Designation: A 335/A 335M – 06

Standard Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service[1]

This standard is issued under the fixed designation A 335/A 335M; 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 specification[2] covers nominal wall and minimum wall seamless ferritic alloy-steel pipe intended for high-temperature service. Pipe ordered to this specification shall be suitable for bending, flanging (vanstoning), and similar forming operations, and for fusion welding. Selection will depend upon design, service conditions, mechanical properties, and high-temperature characteristics.

1.2 Several grades of ferritic steels (see Note 1) are covered. Their compositions are given in Table 1.

NOTE 1—Ferritic steels in this specification are defined as low- and intermediate-alloy steels containing up to and including 10 % chromium.

1.3 Supplementary requirements (S1 to S7) of an optional nature are provided. These supplementary requirements call for additional tests to be made, and when desired, shall be so stated in the order together with the number of such tests required.

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 2—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:* [3]

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

E 527 Practice for Numbering Metals and Alloys (UNS)

E 570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products

2.2 *ASME Standard:*

B36.10M Welded and Seamless Wrought Steel Pipe

2.3 *Other Documents:*

SNT-TC-1A Recommended Practice for Nondestructive Personnel Qualification and Certification[4]

SAE J 1086 Practice for Numbering Metals and Alloys (UNS)[5]

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 alloy steel pipe),

3.1.3 Grade (Table 1),

3.1.4 Manufacture (hot-finished or cold-drawn),

3.1.5 Size using one of the following:

3.1.5.1 NPS and schedule number,

3.1.5.2 Outside diameter and nominal wall thickness,

3.1.5.3 Outside diameter and minimum wall thickness,

3.1.5.4 Inside diameter and nominal wall thickness, and

3.1.5.5 Inside diameter and minimum wall thickness.

3.1.6 Length (specific or random),

3.1.7 End finish (Ends Section of Specification A 999/A 999M),

[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-335 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.

[4] Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518.

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

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

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TABLE 1 Chemical Requirements

Grade	UNS Designation[A]	Composition, %							
		Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon	Chromium	Molybdenum	Others
P1	K11522	0.10–0.20	0.30–0.80	0.025	0.025	0.10–0.50	. . .	0.44–0.65	. . .
P2	K11547	0.10–0.20	0.30–0.61	0.025	0.025	0.10–0.30	0.50–0.81	0.44–0.65	. . .
P5	K41545	0.15 max	0.30–0.60	0.025	0.025	0.50 max	4.00–6.00	0.45–0.65	. . .
P5b	K51545	0.15 max	0.30–0.60	0.025	0.025	1.00–2.00	4.00–6.00	0.45–0.65	. . .
P5c	K41245	0.12 max	0.30–0.60	0.025	0.025	0.50 max	4.00–6.00	0.45–0.65	. . .[B]
P9	S50400	0.15 max	0.30–0.60	0.025	0.025	0.25–1.00	8.00–10.00	0.90–1.10	. . .
P11	K11597	0.05–0.15	0.30–0.60	0.025	0.025	0.50–1.00	1.00–1.50	0.44–0.65	. . .
P12	K11562	0.05–0.15	0.30–0.61	0.025	0.025	0.50 max	0.80–1.25	0.44–0.65	. . .
P15	K11578	0.05–0.15	0.30–0.60	0.025	0.025	1.15–1.65	. . .	0.44–0.65	. . .
P21	K31545	0.05–0.15	0.30–0.60	0.025	0.025	0.50 max	2.65–3.35	0.80–1.06	. . .
P22	K21590	0.05–0.15	0.30–0.60	0.025	0.025	0.50 max	1.90–2.60	0.87–1.13	. . .
P23	K41650	0.04–0.10	0.10–0.60	0.030 max	0.010 max	0.50 max	1.90–2.60	0.05–0.30	V 0.20–0.30 Cb 0.02–0.08 B 0.0005–0.006 N 0.030 max Al 0.030 max W 1.45–1.75
P36	K21001	0.10–0.17	0.80–1.20	0.030 max	0.025 max	0.25–0.50	0.30 max	0.25–0.50	Ni 1.00-1.30 Cu 0.50-0.80 Cb 0.015-0.045 V 0.02 max N 0.02 max Al 0.050 max
P91	K91560	0.08–0.12	0.30–0.60	0.020	0.010	0.20–0.50	8.00–9.50	0.85–1.05	V 0.18–0.25 N 0.030–0.070 Ni 0.40 max Al 0.02 max Cb 0.06–0.10 Ti 0.01 max Zr 0.01 max
P92	K92460	0.07–0.13	0.30–0.60	0.020	0.010	0.50 max	8.50–9.50	0.30–0.60	V 0.15–0.25 N 0.03–0.07 Ni 0.40 max Al 0.02 max Cb 0.04–0.09 W 1.5–2.00 B 0.001–0.006 Ti 0.01 max Zr 0.01 max
P122	K92930	0.07–0.14	0.70 max	0.020	0.010	0.50 max	10.00–11.50	0.25–0.60	V 0.15–0.30 W 1.50–2.50 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 0.020 max Ti 0.01 max Zr 0.01 max
P911	K91061	0.09–0.13	0.30–0.60	0.020 max	0.010 max	0.10–0.50	8.5–9.5	0.90–1.10	V 0.18–0.25 Ni 0.40 max Cb 0.060–0.10 B 0.0003–0.006 N 0.04–0.09 Al 0.02 max W 0.90–1.10 Ti 0.01 max Zr 0.01 max

