



Designation: ~~A790/A790M-05a~~ Designation: A 790/A 790M – 05b

## Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe<sup>1</sup>

This standard is issued under the fixed designation A 790/A 790M; 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 seamless and straight-seam welded ferritic/austenitic steel pipe intended for general corrosive service, with particular emphasis on resistance to stress corrosion cracking. These steels are susceptible to embrittlement if used for prolonged periods at elevated temperatures.

1.2 Optional supplementary requirements are provided for pipe when a greater degree of testing is desired. These supplementary requirements call for additional tests to be made and, when desired, one or more of these may be specified in the order.

1.3 Appendix X1 of this specification lists the dimensions of welded and seamless stainless steel pipe as shown in ANSI B36.19. Pipe having other dimensions may be furnished provided such pipe complies with all other requirements of this specification.

1.4 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.

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.

### 2. Referenced Documents

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

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys and Ferroalloys

A 999/A 999M Specification for General Requirements for Alloy and Stainless Steel Pipe

E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing

E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation

E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings <https://standards.iteh.ai/>

E 426 Practice for Electromagnetic (Eddy-Current) Examination of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys

E 527 Practice for Numbering Metals and Alloys (UNS)

#### 2.2 ANSI Standards:<sup>4</sup>

B1.20.1 Pipe Threads, General Purpose

B36.10 Welded and Seamless Wrought Steel Pipe

B36.19 Stainless Steel Pipe

#### 2.3 SAE Standard:<sup>5</sup>

SAE J 1086

#### 2.4 Other Standard:<sup>6</sup>

SNT-TC-1A Personal Qualification and Certification in Nondestructive Testing

<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.

Current edition approved ~~June 15, 2005~~. Published ~~June~~ October 2005. Originally approved in 1981. Last previous edition approved in 2005 as A 790/A 790M – 05a.

<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-790 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.

<sup>4</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

<sup>5</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

<sup>6</sup> Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518.

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

2.5 AWS Standard

A5.9 Corrosion-Resisting Chromium and Chromium-Nickel Steel Welding Rods and Electrodes

**3. Terminology**

3.1 *Definitions*— For definitions of terms used in this specification refer to Terminology A 941.

**4. Ordering Information**

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

- 4.1.1 Quantity (feet, metres, or number of lengths),
- 4.1.2 Name of material (ferritic/austenitic steel pipe),
- 4.1.3 Process (seamless or welded),
- 4.1.4 Grade (see Table 1),
- 4.1.5 Size (NPS designator or outside diameter and schedule number of average wall thickness),
- 4.1.6 Length (specific or random) (see Section 11),
- 4.1.7 End finish (section on ends of Specification A 999/A 999M),
- 4.1.8 Optional requirements (product analysis, Section 9; hydrostatic test or nondestructive electric test, Section 14),
- 4.1.9 Test report required (section on certification of Specification A 999/A 999M),
- 4.1.10 Specification designation, and
- 4.1.11 Special requirements and any supplementary requirements selected.

**5. General Requirements**

5.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 999/A 999M unless otherwise provided herein.

**TABLE 1 Heat Treatment**

UNS Designation	Temperature °F [°C]	Quench
S31200	1920–2010 [1050–1100]	Rapid cooling in water
S31260	1870–2010 [1020–1100]	Rapid cooling in air or water
S31500	1800–1900 [980–1040]	Rapid cooling in air or water
S31803	1870–2010 [1020–1100]	Rapid cooling in air or water
S32003	1850–2050 [1010–1120]	Rapid cooling in air or water
S32101	1870 [1020]	Quenched in water or rapidly cooled by other means
S32205	1870–2010 [1020–1100]	Rapid cooling in air or water
S32304	1700–1920 [925–1050]	Rapid cooling in air or water
S32520	1975–2050 [1080–1120]	Rapid cooling in air or water
S32550	1900 [1040] min	Rapid cooling in air or water
S32707	1975–2050 [1080–1120]	Rapid cooling in air or water
S32750	1880–2060 [1025–1125]	Rapid cooling in air or water
S32760	2010–2085 [1100–1140]	Rapid cooling in air or water
S32808	1920–2100 [1050–1150]	Rapid cooling in air or water
S32900	1700–1750 [925–955]	Rapid cooling in air or water
S32906	1900–1980 [1040–1080]	Rapid cooling in air or water
S32906	1870–2100 [1040–1080]	Rapid cooling in air or water
S32950	1820–1880 [990–1025]	Air cool
S39274	1920–2060 [1025–1125]	Rapid cooling in air or water
S39277	1975–2155 [1080–1180]	Rapid cooling in air or water

## 6. Materials and Manufacture

### 6.1 Manufacture:

6.1.1 The pipe shall be made by the seamless or an automatic welding process, with no addition of filler metal in the welding operation.

