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Standard Specification for Spray-Formed Seamless Ferritic/Austenitic Stainless Steel Pipe[1]

This standard is issued under the fixed designation A 949/A 949M; 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.

1. Scope

1.1 This specification covers spray-formed seamless ferritic/austenitic stainless 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 where 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 seamless stainless steel pipe as shown in ANSI B 36.19. 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:* [2]

A 450/A 450M Specification for General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes

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 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

E 527 Practice for Numbering Metals and Alloys (UNS)

2.2 *ANSI/ASME Standards:*

B 1.20.1 Pipe Threads, General Purpose[3]

B 36.10M-1995 Welded and Seamless Wrought Steel Pipe[3]

B 36.19 Stainless Steel Pipe

2.3 *Other Standard:*

SAE J1086 Practice for Numbering Metals and Alloys (UNS)[4]

3. Terminology

3.1 *Definitions*:

3.1.1 For definitions of terms used in this specification, refer to Terminology A 941.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *spray-formed*—denotes the fabrication of different shapes of a metallic material by deposition of a spray, consisting of droplets, solid particles, and particles that are partially solid, onto a moving substrate.

3.2.1.1 *Discussion*—The spray is produced by gas atomization of the liquid metal or alloy. On impingement with the substrate, the species of the spray consolidate and solidify completely to produce a product that is essentially free of porosity. The metallurgical characteristics of the spray-formed product are controlled primarily by the thermal condition of the spray, and that of the surface of the metallic deposit formed on the substrate.

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 Grade (Table 1),

4.1.4 Size (NPS designator or outside diameter and schedule number of average wall thickness, or other),

[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 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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

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TABLE 1 Heat Treatment

UNS Designation	Temperature	Quench
S31803	1870–2010°F [1020–1100°C]	rapid cooling in air or water
S31500	1800–1900°F [980–1040°C]	rapid cooling in air or water
S31200	1920–2010°F [1050–1100°C]	rapid cooling in water
S32550	1900°F [1040°C] min	rapid cooling in air or water
S31260	1870–2010°F [1020–1100°C]	rapid cooling in water
S32304	1700–1920°F [925–1050°C]	rapid cooling in air or water
S32750	1880–2060°F [1025–1125°C]	rapid cooling in air or water
S32900	1700–1750°F [925–955°C]	rapid cooling in air or water
S32950	1820–1880°F [995–1025°C]	air cool

4.1.5 Length (specific or random) (Section 10),

4.1.6 End finish (section on Ends of Specification A 999/A 999M),

4.1.7 Optional requirements (Section 9), Supplementary Requirements S1 to S4,

4.1.8 Test report required (section on Certification of Specification A 999/A 999M),

4.1.9 Specification designation, and

4.1.10 Special requirements or exceptions to the specification.

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.

6. Materials and Manufacture

6.1 *Melting*—The steel shall be made by the electric-furnace process or other primary processes approved by the purchaser.

6.2 *Pipe Manufacture*:

6.2.1 The pipe shall be made by the spray forming process using the melt from the primary melting as noted in 7.1.

6.2.2 The pipe shall be made by spraying the melt on to a thin-walled collector tube. The as spray formed tube shall be machined on both the inner and outer surfaces. The remaining metal shall be homogeneous, sound, and meet the requirements of Section 11.

6.2.3 Unless specified by the purchaser, pipe may be furnished as spray formed or as spray-formed and cold-finished.

6.2.4 All pipe shall be furnished in the heat-treated condition as shown in Table 1.

6.2.5 All pipe shall be furnished in the descaled condition and be free of 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.

7. Chemical Composition

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

8. Product Analysis

8.1 At the request of the purchaser, an analysis of 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 stainless 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

8.2 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 5.

8.3 If the analysis of one of the tests specified in 8.1 does not conform to the requirements specified in Section 5, an analysis of each pipe from the same heat or lot may be made, and all pipes conforming to the requirements shall be accepted.

9. Tensile and Hardness Properties

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

10. Lengths

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

10.1.1 Unless otherwise agreed upon, all sizes from NPS ⅛ to and including NPS 8 are available in a length up to 24 ft (Note 2) with the permissible range of 15 to 24 ft (Note 2). Short lengths are acceptable and the number and minimum length shall be agreed upon between the manufacturer and the purchaser.

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 the purchaser.

10.1.2 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.