[A] New designation established in accordance with Practice E 527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).
[B] Grade P 5c shall have a titanium content of not less than 4 times the carbon content and not more than 0.70 %; or a columbium content of 8 to 10 times the carbon content.

3.1.8 Optional requirements (Section 8, 12 and 13 of this specification. See the Sections on Hydrostatic Test Requirements and Permissible Variation in Weight for Seamless Pipe in Specification A 999/A 999M),

3.1.9 Test report required (Certification Section of Specification A 999/A 999M),

3.1.10 Specification designation, and

3.1.11 Special requirements or any supplementary requirements selected, or both.

4. General Requirements

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

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5. Materials and Manufacture

5.1 Pipe may be either hot finished or cold drawn with the finishing treatment as required in 5.3.

5.2 *Grade P2 and P12*—The steel shall be made by coarse-grain melting practice. Specific limits, if any, on grain size or deoxidation practice shall be a matter of agreement between the manufacturer and purchaser.

5.3 *Heat Treatment*:

5.3.1 All pipe shall be reheated for heat treatment and heat treated in accordance with the requirements of Table 2.

NOTE 3—It is recommended that the temperature for tempering should be at least 100 °F [50 °C] above the intended service temperature; consequently, the purchaser should advise the manufacturer if the service temperature is to be over 1100 °F [600 °C].

NOTE 4—Certain of the ferritic steels covered by this specification will harden if cooled rapidly from above their critical temperature. Some will air harden, that is, become hardened to an undesirable degree when cooled in air from high temperatures. Therefore, operations involving heating such steels above their critical temperatures, such as welding, flanging, and hot bending, should be followed by suitable heat treatment.

6. Chemical Composition

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

7. Workmanship, Finish, and Appearance

7.1 The pipe manufacturer shall explore a sufficient number of visual surface imperfections to provide reasonable assurance that they have been properly evaluated with respect to depth. Exploration of all surface imperfections is not required but may be necessary to ensure compliance with 7.2

7.2 Surface imperfections that penetrate more than 12½ % of the nominal wall thickness or encroach on the minimum wall thickness shall be considered defects. Pipe with such defects shall be given one of the following dispositions:

7.2.1 The defect may be removed by grinding provided that the remaining wall thickness is within specified limits.

7.2.2 Repaired in accordance with the repair welding provisions of 7.6.

7.2.3 The section of pipe containing the defect may be cut off within the limits of requirements on length.

7.2.4 Rejected.

7.3 To provide a workmanlike finish and basis for evaluating conformance with 7.2, the pipe manufacturer shall remove by grinding the following:

7.3.1 Mechanical marks, abrasions (see Note 5) and pits, any of which imperfections are deeper than 1/16 in. [1.6 mm].

TABLE 2 Heat Treatment Requirements[A]