6.1.2 At the manufacturer's option, pipe may be either hot-finished or cold-finished.

6.1.3 The pipe shall be pickled free of scale. When bright annealing is used, pickling is not necessary.

6.2 *Discard*—A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

6.3 All pipe shall be furnished in the heat-treated condition as shown in Table 1. For seamless pipe, as an alternate to final heat treatment in a continuous furnace or batch-type furnace, immediately following hot forming while the temperature of the pipes is not less than the specified minimum solution treatment temperature, pipes shall be individually quenched in water or rapidly cooled by other means, except for UNS S32950, which shall be air cooled.

## 7. Chemical Composition

7.1 The steel shall conform to the chemical requirements as prescribed in Table 2.

## 8. Heat Analysis

8.1 An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of the elements specified.

## 9. Product Analysis

9.1 At the request of the purchaser's inspector, an analysis of one billet or one length of flat-rolled stock from each heat, or two pipes from each lot, shall be made by the manufacturer. A lot of pipe shall consist of the following number of lengths of the same size and wall thickness from any one heat of steel:

NPS Designator	Lengths of Pipe in Lot
Under 2	400 or fraction thereof
2 to 5, incl	200 or fraction thereof
6 and over	100 or fraction thereof

9.2 The results of these analyses shall be reported to the purchaser or the purchaser's representative and shall conform to the requirements specified in Section 7.

9.3 If the analysis of one of the tests specified in 8.1 or 9.1 does not conform to the requirements specified in Section 7, an analysis of each billet or pipe from the same heat or lot may be made, and all billets or pipe conforming to the requirements shall be accepted.

**TABLE 2 Chemical Requirements<sup>A</sup>**

UNS Designation <sup>B</sup>	C	Mn	P	S	Si	Ni	Cr	Mo	N	Cu	Others <sup>b</sup>
S31200	0.030	2.00	0.045	0.030	1.00	5.5–6.5	24.0–26.0	1.20–2.00	0.14–0.20	...	...
S31260	0.030	1.00	0.030	0.030	0.75	5.5–7.5	24.0–26.0	2.5–3.5	0.10–0.30	0.20–0.80	W
S31500	0.030	1.20–2.00	0.030	0.030	1.40–2.00	4.2–5.2	18.0–19.0	2.50–3.00	0.05–0.10	...	...
S31803	0.030	2.00	0.030	0.020	1.00	4.5–6.5	21.0–23.0	2.5–3.5	0.08–0.20	...	...
S32003	0.030	2.00	0.030	0.020	1.00	3.0–4.0	19.5–22.5	1.50–2.00	0.14–0.20	...	...
S32101	0.040	4.0–6.0	0.040	0.030	1.00	1.35–1.70	21.0–22.0	0.10–0.80	0.20–0.25	0.10–0.80	...
S32205	0.030	2.00	0.030	0.020	1.00	4.5–6.5	22.0–23.0	3.0–3.5	0.14–0.20	...	...
S32304	0.030	2.50	0.040	0.040	1.00	3.0–5.5	21.5–24.5	0.05–0.60	0.05–0.20	0.05–0.60	...
S32520	0.030	1.5	0.035	0.020	0.80	5.5–8.0	24.0–26.0	3.0–5.0	0.20–0.35	0.5–3.00	...
S32550	0.04	1.50	0.040	0.030	1.00	4.5–6.5	24.0–27.0	2.9–3.9	0.10–0.25	1.50–2.50	...
S32707	0.030	1.50	0.035	0.010	0.50	5.5–9.5	26.0–29.0	4.0–5.0	0.30–0.50	1.0	Co 0.5–2.0
S32750	0.030	1.20	0.035	0.020	0.80	6.0–8.0	24.0–26.0	3.0–5.0	0.24–0.32	0.5	...
S32760	0.05	1.00	0.030	0.010	1.00	6.0–8.0	24.0–26.0	3.0–4.0	0.20–0.30	0.50–1.00	W
S32808	0.030	1.10	0.030	0.030	0.50	7.0–8.2	27.0–27.9	0.80–1.20	0.30–0.40	...	W 0.50–1.00 40 min <sup>C</sup> 2.10–2.50
S32900	0.08	1.00	0.040	0.030	0.75	2.5–5.0	23.0–28.0	1.00–2.00	...	...	...
S32906	0.030	0.80–1.50	0.030	0.030	0.50	5.8–7.5	28.0–30.0	1.50–2.60	0.30–0.40	0.80	...
S32906	0.030	0.80–1.50	0.030	0.030	0.80	5.8–7.5	28.0–30.0	1.50–2.60	0.30–0.40	0.80	...
S32950	0.030	2.00	0.035	0.010	0.60	3.5–5.2	26.0–29.0	1.00–2.50	0.15–0.35	...	...
S39274	0.030	1.00	0.030	0.020	0.80	6.0–8.0	24.0–26.0	2.5–3.5	0.24–0.32	0.20–0.80	W 1.50–2.50
S39277	0.025	0.80	0.025	0.002	0.80	6.5–8.0	24.0–26.0	3.0–4.0	0.23–0.33	1.20–2.00	W 0.8–1.2

