



Designation: **A409/A409M—19 A409/A409M – 24**

## Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service<sup>1</sup>

This standard is issued under the fixed designation A409/A409M; 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.

### 1. Scope\*

1.1 This specification<sup>2</sup> covers straight seam or spiral seam electric-fusion-welded, light-wall, austenitic chromium-nickel alloy steel pipe for corrosive or high-temperature service. The sizes covered are NPS 14 to 30 with extra light (Schedule 5S) and light (Schedule 10S) wall thicknesses. **Table X1.1** shows the wall thickness of Schedule 5S and 10S pipe. Pipe having other dimensions may be furnished provided such pipe complies with all other requirements of this specification.

1.2 Several grades of alloy steel are covered as indicated in **Table 1**.

1.3 Optional supplementary requirements are provided. These call for additional tests to be made, and when desired shall be stated in the order, together with the number of such tests required.

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.

<https://standards.iteh.ai/catalog/standards/astm/93aea067-9d11-4bf3-ad25-6dbf9d3436a2/astm-a409-a409m-24>

NOTE 1—The dimensionless designator NPS (nominal pipe size) has been substituted in this standard for such traditional terms as *nominal diameter*, *size*, and *nominal size*.

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.*

### 2. Referenced Documents

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

**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

**A999/A999M** Specification for General Requirements for Alloy and Stainless Steel Pipe

**E527** Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

<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-409 in Section II of that Code.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto: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



TABLE 1 Chemical Requirements

	UNS Designations <sup>A</sup>	Composition, %											
		Carbon, max	Manganese, max	Phosphorus, max	Sulfur, max	Silicon	Nickel	Chromium	Molybdenum	Titanium	Columbium	Cerium	Other Elements
TP201	S20100	0.15	5.5–7.5	0.060	0.030	1.00	3.5–5.5	16.0–18.0	...	...	...	...	N 0.25
TP201LN	S20153	0.03	6.4–7.5	0.045	0.015	0.75	4.0–5.0	16.0–17.5	...	...	...	...	N 0.10–0.25, Cu 1.00
TP304	S30400	0.08	2.00	0.045	0.030	1.00 max	8.0–11.0	18.0–20.0	...	...	...	...	...
TP304L	S30403	0.035	2.00	0.045	0.030	1.00 max	8.0–12.0	18.0–20.0	...	...	...	...	...
...	S30416	0.030	2.00	0.045	0.015	0.80–2.00	9.0–11.0	17.5–19.5	0.40–0.80	...	...	...	N 0.10 max
TP309Cb	S30940	0.08	2.00	0.045	0.030	1.00 max	12.0–16.0	22.0–24.0	...	...	...	...	Cb 10 × C min, 1.10 max
TP309S	S30908	0.08	2.00	0.045	0.030	1.00 max	12.0–15.0	22.0–24.0	...	...	...	...	...
TP310Cb	S31040	0.08	2.00	0.045	0.030	1.00 max	19.0–22.0	24.0–26.0	...	...	...	...	Cb 10 × C min, 1.10 max
TP310S	S31008	0.08	2.00	0.045	0.030	1.00 max	19.0–22.0	24.0–26.0	...	...	...	...	...
TP316	S31600	0.08	2.00	0.045	0.030	1.00 max	10.0–14.0	16.0–18.0	2.00–3.00	...	...	...	...
TP316L	S31603	0.035	2.00	0.045	0.030	1.00 max	10.0–14.0	16.0–18.0	2.00–3.00	...	...	...	...
TP317	S31700	0.08	2.00	0.045	0.030	1.00 max	11.0–15.0	18.0–20.0	3.0–4.0	...	...	...	...
...	S31727	0.030	1.00	0.030	0.030	1.00 max	14.5–16.5	17.5–19.0	3.8–4.5	...	...	...	N 0.15–0.21 Cu 2.8–4.0
...	S32053	0.030	1.00	0.030	0.010	1.00 max	24.0–26.0	22.0–24.0	5.0–6.0	...	...	...	N 0.17–0.22
TP321	S32100	0.08	2.00	0.045	0.030	1.00 max	9.00–12.0	17.0–20.0	...	<sup>B</sup>	...	...	...
TP347	S34700	0.08	2.00	0.045	0.030	1.00 max	9.00–12.0	17.0–19.0	...	...	<sup>C</sup>	...	...
TP348	S34800	0.08	2.00	0.045	0.030	1.00 max	9.00–12.0	17.0–19.0	...	...	<sup>D</sup>	...	...
...	S31254	0.020	1.00	0.030	0.010	0.80 max	17.5–18.5	19.5–19.5	6.0–6.5	...	...	...	Cu 0.50–1.00 N 0.18–0.25
...	S30815	0.05–0.10	0.80	0.040	0.030	1.40–2.00	10.0–12.0	20.0–22.0	...	...	...	0.03–0.08	N 0.14–0.20
...	S31725	0.030	2.00	0.045	0.030	1.00 max	13.5–17.5	18.0–20.0	4.0–5.0	...	...	...	N 0.020 max
...	S31726	0.030	2.00	0.045	0.030	1.00 max	14.5–17.5	17.0–20.0	4.0–5.0	...	...	...	N 0.10–0.20
...	S34565	0.030	5.0–7.0	0.030	0.010	1.00 max	16.0–18.0	23.0–25.0	4.0–5.0	...	0.10 max	...	N 0.40–0.60
...	N08367	0.030	2.00	0.040	0.030	1.00 max	23.5–25.5	20.0–22.0	6.0–7.0	...	...	...	Cu 0.75 max Ni 0.18–0.25
...	S20400	0.030	7.0–9.0	0.45	0.030	1.00 max	1.50–3.00	15.0–17.0	...	...	...	...	N 0.15–0.30
...	S31266	0.030	2.00–4.00	0.035	0.020	1.00 max	21.0–24.0	23.0–25.0	5.2–6.2	...	...	...	Cu 1.00–2.50 W 1.50–2.50 N 0.35–0.60