Grade	Heat Treat Type	Normalizing Temperature, min or range °F [°C]	Cooling Media	Subcritical Annealing or Tempering Temperature, min or range °F [°C]
P1	full or isothermal anneal	. . .	. . .	. . .
	normalize and temper	. . .	. . .	1200 [650]
	subcritical anneal	. . .	. . .	1200-1300 [650-705]
P2	full or isothermal anneal	. . .	. . .	. . .
	normalize and temper	. . .	. . .	1250 [675]
	subcritical anneal	. . .	. . .	1200-1300 [650-705]
P5	full or isothermal anneal	. . .	. . .	. . .
	normalize and temper	. . .	. . .	1250 [675]
P5b	full or isothermal anneal	. . .	. . .	. . .
	normalize and temper	. . .	. . .	1250 [675]
P5c	subcritical anneal	. . .	. . .	1325-1375 [715-745]
P9	full or isothermal anneal	. . .	. . .	. . .
	normalize and temper	. . .	. . .	1250 [675]
P11	full or isothermal anneal	. . .	. . .	. . .
	normalize and temper	. . .	. . .	1200 [650]
P12	full or isothermal anneal	. . .	. . .	. . .
	normalize and temper	. . .	. . .	1200 [650]
	subcritical anneal	. . .	. . .	1200-1300 [650-705]
P15	full or isothermal anneal	. . .	. . .	. . .
	normalize and temper	. . .	. . .	1200 [650]
P21	full or isothermal anneal	. . .	. . .	. . .
	normalize and temper	. . .	. . .	1250 [675]
P22	full or isothermal anneal	. . .	. . .	. . .
	normalize and temper	. . .	. . .	1250 [675]
P23	normalize and temper	1900-1975 [1040-1080]	air or accelerated cooling	1350-1470 [730-800]
P36	normalize and temper[B]	1650 [900]	. . .	1100 [595]
P91	normalize and temper	1900-1975 [1040-1080]	. . .	1350-1470 [730-800][C]
	quench and temper[D]	1900-1975 [1040-1080]	. . .	1350-1470 [730-800]
P92	normalize and temper	1900-1975 [1040-1080]	. . .	1350-1470 [730-800]
P122	normalize and temper	1900-1975 [1040-1080]	. . .	1350-1470 [730-800]
P911	normalize and temper	1900-1975 [1040-1080]	[E]	1365-1435 [740-780]

[A] Where ellipses (…) appear in this table there is no requirement.
[B] Alternatively, Grade P36, Class 2 shall be cooled from the austenitizing temperature by accelerated cooling in air or by liquid quenching.
[C] Except when Supplementary Requirement S7 is specified by the purchaser.
[D] When mutually agreed upon between the manufacturer and the purchaser, quenching and tempering shall be permitted for thicknesses greater than 3 in. [75 mm].
[E] Accelerated cooling from the normalizing temperature shall be permitted for section thicknesses greater than 3 in. [75 mm].

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NOTE 5—Marks and abrasions are defined as cable marks, dinges, guide marks, roll marks, ball scratches, scores, die marks, and the like.

7.3.2 Visual imperfections, commonly referred to as scabs, seams, laps, tears, or slivers, found by exploration in accordance with 7.1 to be deeper than 5 % of the nominal wall thickness.

7.4 At the purchaser's discretion, pipe shall be subject to rejection if surface imperfections acceptable under 7.2 are not scattered, but appear over a large area in excess of what is considered a workmanlike finish. Disposition of such pipe shall be a matter of agreement between the manufacturer and the purchaser.

7.5 When imperfections or defects are removed by grinding, a smooth curved surface shall be maintained, and the wall thickness shall not be decreased below that permitted by this specification. The outside diameter at the point of grinding may be reduced by the amount so removed.

7.5.1 Wall thickness measurements shall be made with a mechanical caliper or with a properly calibrated nondestructive testing device of appropriate accuracy. In case of dispute, the measurement determined by use of the mechanical caliper shall govern.

7.6 Weld repair shall be permitted only subject to the approval of the purchaser and in accordance with Specification A 999/A 999M.

