0.10 Cb 10xC-1.10 |
| TP347H | S34709 | 0.04-0.10 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0-19.0 | 9.0-12.0 | ... | ... | ... | Cb 8xC-1.10 |
| TP348 | S34800 | 0.08 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0-19.0 | 9.0-12.0 | ... | ... | ... | (Cb+Ta) 10xC-1.10 |
| TP348H | S34809 | 0.04-0.10 | 2.00 | 0.045 | 0.030 | 1.00 | 17.0-19.0 | 9.0-12.0 | ... | ... | ... | Ta 0.10 Co 0.20 (Cb+Ta) 8xC-1.10 Ta 0.10 Co 0.20 |
| ... | S35045 | 0.06-0.10 | 1.50 | 0.045 | 0.015 | 1.00 | 25.0-29.0 | 32.0-37.0 | ... | ... | 0.75 | Al 0.15-0.60 |
| TPXM-15 | S38100 | 0.08 | 2.00 | 0.030 | 0.030 | 1.50-2.50 | 17.0-19.0 | 17.5-18.5 | ... | ... | ... | Ti 0.15-0.60 |
| ... | 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 | ... | 0.75-1.50 | Al 0.30 max |
| ... | N08367 | 0.030 | 2.00 | 0.040 | 0.030 | 1.00 | 20.0-22.0 | 23.5-25.5 | 6.0-7.0 | 0.18-0.25 | 0.75 | ... |
| ... | 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 | 0.50-1.50 | ... |
| ... | 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 | 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.

6. Heat Treatment

6.1 All material shall be furnished in the heat-treated condition in accordance with the requirements of Table 2.

6.2 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. When specified by the purchaser, a lower temperature stabilization or re-solution anneal shall be used subsequent to the initial high temperature solution anneal (see Supplementary Requirement S4).

7. Chemical Composition

7.1 The heat analysis shall conform to the requirements as to chemical composition given in Table 1.

8. Product Analysis

8.1 An analysis of either one length of flat-rolled stock or one tube shall be made for each heat. The chemical composition thus determined shall conform to the requirements given in Section 7.

8.2 A product analysis tolerance of Table A1.1 in Specification A480/A480M shall apply. The product analysis tolerance is not applicable to the carbon content for material with a specified maximum carbon of 0.04 % or less.

8.3 If the original test for product analysis fails, retests of two additional lengths of flat-rolled stock 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 or lot (See Note 1) shall be rejected or, at the option of the producer, each length of flat-rolled stock or tube may be individually tested for acceptance. Lengths of flat-rolled stock or tubes that do not meet the requirements of the specification shall be rejected.

NOTE 1—For flattening and flange requirements, the term lot applies to all tubes prior to cutting of the same nominal size and wall thickness which 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 from the same heat which are heat treated in the same furnace charge. When the final heat treatment is in a continuous furnace, 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 3.

NOTE 2—For tension and hardness test requirements, the term lot applies to all tubes prior to cutting, of the same nominal diameter and wall thickness which 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 which are heat treated in the same furnace charge. When the final heat treatment is in a continuous furnace, a lot shall include all tubes of the same size and heat, annealed in the same furnace at the same temperature, time at heat, and furnace speed.

TABLE 2 Heat Treatment Requirements

| Grade | UNS Number | Solutioning Temperature, min or range | Quenching Method |
|--|------------|---|------------------|
| All grades not individually listed below | | 1900 °F [1040 °C] | A |
| ... | 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 |
| ... | 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 |
| ... | N08367 | 2025 °F [1110 °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 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 (See Supplementary Requirement S6). 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 of the 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 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 (See Supplementary Requirement S4).

^D Cooled in still air, or faster.