<sup>A</sup> New designation established in accordance with ASTM E527 and SAE J1086.

<sup>B</sup> The titanium content shall be not less than 5 times the carbon content and not more than 0.70 %.

<sup>C</sup> The columbium plus tantalum content shall be not less than 10 times the carbon content and not more than 1.10 %.

<sup>D</sup> The columbium plus tantalum content shall be not less than 10 times the carbon content and not more than 1.10 %. The tantalum content shall be 0.10 % maximum, CO 0.20 % maximum.

## 2.2 ASME Boiler and Pressure Vessel Code:<sup>4</sup>

### Section III

### Section VIII, Division 1

### Section IX

## 2.3 AWS Standards:<sup>5</sup>

### A 5.22 Flux Cored Arc Welding

### A 5.30 Consumable Weld Inserts for Gas Tungsten Arc Welding

### A 5.4 Corrosion-Resisting Chromium and Chromium-Nickel Steel Covered Welding Electrodes

### A 5.9 Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Rods and Bare Electrodes

### A 5.11 Nickel and Nickel-Alloy Covered Welding Electrodes

### A 5.14 Nickel and Nickel-Alloy Bare Welding Rods and Electrodes

## 2.4 Other Standard:

### SAE J1086 Practice for Numbering Metals and Alloys (UNS)<sup>6</sup>

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

<sup>5</sup> Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, <http://www.aws.org>.

<sup>6</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.



### 3. Ordering Information

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

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

3.1.2 Name of material (straight seam or spiral seam electric-fusion-welded austenitic steel pipe),

3.1.3 Grade (Table 1),

3.1.4 Size (outside diameter and schedule number, or wall thickness).

3.1.5 Length (specific or random) (Section 11),

3.1.6 End finish (Section on Ends of Specification A999/A999M),

3.1.7 Optional requirements (5.2.1 – 5.2.3 removal of weld bead; 5.3.2, special heat treatment; 15.2, nondestructive test; 10.1.1, outside diameter tolerance; 11.2, length circumferentially welded; 12.3, repair by welding and heat treatment subsequent to repair welding; 12.4, sand blasted or pickled; 17.1 Certification; Supplementary Requirements S1 to S6).

3.1.8 Specification designation, and

3.1.9 Special requirements.

### 4. General Requirements

4.1 Material furnished to this specification shall conform to the applicable requirements of the current edition of Specification A999/A999M, unless otherwise provided herein.

### 5. Materials and Manufacture

5.1 If a specific type of melting is required by the purchaser it shall be stated on the order.

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5.2 *Welding:*

5.2.1 The welds shall be made by the manual or automatic electric-welding process. For manual welding, the operator and procedure shall be qualified in accordance with the ASME Boiler and Pressure Vessel Code, Section IX. Unless otherwise specified on the purchase order, the pipe may be welded with or without filler metal when the automatic electric-welding process is used.