7.6.1 After weld repair, Grades P23, P91, P92, and P122 shall be heat treated at 1350-1470 ºF [730-800 ºC].

7.6.2 After weld repair, Grade P911 shall be heat treated at 1365-1435 ºF [740-780 ºC].

7.7 The finished pipe shall be reasonably straight.

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 (see Note 6) of pipe shall consist of the following:

NPS Designator	
Under 2	400 or fraction thereof
2 to 5	200 or fraction thereof
6 and over	100 or fraction thereof

NOTE 6—A lot shall consist of the number of lengths specified in 8.1 of the same size and wall thickness from any one heat of steel.

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 Table 1.

8.3 For grade P 91 the carbon content may vary for the product analysis by −0.01 % and +0.02 % from the specified range as per Table 1.

8.4 If the analysis of one of the tests specified in 8.1 does not conform to the requirements specified in 6.1, 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.

9. Tensile and Hardness Requirements

9.1 The tensile properties of the material shall conform to the requirements prescribed in Table 3.

9.2 Table 4 lists elongation requirements.

9.3 Pipe of Grades P91, P92, P122, and P36 shall have a hardness not exceeding 250 HB/265 HV [25 HRC].

9.4 Table 5 gives the computed minimum elongation values for each 1/32-in. [0.8-mm] decrease in wall thickness. Where the wall thickness lies between two values above, the minimum elongation value is determined by the following formula:

Direction of Test	Equation[B]
Longitudinal, all grades except P23, P91, P92, P122, and P911	E = 48t + 15.00 [E = 1.87*t* + 15.00]
Transverse, all grades except P23, P91, P92, P122, and P911	E = 32t + 10.00 [E = 1.25*t* + 10.00]
Longitudinal, P23, P91, P92, P122, and P911	E = 32t + 10.00 [E = 1.25*t* + 10.00]
Longitudinal, P36	E = 32t + 5.0 [E = 1.25*t* + 5.0]

where:
E = elongation in 2 in. or 50 mm, %, and
t = actual thickness of specimens, in. [mm].

10. Permissible Variations in Diameter

10.1 For pipe ordered to NPS [DN] or outside diameter, variations in outside diameter shall not exceed those specified in Table 6.

10.2 For pipe ordered to inside diameter, the inside diameter shall not vary more than ± 1 % from the specified inside diameter.

11. Permissible Variations in Wall Thickness

11.1 In addition to the implicit limitation of wall thickness for pipe imposed by the limitation on weight in Specification A 999/A 999M, the wall thickness for pipe at any point shall be within the tolerances specified in Table 7. The minimum wall thickness and outside diameter for inspection for compliance with this requirement for pipe ordered by NPS [DN] and schedule number is shown in ASME B36.10M.

12. Hydrostatic Test

12.1 Each length of pipe shall be subjected to the hydrostatic test, except as provided for in 12.2 or 12.3.

TABLE 3 Tensile Requirements

	Grade							
	P1, P2	P12	P23	P91	P92, P911 P36 Class 1	P122	P36 Class 2	All Others
Tensile strength, min:								
ksi	55	60	74	85	90	90	95.5	60
MPa	380	415	510	585	620	620	660	415
Yield strength, min:								
ksi	30	32	58	60	64	58	66.5	30
MPa	205	220	400	415	440	400	460	205

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TABLE 4 Elongation Requirements

	Elongation Requirements				
	All grades except P23, P36 P91, P92, P122, and P911		P23, P91, P92, P122, and P 911		P36
	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal
Elongation in 2 in. or 50 mm, (or 4*D*), min, %:					
Basic minimum elongation for wall 5/16 in. [8 mm] and over in thickness, strip tests, and for all small sizes tested in full section	30	20	20	. . .	15
When standard round 2-in. or 50-mm gage length or proportionally smaller size specimen with the gage length equal to 4*D* (4 times the diameter) is used	22	14	20	13	. . .
For strip tests a deduction for each 1/32-in. [0.8 mm] decrease in wall thickness below in. [8 mm] from the basic minimum elongation of the following percentage points shall be made	1.50[A]	1.00[A]	1.00[A]	. . .	1.00[A]

[A] Table 5 gives the calculated minimum values.

12.2 Unless otherwise specified in the purchase order, each length of pipe shall, at the option of the manufacturer, be subjected to the nondestructive electric test as shown in Section 13 in lieu of the hydrostatic test.

12.3 When specified by the purchaser, pipe shall be furnished without hydrostatic test and without nondestructive examination.