<sup>A</sup>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.

<sup>B</sup>New designation established in accordance with Practice E 527 and SAE J1086.

<sup>C</sup>% Cr + 3.3 × % Mo + 16 × % N.

## 10. Tensile and Hardness Properties

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

## 11. Lengths

11.1 Pipe lengths shall be in accordance with the following regular practice:

11.1.1 Unless otherwise agreed upon, all sizes from NPS ½ to and including NPS 8 are available in a length up to 24 ft (see Note 2) with the permissible range of 15 to 24 ft (see Note 2). Short lengths are acceptable and the number and minimum length shall be agreed upon between the manufacturer and the purchaser.

**TABLE 3 Tensile and Hardness Requirements**

UNS Designation	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa]	Elongation in 2 in. or 50 mm, min, %	Hardness, max	
				HBW	HRC
S31200	100 [690]	65 [450]	25	280	...
S31260	100 [690]	65 [450]	25	...	...
S31500	92 [630]	64 [440]	30	290	30
S31803	90 [620]	65 [450]	25	290	30
S32003	90 [620]	65 [450]	25	290	30
S32101					
t ≤ 0.187 in. [5.00 mm]	101 [700]	77 [530]	30	290	...
t > 0.187 in. [5.00 mm]	94 [650]	65 [450]	30	290	...
S32205	95 [655]	65 [450]	25	290	30
S32304	87 [600]	58 [400]	25	290	30
S32520	112 [770]	80 [550]	25	310	...
S32550	110 [760]	80 [550]	15	297	31
S32707	133 [920]	101 [700]	25	318	34
S32750	116 [800]	80 [550]	15	300	32
S32760 <sup>A</sup>	109 [750]	80 [550]	25	270	...
S32808	116 [800]	80 [550]	15	310	32
S32900	90 [620]	70 [485]	20	271	28
S32906					
Wall below 0.40 in. (10 mm)	116 [800]	94 [650]	25	300	32
Wall 0.40 in. (10 mm) and above	109 [750]	80 [550]	25	300	32
S32950	100 [690]	70 [480]	20	290	30
S39274	116 [800]	80 [550]	15	310	...
S39277	120 [825]	90 [620]	25	290	30

<sup>A</sup> Prior to A 790/A 790M – 04, the tensile strength value for UNS 32760 was 109–130 ksi [750–895 MPa].

NOTE 2—This value applies when the inch-pound designation of this specification is the basis of purchase. When the *M* designation of this specification is the basis of purchase, the corresponding metric value(s) shall be agreed upon between the manufacturer and purchaser.

11.1.2 If definite cut lengths are desired, the lengths required shall be specified in the order. No pipe shall be less than the specified length and no more than ¼ in. [6 mm] over it.

11.1.3 No jointers are permitted unless otherwise specified.

## 12. Workmanship, Finish, and Appearance

12.1 The finished pipes shall be reasonably straight and shall have a workmanlike finish. Imperfections may be removed by grinding, provided the wall thicknesses are not decreased to less than that permitted, in the Permissible Variations in Wall Thickness Section of Specification A 999/A 999M.