5.2.2 The weld surface on either side of the weld may be flush with the base plate or may have a reasonably uniform crown, not to exceed  $\frac{1}{16}$  in. [2 mm]. Any weld reinforcement may be removed at the manufacturer's option or by agreement between the manufacturer and purchaser. The contour of the reinforcement should be reasonably smooth and free from irregularities. The weld metal shall be fused uniformly into the plate surface. No concavity of contour is permitted unless the resulting thickness of weld metal is equal to or greater than the minimum thickness of the adjacent base metal.

5.2.3 Weld defects, as determined by specified inspection requirements, shall be repaired by removal to sound metal and rewelding.

5.3 *Heat Treatment:*

5.3.1 Except as provided in 5.3.2, all pipe shall be furnished in the heat-treated condition. The heat-treatment procedure shall consist of heating the material to a minimum temperature of 1900 °F [1040 °C], except for S31254, S31266, and S30815 which shall be heat treated to 2100 °F [1150 °C] and 1920 °F [1050 °C] respectively, S31727 and S32053 which shall be heat treated in the range 1975 to 2155 °F [1080 to 1180 °C], S34565 which shall be heat treated in the range 2050 °F [1120 °C] to 2140 °F [1170 °C], and N08367, which shall be heated to a minimum temperature of 2025 °F [1107 °C], all materials to be followed by quenching in water or rapidly cooling by other means.

5.3.2 The purchase order shall specify one of the following conditions if the heat-treated condition specified in 5.3.1 is not desired by the purchaser:

5.3.2.1 A final heat-treatment temperature under 1900 °F [1040 °C]. Each pipe supplied under this requirement shall be stenciled with the final heat-treatment temperature in degrees Fahrenheit or degrees Celsius after the suffix “HT.” Controlled structural or special service characteristics may be specified as a guide for the most suitable heat treatment.

5.3.2.2 No final heat treatment of pipe fabricated of plate, that has been solution heat treated at temperatures required by this specification. Each pipe supplied under this requirement shall be stenciled with the suffix “HT-O.”

5.3.2.3 No final heat treatment of pipe fabricated of plate, that has not been solution heat treated. Each pipe supplied under this requirement shall be stenciled with the suffix “HT-SO.”

5.4 A solution annealing temperature above 1950 °F [1065 °C] may impair the resistance to intergranular corrosion after subsequent exposure to sensitizing conditions in TP321, TP347, and TP348. 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 S5).

## 6. Chemical Composition

6.1 The steel shall conform to the chemical composition in Table 1.

6.2 When specified on the purchase order, a product analysis shall be supplied from one tube or coil of steel per heat. The product analysis tolerance of Specification A480/A480M shall apply.

6.3 Unless otherwise specified in the purchase order, the chemical composition of the welding filler metal shall conform to the requirements of the applicable AWS specification for the corresponding grade shown in Table 2. Grades with no filler metal classification indicated shall be welded with filler metals producing deposited weld metal having a composition in accordance with the chemical composition specified in Table 1. The method of analysis for nitrogen and cerium shall be a matter of agreement between the purchaser and manufacturer. The purchaser may choose a higher-alloy filler metal when needed for corrosion resistance.

## 7. Tensile Requirements

7.1 The tensile properties of the plate or sheet used in making the pipe shall conform to the requirements prescribed in Table 3. Certified mill test reports shall be submitted to the pipe manufacturer.

7.2 A transverse tension test taken across the welded joint of the finished pipe shall meet the same minimum tensile strength requirements as the sheet or plate. The weld section on the tension specimen shall be in the same condition as the finished pipe (with or without bead as specified).

## 8. Mechanical Tests Required

8.1 *Tension Test*—One transverse tension test of the weld shall be made on each lot (Note 2) of finished pipe.

NOTE 2—The term “lot” applies to each 200 ft [60 m] or less of pipe of the same NPS and wall thickness (or schedule number) which is produced from the same heat of steel and subjected to the same finishing treatment in a continuous furnace. When final heat treatment is in a batch-type furnace, the lot shall include only that pipe which is heat treated in the same furnace charge. When no heat treatment is performed following final forming operations, the lot shall include each 200 ft [60 m] or less of pipe of the same NPS and wall thickness (or schedule number) which is produced from the same heat of steel.