12.4 When specified by the purchaser, pipe shall be furnished with both the hydrostatic test and a nondestructive examination having been performed.

13. Nondestructive Examination

13.1 When selected by the manufacturer or when specified in the order, as an alternative to the hydrostatic test (12.2), or when specified in the purchase order in addition to the hydrostatic test (12.4), each pipe shall be examined by a nondestructive examination method in accordance with Practice E 213, Practice E 309 or Practice E 570. 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.

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

13.2.1 The reference standards defined in 13.8 are convenient standards for standardization of nondestructive examination equipment. The dimensions of these standards should not be construed as the minimum size imperfection detectable by such equipment.

13.2.2 Ultrasonic examination can be performed to detect both longitudinally and transversely oriented discontinuities. It should be recognized that different techniques should be employed to detect differently oriented imperfections. The examination may not detect short, deep imperfections.

13.2.3 The eddy current examination referenced in this specification has the capability to detect significant discontinuities, especially of the short abrupt type.

13.2.4 The flux leakage examination referred to in this specification is capable of detecting the presence and location of significant longitudinally or transversely oriented discontinuities. It should be recognized that different techniques should be employed to detect differently oriented imperfections.

13.2.5 The hydrostatic test of Section 12 has the capability to find imperfections of a size that permit the test fluid to leak through the pipe wall so that it may be either visually seen or detected by a loss of fluid pressure. This test may not detect very tight, through-wall imperfections, or imperfections that extend into the wall without complete penetration.

13.2.6 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 products.

13.3 *Time of Examination*:

Nondestructive examination 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.

13.4 *Surface Conditions*:

13.4.1 All surfaces shall be clean and 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.

13.4.2 Excessive surface roughness or deep scratches can produce signals that interfere with the test (see 13.10.2.3).

13.5 *Extent of Examination*:

13.5.1 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 for end effects as noted in 13.5.2.

13.5.2 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.

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

13.7 *Test Conditions*:

13.7.1 For examination by the ultrasonic method, the minimum nominal transducer frequency shall be 2.25 MHz.

13.7.2 For eddy current testing, the excitation coil frequency shall be 10 kHz, or less.

13.8 *Reference Standards*:

13.8.1 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.

13.8.2 For ultrasonic testing, the reference 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 the notch

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TABLE 5 Calculated Minimum Elongation Values

Wall Thickness		Elongation in 2 in. or 50 mm, min, %			
		All grades except P23, P36, P91, P92, P122, and P911		P23, P91, P92, P122, and P911	P36
in.	mm	Longitudinal	Transverse	Longitudinal	Longitudinal
5/16 (0.312)	8	30	20	20	15
9/32 (0.281)	7.2	28	19	19	14
1/4 (0.250)	6.4	27	18	18	13
7/32 (0.219)	5.6	26	. . .	17	12
3/16 (0.188)	4.8	24	. . .	16	11
5/32 (0.156)	4	22	. . .	15	10
1/8 (0.125)	3.2	21	. . .	14	9
3/32 (0.094)	2.4	20	. . .	13	8
1/16 (0.062)	1.6	18	. . .	12	7

TABLE 6 Permissible Variations in Outside Diameter

	Over		Under	
NPS [DN] Designator	in.	mm	in.	mm
1/8 to 1½ [6 to 40], incl.	1/64 (0.015)	0.40	1/64 (0.015)	0.40
Over 1½ to 4 [40 to 100], incl.	1/32 (0.031)	0.79	1/32 (0.031)	0.79
Over 4 to 8 [100 to 200], incl.	1/16 (0.062)	1.59	1/32 (0.031)	0.79
Over 8 to 12 [200 to 300], incl.	3/32 (0.093)	2.38	1/32 (0.031)	0.79
Over 12 [300]	± 1 % of the specified outside diameter			

TABLE 7 Permitted Variations in Wall Thickness

NPS [DN] Designator	Tolerance, % from Specified	
	Over	Under
1/8 to 2½ [6 to 65] incl., all t/D ratios[A]	20.0	12.5
Above 2½ [65], t/D ≤ 5 %[A]	22.5	12.5
Above 2½ [65], t/D > 5 %[A]	15.0	12.5

[A] t = Specified Wall Thickness; D = Specified Outside Diameter.

shall not exceed 12½ % of the specified nominal wall thickness of the pipe or 0.004 in. (0.1 mm), whichever is greater. The length of the notch shall be at least twice the diameter of the transducer(s). The width of the notch shall not exceed the depth.