TABLE 2 Chemical Requirements

UNS Designation[A]	C	Mn	P	S	Si	Ni	Cr	Mo	N	Cu	Others
S31803	0.030 max	2.00 max	0.030 max	0.020 max	1.00 max	4.5–6.5	21.0–23.0	2.5–3.5	0.08–0.20	. . .	
S31500	0.030 max	1.20–2.00	0.030 max	0.030 max	1.40–2.00	4.3–5.2	18.0–19.0	2.50–3.00	0.05–0.10	. . .	
S32550	0.040 max	1.50 max	0.040 max	0.030 max	1.00 max	4.5–6.5	24.0–27.0	2.9–3.9	0.10–0.25	1.50–2.50	
S31200	0.030 max	2.00 max	0.045 max	0.030 max	1.00 max	5.5–6.5	24.0–26.0	1.20–2.00	0.14–0.20	. . .	
S31260	0.030 max	1.00 max	0.030 max	0.030 max	0.75 max	5.5–7.5	24.0–26.0	2.5–3.5	0.10–0.30	0.20–0.80	W 0.10–0.50
S32304	0.030 max	2.50 max	0.040 max	0.040 max	1.00 max	3.0–5.5	21.5–24.5	0.05–0.60	0.05–0.20	0.05–0.60	
S32750	0.030 max	1.20 max	0.035 max	0.020 max	0.80 max	6.0–8.0	24.0–26.0	3.0–5.0	0.24–0.32	0.50 max	. . .
S32900	0.08 max	1.00 max	0.040 max	0.030 max	0.75 max	2.5–5.0	23.0–28.0	1.00–2.00	. . .	. . .	. . .
S32950	0.03 max	2.00 max	0.035 max	0.010 max	0.60 max	3.5–5.2	26.0–29.0	1.00–2.50	0.15–0.35	. . .	

[A] New designation established in accordance with Practice E 527 and SAE J1086.

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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	
				Brinell	Rockwell C
S31803	90 [620]	65 [450]	25	290	30.5
S31500	92 [635]	64 [440]	30	290	30.5
S31200	110 [760]	80 [550]	15	297	31.5
S32550	100 [690]	65 [450]	25	280	. . .
S31260	100 [690]	65 [450]	25	. . .	. . .
S32304	87 [600]	58 [400]	25	290	30.5
S32750	116 [800]	80 [550]	15	310	32
S32900	90 [620]	70 [485]	20	271	28
S32950	90 [620]	70 [485]	20	290	30.5

11. Workmanship, Finish, and Appearance

11.1 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.

12. Mechanical Tests Required

12.1 *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 two pipes for lots of more than 100 pipes.

NOTE 3—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: (*1*) in a continuous heat-treatment furnace, or (*2*) in a batch-type heat-treatment furnace, equipped with recording pyrometers and automatically controlled within a 50°F [30°C] range, the larger of: (*a*) each 200 ft [60 m] or fraction thereof or, (*b*) that pipe heat treated in the same batch furnace charge.

12.2 *Flattening Test*—For material heat treated in a batch-type furnace, flattening tests shall be made on 5 % of the pipe from each heat-treated lot. For material heat treated by the continuous process, 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.

12.3 *Hydrostatic Test*—Each length of finished pipe shall be subjected to the hydrostatic test.

12.3.1 The hydrostatic test shall be in accordance with Specification A 999/A 999M. When making the calculations in the Hydrostatic Test Requirements Section of Specification A 999/A 999M, an *S* value 50 % of the specified minimum yield strength shall be used.

12.3.2 When specified by the purchaser, a nondestructive electric test in accordance with Specification A 450/A 450M may be used instead of, or in addition to, the hydrostatic test.

13. Product Marking

13.1 In addition to the marking specified in Specification A 999/A 999M, all marking shall include the manufacturer's private identifying mark and be given the designator, CF, when cold finished. If specified in the purchase order, the marking for pipe larger than NPS 4 shall include the weight.

14. Keywords

14.1 austenitic/ferritic; pipe; spray-formed; stainless

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified in the purchase order. The purchaser may specify a different frequency of test or analysis than is provided in the supplementary requirement. Subject to agreement between the purchaser and manufacturer, retest and retreatment provisions of these supplementary requirements may also be modified.

S1. Product Analysis

S1.1 For all pipe over NPS 5 there shall be one product analysis made of a representative sample from one piece for each ten lengths or fraction thereof from each heat of steel.

S1.2 For pipe smaller than NPS 5 there shall be one product analysis made from ten lengths per heat of steel or from 10 % of the number of lengths per heat of steel, whichever number is smaller.

S1.3 Individual lengths failing to conform to the chemical requirements specified in Section 5 shall be rejected.

S2. Transverse Tension Tests

S2.1 There shall be one transverse tension test made from one end of 10 % of the lengths furnished per heat of steel. This applies only to pipe over NPS 8.

S2.2 If a specimen from any length fails to conform to the tensile properties specified that length shall be rejected.

S3. Flattening Test

S3.1 The flattening test of Specification A 999/A 999M shall be made on a specimen from one end or both ends of each pipe. Crop ends may be used. If this supplementary requirement is specified, the number of tests per pipe shall also be specified. If a specimen from any length fails because of lack of ductility prior to satisfactory completion of the first step of the flattening test requirement, that pipe shall be rejected subject to retreatment in accordance with Specification A 999/A 999M and satisfactory retest. If a specimen from any length of pipe fails because of a lack of soundness that length shall be rejected, unless subsequent retesting indicates that the remaining length is sound.