8.2 *Transverse Guided-Bend Weld Test*—One test (two specimens) of the weld shall be made on each lot (Note 2) of finished pipe.

8.3 *Pressure or Nondestructive Electric Test*—Each length of pipe shall be subjected to a pressure test or a nondestructive electric test as prescribed in Section 5.



TABLE 2 Filler Metal Specifications

Grade	UNS Designation	Filler Metal Classification and UNS Designation <sup>A</sup> for Applicable <sup>B</sup> AWS Specification											
		A5.4		A5.9		A5.11		A5.14		A5.22		A5.30	
		Class.	UNS	Class.	UNS	Class.	UNS	Class.	UNS	Class.	UNS	Class.	UNS
TP201	S20100	...	...	...	...	...	...	...	...	...	...	...	...
TP201LN	S20153	...	...	...	...	...	...	...	...	...	...	...	...
TP304	S30400	E308	W30810	ER308	S30880 W30840	...	...	...	...	E308T	W30831	IN308	S30880
TP304L	S30403	E308L	W30813	ER308L	S30883 W30843	...	...	...	...	E308T	W30835	IN308L	S30883
...	<u>S30416</u>	<u>E316L</u>	<u>W31603</u>	<u>ER316L</u>	<u>S31683</u> <u>W31643</u>	...	...	...	...	<u>E316LT</u>	<u>W31635</u>	<u>IN316L</u>	<u>S31683</u>
TP309Cb	S30940	E309Cb	W30917	...	...	...	...	...	...	...	...	...	...
TP310Cb	S31040	E310Cb	W31017	...	...	...	...	...	...	...	...	...	...
TP316	S31600	E316	W31610	ER316	S31680 W31640	...	...	...	...	E316T	W31631	IN316	S31680
TP316L	S31603	E316L	W31603	ER316L	S31683 W31643	...	...	...	...	E316LT	W31635	IN316L	S31683
TP317	S31700	E317	W31700	ER317	S31783 W31743	...	...	...	...	E317T	W31731	IN317	S31780
...	S31727	...	...	...	...	...	...	...	...	...	...	...	...
...	S32053	...	...	...	...	...	...	...	...	...	...	...	...
TP321	S32100	E347	W34710	ER321 ER347	S32180 W32140 S34780 W34740	...	...	...	...	E347T	W34733	IN348	S34780
TP347	S34700	E347	W34710	ER347	S34780 W34740	...	...	...	...	E347T	W34733	IN348	S34780
TP348	S34800	E347	W34710	ER347	S34780 W34740	...	...	...	...	E347T	W34733	IN348	S34780
...	S31254	...	...	...	...	ENiCrMo-3	W86112	ERNiCrMo-3	N06625	...	...	...	...
...	S31725	...	...	...	...	ENiCrMo-3	W86112	ERNiCrMo-3	N06625	...	...	...	...
...	S31726	...	...	...	...	ENiCrMo-3	W86112	ERNiCrMo-3	N06625	...	...	...	...
...	S34565	...	...	...	...	...	...	...	...	...	...	...	...
...	N08367	...	...	...	...	ENiCrMo-3	W86112	ERNiCrMo-3	N06625	...	...	...	...
...	S20400	E209	W32210	ER209	W32240	...	...	...	...	...	...	...	...
...	S31266	...	...	...	...	ENiCrMo-4	W80276	ERNiCrMo-4	N10276	...	...	...	...
...	...	...	...	...	...	ENiCrMo-10	W86022	ERNiCrMo-10	N06022	...	...	...	...
...	...	...	...	...	...	ENiCrMo-13	W86059	ERNiCrMo-13	N06059	...	...	...	...
...	...	...	...	...	...	ENiCrMo-14	W86026	ERNiCrMo-14	N06686	...	...	...	...
...	...	...	...	...	...	ENiCrMo-17	W86200	ERNiCrMo-17	N06200	...	...	...	...

<sup>A</sup>New designation established in accordance with Practice E527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

<sup>B</sup>Choice of American Welding Society specification depends on the welding process used.

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## 9. Permissible Variations in Wall Thickness

9.1 The minimum wall thickness at any point shall not be more than 0.018 in. [0.46 mm] under the specified wall thickness. (This tolerance is slightly more than commercial tolerances on sheet and plate to allow for possible loss of thickness caused by manufacturing operations.)