13.8.3 For eddy current testing, the reference standard shall contain, at the option of the manufacturer, any one of the following discontinuities:

13.8.3.1 *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. The hole diameter shall vary with NPS as follows:

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

13.8.3.2 *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 12½ % of the specified nominal wall thickness of the pipe or 0.004 in. (0.1 mm), whichever is greater.

13.8.3.3 *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 12½ % of the specified nominal wall thickness of the pipe or 0.004 in. (0.1 mm), whichever is greater. The length of the notch shall be compatible with the testing method.

13.8.4 For flux leakage testing, the longitudinal reference notches shall be straight-sided notches machined in a radial plane parallel to the pipe axis. For wall thickness less than ½ in. (12.7 mm), outside and inside notches shall be used; for wall thicknesses equal to or greater than ½ in., only an outside notch shall be used. Notch depth shall not exceed 12½ % of the specified nominal wall thickness or 0.004 in. (0.1 mm), whichever is greater. Notch length shall not exceed 1 in. (25.4 mm), and the width shall not exceed the depth. Outside and inside notches shall have sufficient separation to allow distinct identification of the signal from each notch.

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

13.9 *Standardization Procedure:*

13.9.1 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

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during the examination of such pipe. More frequent standardizations may be performed at the manufacturer's option or may be required upon agreement between the purchaser and the manufacturer.

13.9.2 The test apparatus shall also be standardized after any change in test system settings, change of operator, equipment repair, or interruption due to power loss, shutdown or operator breaks.

13.9.3 The reference standard shall be passed through the test apparatus at same speed and test system settings as the pipe to be tested.

13.9.4 The signal-to-noise ratio for the reference standard shall be 2.5 to 1 or greater and the reference signal amplitude for each discontinuity shall be at least 50 % of full scale of the display.

13.9.5 If upon any standardization, the reference signal amplitude has decreased by 25 % (2 db), the test apparatus shall be considered out of standardization. The test system settings may be changed, or the transducer(s), coil(s) or sensor(s) adjusted, and the unit restandardized, but all pipe tested since the last acceptable standardization must be retested.

13.10 *Evaluation of Imperfections:*

13.10.1 Pipes producing a signal equal to or greater than the signal produced by the reference standard shall be positively identified and they shall be separated from the acceptable pipes. The area producing the signal may be reexamined.

13.10.2 Such pipes shall be subject to one of the following three dispositions:

13.10.2.1 The pipes may be rejected without further examination, at the discretion of the manufacturer.

13.10.2.2 The pipes shall be rejected, but may be repaired, if the test signal was produced by imperfections which cannot be identified, or was produced by cracks or crack-like imperfections. These pipes may be repaired by grinding (in accordance with 7.2.1), welding (in accordance with 7.6) or sectioning (in accordance with 7.2.3). To be accepted, a repaired pipe must pass the same nondestructive examination by which it was rejected, and it must meet the remaining wall thickness requirements of this specification.

13.10.2.3 Such pipes may be evaluated in accordance with the provisions of Section 7, if the test signals were produced by visual imperfections such as those listed below:

(*1*) Scratches,
(*2*) Surface roughness,
(*3*) Dings,
(*4*) Straightener marks,
(*5*) Cutting chips,
(*6*) Steel die stamps,
(*7*) Stop marks, or
(*8*) Pipe reducer ripple.

14. Mechanical Tests Required

14.1 *Transverse or Longitudinal Tension Test and Flattening Test, Hardness Test, or Bend Test*—For material heat treated in a batch-type furnace, tests shall be made on 5 % of the pipe from each treated lot (see Note 7). For small lots, at least 1 pipe shall be tested. For material heat treated by the continuous process, tests shall be made on a sufficient number of pipe to constitute 5 % of the lot (see Note 7), but in no case less than 2 pipe.

NOTE 7—The term "lot" applies to all pipe of the same nominal size and wall thickness (or schedule) 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.