S4. Etching Tests

S4.1 The steel shall be homogeneous as shown by etching tests conducted in accordance with the appropriate portions of Method E 381. Etching tests shall be made on a cross section

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from one end or both ends of each pipe and shall show sound and reasonably uniform material free of injurious laminations, cracks, and similar objectionable defects. If this supplementary requirement is specified, the number of tests per pipe required shall also be specified. If a specimen from any length shows objectionable defects, the length shall be rejected, subject to removal of the defective end and subsequent retests indicating the remainder of the length to be sound and reasonably uniform material.

APPENDIX

(Nonmandatory Information)

X1. Table X1.1 IS BASED ON TABLE 1 OF THE AMERICAN NATIONAL STANDARD FOR STAINLESS STEEL PIPE (ANSI/ASME B36.19M-1985)

TABLE X1.1 Dimensions of Welded and Seamless Stainless Steel Pipe

NOTE 1—The decimal thickness listed for the respective pipe sizes represents their nominal or average wall dimensions.

NPS Designator	Outside Diameter		Nominal Wall Thickness							
			Schedule 5S[A]		Schedule 10S[A]		Schedule 40S		Schedule 80S	
			in.	mm	in.	mm	in.	mm	in.	mm
⅛	0.405	[10.29]	. . .	. . .	0.049[B]	[1.24]	0.068	[1.73]	0.095	[2.41]
¼	0.540	[13.72]	. . .	. . .	0.065[B]	[1.65]	0.088	[2.24]	0.119	[3.02]
⅜	0.675	[17.15]	. . .	. . .	0.065[B]	[1.65]	0.091	[2.31]	0.126	[3.20]
½	0.840	[21.34]	0.065[B]	[1.65]	0.083[B]	[2.11]	0.109	[2.77]	0.147	[3.73]
¾	1.050	[26.67]	0.065[B]	[1.65]	0.083[B]	[2.11]	0.113	[2.87]	0.154	[3.91]
1.0	1.315	[33.40]	0.065[B]	[1.65]	0.109[B]	[2.77]	0.133	[3.38]	0.179	[4.55]
1¼	1.660	[42.16]	0.065[B]	[1.65]	0.109[B]	[2.77]	0.140	[3.56]	0.191	[4.85]
1½	1.900	[48.26]	0.065[B]	[1.65]	0.109[B]	[2.77]	0.145	[3.68]	0.200	[5.08]
2	2.375	[60.33]	0.065[B]	[1.65]	0.109[B]	[2.77]	0.154	[3.91]	0.218	[5.54]
2½	2.875	[73.03]	0.083	[2.11]	0.120[B]	[3.05]	0.203	[5.16]	0.276	[7.01]
3	3.500	[88.90]	0.083	[2.11]	0.120[B]	[3.05]	0.216	[5.49]	0.300	[7.62]
3½	4.000	[101.60]	0.083	[2.11]	0.120[B]	[3.05]	0.226	[5.74]	0.318	[8.08]
4	4.500	[114.30]	0.083	[2.11]	0.120[B]	[3.05]	0.237	[6.02]	0.337	[8.56]
5	5.563	[141.30]	0.109[B]	[2.77]	0.134[B]	[3.40]	0.258	[6.55]	0.375	[9.52]
6	6.625	[168.28]	0.109	[2.77]	0.134[B]	[3.40]	0.280	[7.11]	0.432	[10.97]
8	8.625	[219.08]	0.109[B]	[2.77]	0.148[B]	[3.76]	0.322	[8.18]	0.500	[12.70]
10	10.750	[273.05]	0.134[B]	[3.40]	0.165[B]	[4.19]	0.365	[9.27]	0.500[B]	[12.70][B]
12	12.750	[323.85]	0.156[B]	[3.96]	0.180[B]	[4.57]	0.375[B]	[9.52][B]	0.500[B]	[12.70][B]
14	14.000	[355.60]	0.156[B]	[3.96]	0.188	[4.78]	. . .	. . .	. . .	. . .
16	16.000	[406.40]	0.165[B]	[4.19]	0.188	[4.78]	. . .	. . .	. . .	. . .
18	18.000	[457.20]	0.165[B]	[4.19]	0.188	[4.78]	. . .	. . .	. . .	. . .
20	20.000	[508.00]	0.188[B]	[4.78]	0.218[B]	[5.54]	. . .	. . .	. . .	. . .
22	22.000	[558.80]	0.188[B]	[4.78]	0.218[B]	[5.54]	. . .	. . .	. . .	. . .
24	24.000	[609.60]	0.218[B]	[5.54]	0.250	[6.35]	. . .	. . .	. . .	. . .
30	30.000	[762.00]	0.250	[6.35]	0.312	[7.92]	. . .	. . .	. . .	. . .

[A] Schedules 5S and 10S wall thicknesses do not permit threading in accordance with the American National Standard for Pipe Threads (ANSI/ASME B 1.20.1).
[B] These do not conform to the American National Standard for Welded and Seamless Wrought Steel Pipe (ANSI/ASME B 36.10M-1995).

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