## 10. Permissible Variations in Dimensions

10.1 Permissible variations in dimensions shall not exceed the following at any point in each length of pipe.

10.1.1 *Specified Diameter*—Where the specified wall thickness is less than 0.188 in. [4.8 mm], the actual outside diameter, based on circumferential measurement, shall not vary more than ±0.20 % from the specified outside diameter. Where the specified wall thickness is 0.188 in. [4.8 mm] and heavier, the actual outside diameter, based on circumferential measurement, may vary a maximum of ±0.40 % from the specified outside diameter. (Outside diameter tolerances closer than shown above may be obtained by agreement between the pipe manufacturer and purchaser.)

10.1.2 *Out-of-Roundness*—The difference between the major and the minor outside diameter shall not be more than 1.5 % of the specified outside diameter.

10.1.3 *Alignment (Camber)*—Using a 10-ft [3.0-m] straightedge placed so that both ends are in contact with the pipe, the camber shall not be more than 3/16 in. [4.8 mm].



TABLE 3 Tensile Requirements

Grade	UNS Designation	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa]
TP201	S20100	75 [515]	38 [260]
TP201LN	S20153	95 [655]	45 [310]
TP304	S30400	75 [515]	30 [205]
TP304L	S30403	70 [485]	25 [170]
...	S30416	73 [500]	32 [220]
TP309Cb	S30940	75 [515]	30 [205]
TP309S	S30908	75 [515]	30 [205]
TP310Cb	S31040	75 [515]	30 [205]
TP310S	S31008	75 [515]	30 [205]
TP316	S31600	75 [515]	30 [205]
TP316L	S31603	70 [485]	25 [170]
TP317	S31700	75 [515]	30 [205]
...	S31727	80 [550]	36 [245]
...	S32053	93 [640]	43 [295]
TP321	S32100	75 [515]	30 [205]
TP347	S34700	75 [515]	30 [205]
TP348	S34800	75 [515]	30 [205]
...	S31254	94 [650]	44 [300]
...	S30815	87 [600]	45 [310]
...	S31725	75 [515]	30 [205]
...	S31726	80 [550]	35 [240]
...	S34565	115 [795]	60 [415]
...	S20400	95 [655]	48 [330]
...	N08367		
	t ≤ 0.187	100 [690]	45 [310]
	t > 0.187	95 [655]	45 [310]
...	S31266	109 [750]	61 [420]

## 11. Lengths

11.1 Unless otherwise specified in the purchase order, pipe of NPS 22 or less will be furnished in random lengths of 9 to 12 ft (Note 3). For outside diameters of over NPS 22, the minimum length will be 5 ft (Note 3).

NOTE 3—This value(s) applies when the inch-pound designation of this specification is the basis of purchase. The corresponding metric value(s) shall be agreed upon between the manufacturer and the purchaser.

11.2 When specified by the purchaser, two or more lengths may be circumferentially welded together to produce longer lengths.

11.3 Circumferentially welded joints shall be of the same quality as the longitudinal joints.

## 12. Workmanship, Finish, and Appearance

12.1 The finished pipe shall have a workmanlike finish.

12.2 *Repair of Defects by Machining or Grinding*—Pipe showing moderate slivers or other surface defects may be machined or ground inside or outside to a depth which will ensure the removal of all defects providing the wall thickness is not reduced below the minimum specified in 9.1.

12.3 *Repair of Defects by Welding*—Defects which violate minimum wall thickness may be repaired by welding, but only with the approval of the purchaser. Areas shall be suitably prepared for welding with tightly closed defects removed by grinding. Open, clean defects, such as pits or impressions, may require no preparation. All welders, welding operators, and weld procedures shall be qualified to the ASME Boiler and Pressure Vessel Code, Section IX. Unless the purchaser specifies otherwise, pipe required to be heat treated under the provisions of 5.3 shall be heat treated or reheat treated following repair welding. Repaired lengths, where repair depth is greater than ¼ of the thickness, shall be pressure tested or repressure tested after repair and heat treatment (if any). Repair welds shall also be examined by suitable non-destructive examination techniques, including any techniques specifically required of the primary weld.

12.4 The pipe shall be free of scale and contaminating iron particles. Pickling, blasting, or surface finishing is not mandatory when pipe is bright annealed. The purchaser may request that a passivating treatment be applied.