14.2 *Hardness Test*:

14.2.1 For pipe of Grades P91, P92, P122, P911, and P36, Brinell, Vickers, or Rockwell hardness tests shall be made on a specimen from each lot (see Note 7).

14.3 *Bend Test*:

14.3.1 For pipe whose diameter exceeds NPS 25 and whose diameter to wall thickness ratio is 7.0 or less shall be subjected to the bend test instead of the flattening test. Other pipe whose diameter equals or exceeds NPS 10 may be given the bend test in place of the flattening test subject to the approval of the purchaser.

14.3.2 The bend test specimens shall be bent at room temperature through 180° without cracking on the outside of the bent portion. The inside diameter of the bend shall be 1 in. [25 mm].

14.3.3 Test specimens for the bend test specified in 14.3 shall be cut from one end of the pipe and, unless otherwise specified, shall be taken in a transverse direction. One test specimen shall be taken as close to the outer surface as possible and another from as close to the inner surface as possible. The specimens shall be either ½ by ½ in. [12.5 by 12.5 mm] in section or 1 by ½ in. [25 by 12.5 mm] in section with the corners rounded to a radius not over 1/16 in. [1.6 mm] and need not exceed 6 in. [150 mm] in length. The side of the samples placed in tension during the bend shall be the side closest to the inner and outer surface of the pipe, respectively.

15. Certification

15.1 In addition to the information required by Specification A 999/A 999M, the certification shall state whether or not the pipe was hydrostatically tested. If the pipe was nondestructively examined, the certification shall so state and shall show which practice was followed and what reference discontinuities were used. In addition, the test method information as given in Table 8 shall be appended to the specification number and grade shown on the certification.

16. Product Marking

16.1 In addition to the marking prescribed in Specification A 999/A 999M, the marking shall include the length, an additional symbol "S", if the pipe conforms to any of the Supplementary Requirements S1 to S6, the schedule number, if the pipe is ordered to a schedule number, and the heat number

TABLE 8 Test Method Information for Certification and Marking

Hydrostatic	Nondestructive	Marking
YES	NO	Test Pressure
NO	YES	NDE
NO	NO	NH
YES	YES	Test Pressure/NDE

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or manufacturer's number by which the heat can be identified. Furthermore, the marking designated in Table 8 to indicate the test method(s) shall be included. Marking may be by stenciling, stamping, or rolling. Pipe that has been weld repaired in accordance with 7.6 shall be marked "WR."

17. Government Procurement

17.1 *Scale Free Pipe*:

17.1.1 When specified in the contract or order, the following requirements shall be considered in the inquiry contract or order, for agencies of the U.S. Government where scale free pipe is required. These requirements shall take precedence if there is a conflict between these requirements and the product specification.

17.1.2 The requirements of Specification A 999/A 999M for pipe shall be applicable when pipe is ordered to this specification.

17.1.3 Pipe shall be one of the following grades as specified herein:

Grade	UNS Designation
P11	K11597
P22	K21590
P5	K41545

17.1.4 *Part Number*:

17.1.4.1 Pipe shall be ordered to nominal pipe size and schedule specified in ASME B36.10M
Example: A 335/A 335M Pipe P-11 NPS 12 Sch 40

Specification Number	ASTM A 335/A 335M
Pipe	P
Grade	P-11
NPS	12
Wall	0.375

17.1.4.2

Specification Number	ASTM A 335/A 335 M
Tube	T
Grade	P-11
Outside Diameter	0.250
Wall	0.035

17.1.5 *Ordering Information*—Orders for material under this specification shall include the following in addition to the requirements of Section 3:

17.1.5.1 Pipe or tube,

17.1.5.2 Part number,

17.1.5.3 Ultrasonic inspection, if required,

17.1.5.4 If shear wave test is to be conducted in two opposite circumferential directions, and

17.1.5.5 Level of preservation and packing required.

18. Keywords

18.1 alloy steel pipe; high temperature service; seamless steel pipe; steel pipe; temperature service applications

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 Product analysis shall be made on each length of pipe. Individual lengths failing to conform to the chemical composition requirements shall be rejected.

S2. Transverse Tension Tests

S2.1 A transverse tension test shall be made on a specimen from one end or both ends of each pipe NPS 8 and over. If this supplementary requirement is specified, the number of tests per pipe shall also be specified. If a specimen from any length fails to meet the required tensile properties (tensile, yield, and elongation), that length shall be rejected subject to retreatment in accordance with Specification A 999/A 999M and satisfactory retest.