## 13. Mechanical Tests Required

13.1 *Transverse or Longitudinal Tension Test*—One tension test shall be made on a specimen for lots of not more than 100 pipes. Tension tests shall be made on specimens from 2 pipes for lots of more than 100 pipes.

13.2 *Mechanical Testing Lot Definition* — The term *lot* for mechanical tests applies to all pipe of the same nominal size and wall thickness (or schedule) that is produced from the same heat of steel and subjected to the same finishing treatment as defined as follows:

13.2.1 Where the heat treated condition is obtained, consistent with the requirements of 6.3, in a continuous heat treatment furnace or by directly obtaining the heat treated condition by quenching after hot forming, the lot shall include all pipe of the same size and heat, heat treated in the same furnace at the same temperature, time at heat, and furnace speed or all pipe of the same size and heat, hot formed and quenched in the same production run.

13.2.2 Where final heat treatment is obtained, consistent with the requirements of 6.3, in a batch-type heat-treatment furnace equipped with recording pyrometers and automatically controlled within a 50 °F [30 °C] or smaller range, the lot shall be the larger of (a) each 200 ft [60 m] or fraction thereof or (b) that pipe heat treated in the same batch furnace charge.

13.2.3 Where the final heat treatment is obtained, consistent with the requirements of 6.3, in a batch-type heat-treatment furnace not equipped with recording pyrometers and automatically controlled within a 50 °F [30 °C] or smaller range, the term *lot* for mechanical tests applies to the pipe heat treated in the same batch furnace charge, provided that such pipe is of the same nominal size and wall thickness (or schedule) and is produced from the same heat of steel.

13.3 *Flattening Test*—For pipe heat treated in a batch-type furnace, flattening tests shall be made on 5 % of the pipe from each heat-treated lot. For pipe heat treated by the continuous process, or by direct quenching after hot forming, this test shall be made on a sufficient number of pipes to constitute 5 % of the lot, but in no case less than two lengths of pipe.

13.3.1 For welded pipe with a diameter equal to or exceeding NPS 10, a transverse guided face bend test of the weld may be conducted instead of a flattening test in accordance with the method outlined in the steel tubular product supplement of Test Methods and Definitions A 370. The ductility of the weld shall be considered acceptable when there is no evidence of cracks in the weld or between the weld and the base metal after bending. Test specimens from 5 % of the lot shall be taken from the pipes or test plates of the same material as the pipe, the test plates being attached to the end of the cylinder and welded as a prolongation of the pipe longitudinal seam.

13.4 *Hardness Test*—Brinell or Rockwell hardness tests shall be made on specimens from two pipes from each lot (see 13.2).

## 14. Hydrostatic or Nondestructive Electric Test

14.1 Each pipe shall be subjected to the nondestructive 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.

14.2 The hydrostatic test shall be in accordance with Specification A 999/A 999M, except that the value for *S* to be used in the calculation of the hydrostatic test pressure shall be equal to 50 % of the specified minimum yield strength of the pipe.

### 14.3 *Nondestructive Electric Test* :

Nondestructive electric tests shall be in accordance with Practices E 213 or E 309.

14.3.1 As an alternative to the hydrostatic test, and when specified by the purchaser, each pipe shall be examined with a nondestructive test in accordance with Practices E 213 or E 309. Unless specifically called out by the purchaser, the selection of the nondestructive electric test will be at the option of the manufacturer. The range of pipe sizes that may be examined by each method shall be subject to the limitations in the scope of the respective practices.

14.3.1.1 The following information is for the benefit of the user of this specification:

14.3.1.2 The reference standards defined in 14.3.1.3-14.3.1.5 are convenient standards for calibration of nondestructive testing equipment. The dimensions of these standards should not be construed as the minimum size imperfection detectable by such equipment.

14.3.1.3 The ultrasonic testing (UT) can be performed to detect both longitudinally and circumferentially oriented defects. It should be recognized that different techniques should be employed to detect differently oriented imperfections. The examination may not detect short, deep, defects.

14.3.1.4 The eddy-current testing (ET) referenced in this specification (see Practice E 426) has the capability of detecting significant discontinuities, especially the short abrupt type.

14.3.1.5 A purchaser interested in ascertaining the nature (type, size, location, and orientation) of discontinuities that can be detected in the specific application of these examinations should discuss this with the manufacturer of the tubular product.

14.4 *Time of Examination*—Nondestructive testing for specification acceptance shall be performed after all mechanical processing, heat treatments, and straightening operations. This requirement does not preclude additional testing at earlier stages in the processing.

14.5 *Surface Condition:*

14.5.1 All surfaces shall be free of scale, dirt, grease, paint, or other foreign material that could interfere with interpretation of test results. The methods used for cleaning and preparing the surfaces for examination shall not be detrimental to the base metal or the surface finish.

14.5.2 Excessive surface roughness or deep scratches can produce signals that interfere with the test.

14.6 *Extent of Examination:*

14.6.1 The relative motion of the pipe and the transducer(s), coil(s), or sensor(s) shall be such that the entire pipe surface is scanned, except as in 14.6.2.

14.6.2 The existence of end effects is recognized and the extent of such effects shall be determined by the manufacturer and, if requested, shall be reported to the purchaser. Other nondestructive tests may be applied to the end areas, subject to agreement between the purchaser and the manufacturer.

14.7 *Operator Qualifications*—The test unit operator shall be certified in accordance with SNT-TC-1A, or an equivalent recognized and documented standard.

14.8 *Test Conditions:*

14.8.1 For eddy-current testing, the excitation coil frequency shall be chosen to ensure adequate penetration yet provide good signal-to-noise ratio.

14.8.2 The maximum eddy-current coil frequency used shall be as follows:

- On specified walls up to 0.050 in.—100 KHz max
- On specified walls up to 0.150 in.—50 KHz max
- On specified walls over 0.150 in.—10 KHz max

14.8.3 *Ultrasonic*—For examination by the ultrasonic method, the minimum nominal transducer frequency shall be 2.00 MHz and the maximum nominal transducer size shall be 1.5 in. If the equipment contains a reject notice filter setting, this shall remain off during calibration and testing unless linearity can be demonstrated at that setting.

14.9 *Reference Standards*—Reference standards of convenient length shall be prepared from a length of pipe of the same grade, size (NPS, or outside diameter and schedule or wall thickness), surface finish and heat treatment condition as the pipe to be examined.

14.9.1 *For Ultrasonic Testing*, the reference ID and OD notches shall be any one of the three common notch shapes shown in Practice E 213, at the option of the manufacturer. The depth of each notch shall not exceed 12 ½ % of the specified nominal wall thickness of the pipe or 0.004 in., whichever is greater. The width of the notch shall not exceed twice the depth. Notches shall be placed on both the OD and ID surfaces.

14.9.2 *For Eddy-Current Testing*, the reference standard shall contain, at the option of the manufacturer, any one of the following discontinuities:

14.9.2.1 *Drilled Hole*— The reference standard shall contain three or more holes equally spaced circumferentially around the pipe and longitudinally separated by a sufficient distance to allow distinct identification of the signal from each hole. The holes shall be drilled radially and completely through the pipe wall, with care being taken to avoid distortion of the pipe while drilling. One hole shall be drilled in the weld, if visible. Alternately, the producer of welded pipe may choose to drill one hole in the weld and run the calibration standard through the test coils three times with the weld turned at 120° on each pass. The hole diameter shall vary with NPS as follows:

NPS Designator	Hole Diameter
above ½ to 1¼	0.039 in. (1 mm)
above 1¼ to 2	0.055 in. (1.4 mm)
above 2 to 5	0.071 in. (1.8 mm)
above 5	0.087 in. (2.2 mm)
	0.106 in. (2.7 mm)

14.9.2.2 *Transverse Tangential Notch* —Using a round tool or file with a ¼-in. (6.4-mm) diameter, a notch shall be filed or milled tangential to the surface and transverse to the longitudinal axis of the pipe. Said notch shall have a depth not exceeding 12 ½ % of the specified nominal wall thickness of the pipe or 0.004 in. (0.102 mm), whichever is greater.

14.9.2.3 *Longitudinal Notch*—A notch 0.031 in. or less in width shall be machined in a radial plane parallel to the tube axis on the outside surface of the pipe to have a depth not exceeding 12 ½ % of the specified wall thickness of the pipe or 0.004 in., whichever is greater. The length of the notch shall be compatible with the testing method.

More or smaller reference discontinuities, or both, may be used by agreement between the purchaser and the manufacturer.

14.10 *Standardization Procedure:*

14.10.1 The test apparatus shall be standardized at the beginning and end of each series of pipes of the same size (NPS or diameter and schedule or wall thickness, grade, and heat treatment condition), and at intervals not exceeding 4 h. More frequent