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. The bend test of 13.2 shall be substituted for the flattening test for pipe whose diameter exceeds NPS 25 and whose diameter to wall thickness ratio is 7.0 or less.

S4. Metal Structure and 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 from one end or both ends of each pipe and shall show sound and reasonably uniform material free from 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

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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.

NOTE S4.1—Pending development of etching methods applicable to the product covered by this specification, it is recommended that the Recommended Practice for a Standard Macro Etch Test for Routine Inspection of Iron and Steel, described in the *Metals Handbook*, Am. Soc. for Metals, 1948 edition, p. 389, be followed.

S5. Photomicrographs

S5.1 When requested by the purchaser and so stated in the order, the manufacturer shall furnish one photomicrograph at 100 diameters from a specimen of pipe in the as-finished condition for each individual size and wall thickness from each heat, for pipe NPS 3 and over. Such photomicrographs shall be suitably identified as to pipe size, wall thickness, and heat. No photomicrographs for the individual pieces purchased shall be required except as specified in Supplementary Requirement S6. Such photomicrographs are for information only, to show the actual metal structure of the pipe as finished.

S6. Photomicrographs for Individual Pieces

S6.1 In addition to the photomicrographs required in accordance with Supplementary Requirement S5, the purchaser may specify that photomicrographs shall be furnished from each end of one or more pipes from each lot of pipe NPS 3 and larger in the as-finished condition. The purchaser shall state in the order the number of pipes to be tested from each lot. When photomicrographs are required on each length, the photomicrographs from each lot of pipe in the as-finished condition which may be required under Supplementary Requirement S5 may be omitted. All photo-micrographs required shall be properly identified as to heat number, size, and wall thickness of pipe from which the section was taken. Photomicrographs shall be further identified to permit association of each photomicrograph with the individual length of pipe it represents.

S7. Alternative Heat Treatment—Grade P91

S7.1 Grade P91 shall be normalized in accordance with Table 2 and tempered at a temperature, to be specified by the purchaser, less than 1350 °F [730 °C]. It shall be purchaser's responsibility to subsequently temper at 1350-1470 °F [730-800 °C] minimum. All mechanical tests shall be made on material heat treated in accordance with Table 2. The certification shall reference this supplementary requirement indicating the tempering temperature applied. The notation "S7" shall be included with the required marking of the pipe.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 335/A 335M-05a, that may impact the use of this specification. (Approved May 1, 2006)

(*1*) Reduced Cr maximum for Grade 122 in Table 1.

(*2*) Reduce Al maximum and added maximums for Ti and Zr for Grades P91, P92, P122, and P911 in Table 1.

Committee A01 has identified the location of selected changes to this specification since the last issue, A 335/A 335M-05, that may impact the use of this specification. (Approved May 1, 2005)

(*1*) Revised Table 1, Table 3, Table 4, and Table 5 and modified 9.3 and 13.2.1 to provide for new grade P36, Classes 1 and 2.
(*2*) Revised 5.3, Supplementary Requirement S7, and added Table 2, to tabularize the heat treatment requirements and to provide ranges of normalizing and tempering temperatures for Grades P23, P91, P92, P911, and P122. Added permission to use quenching and tempering for P911 over 3 in. [75mm] in thickness.

(*3*) Added 7.6.1 and 7.6.2 to require post-weld heat treatment (PWHT) after weld repair, and to specify temperature ranges for PWHT, for Grades P23, P91, P92, P911, and P122.

Committee A01 has identified the location of selected changes to this specification since the last issue, A 335/A 335M-03, that may impact the use of this specification. (Approved March 1, 2005)

(*1*) Added ASME B36.10M to Referenced Documents and corrected the reference from ANSI B36.10 to ASME B36.10M in 17.1.4.1.
(*2*) Revised Chromium content of Grade P911 in Table 1.
(*3*) Added DN SI-unit designator to 10.1 and Table 6.
(*4*) Added new Section 11 and Table 7 to address maximum wall thickness of pipe and renumbered subsequent paragraphs and tables accordingly.

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