Designation: A 369/A 369M – 06

Standard Specification for Carbon and Ferritic Alloy Steel Forged and Bored Pipe for High-Temperature Service[1]

This standard is issued under the fixed designation A 369/A 369M; 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[2] covers heavy-wall carbon and alloy steel pipe (Note 1) made from turned and bored forgings and is intended for high-temperature service. Pipe ordered under this specification shall be suitable for bending and other forming operations and for fusion welding. Selection will depend on design, service conditions, mechanical properties and high-temperature characteristics.

NOTE 1—The use of the word "pipe" throughout the several sections of this specification is used in the broad sense and intended to mean pipe headers, or leads.

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."

1.2 Several grades of ferritic steels are covered. Their compositions are given in Table 1.

1.3 Supplementary requirements (S1 to S6) 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.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

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

E 290 Test Methods for Bend Testing of Material for Ductility

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

2.2 *ASME Boiler and Pressure Vessel Code:*

Section 1X Welding Qualifications[4]

2.3 *ANSI Standard:*

B 46.1 Surface Texture[5]

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 (forged and bored pipe),

3.1.3 Grade (Table 1),

3.1.4 Size (inside diameter and minimum wall thickness),

3.1.5 Length (Permissible Variations in Length Section of Specification A 999/A 999M),

3.1.6 End finish (13),

3.1.7 Optional requirements (Sections 8, Supplementary Requirements S1 to S6; 13.2),

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

3.1.9 Specification designation, and

3.1.10 Special requirements or exceptions to this specification.

4. General Requirements

4.1 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.

5. Materials and Manufacture

5.1 *Discard*:

[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-369 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 American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

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TABLE 1 Chemical Requirements

Grade	Composition, %			
	FPA	FPB	FP1	FP2
Carbon	0.25 max	0.30 max	0.10–0.20	0.10–0.20
Manganese	0.27–0.93	0.29–1.06	0.30–0.80	0.30–0.61
Phosphorus, max	0.035	0.035	0.025	0.025
Sulfur, max	0.035	0.035	0.025	0.025
Silicon	0.10 min	0.10 min	0.10–0.50	0.10–0.30
Chromium	...	...	...	0.50–0.81
Molybdenum	...	...	0.44–0.65	0.44–0.65
Grade	FP5	FP9	FP11	FP12
Carbon	0.15 max	0.15 max	0.05–0.15	0.05–0.15
Manganese	0.30–0.60	0.30–0.60	0.30–0.60	0.30–0.61
Phosphorus, max	0.025	0.030	0.025	0.025
Sulfur, max	0.025	0.030	0.025	0.025
Silicon	0.50 max	0.50–1.00	0.50–1.00	0.50 max
Chromium	4.00–6.00	8.00–10.00	1.00–1.50	0.80–1.25
Molybdenum	0.45–0.65	0.90–1.10	0.44–0.65	0.44–0.65
Grade	FP21	FP22	FP91	FP92
Carbon	0.05–0.15	0.05–0.15	0.08–0.12	0.07–0.13
Manganese	0.30–0.60	0.30–0.60	0.30–0.60	0.30–0.60
Phosphorus, max	0.025	0.025	0.025	0.020
Sulfur, max	0.025	0.025	0.025	0.010
Silicon	0.50 max	0.50 max	0.20–0.50	0.50 max
Chromium	2.65–3.35	1.90–2.60	8.00–9.50	8.50–9.50
Molybdenum	0.80–1.06	0.87–1.13	0.85–1.05	0.30–0.60
			Others:	W 1.50–2.00
			Ni 0.40 max	V 0.15–0.25
			V 0.18–0.25	Cb 0.04–0.09
			Cb 0.06–0.10	N 0.030–0.070
			N 0.03–0.07	Ni 0.40 max
			Al 0.02 max	Al 0.02 max
			Ti 0.01 max	Ti 0.01 max
			Zr 0.01 max	Zr 0.01 max
				B 0.001–0.006

5.1.1 A sufficient discard shall be made from each ingot to secure freedom from injurious defects. The steel shall have a homogeneous structure.

5.2 *Manufacture*:

5.2.1 Material for forging shall consist of ingots or of blooms, billets, or solid-rolled bars forged or rolled from an ingot, and cut to the required length by a process that will not produce injurious defects in the forging.

5.2.2 The material shall be forged (Note 3) by hammering or pressing, and shall be brought as nearly as practicable to the finished shape and size by hot working.

NOTE 3—The cross-sectional area of the solid forging shall have a reduction by forging or by rolling and forging from that of the ingot in the ratio of not less than 3 to 1.

5.2.3 Unless otherwise specified, the final forging operation shall be followed by a treatment suitable to the grade as specified in 5.4.

5.3 *Machining*:

5.3.1 All forgings shall have both the inner and outer surfaces machined.

5.3.2 After heat treatment, the pipe shall be machined to a finish with a roughness value no greater than 250-µin. [6.4-µm] arithmetical average deviation (AA), terms as defined in ANSI B 46.1-1962, unless otherwise specified.

5.4 *Heat Treatment*:

5.4.1 All pipe of the grades shown in Table 1 other than FPA, FPB, FP1, FP2, FP12, FP91, and FP92 shall be reheated and furnished in the full-annealed or normalized and tempered condition. If furnished in the normalized and tempered condition (Note 4), the temperature for tempering shall be 1250 °F [680 °C] or higher for Grades FP5, FP9, FP21, and FP22, and 1200 °F [650 °C] or higher for Grades FP36 and FP11.

NOTE 4—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].

5.4.2 Pipe in Grades FPA and FPB as a final heat treatment shall be either normalized or shall be given a stress relieving treatment at 1200 to 1300 °F [650 to 705 °C]. Pipe in Grades FP1, FP2, and FP12, as a final heat treatment shall be given a stress-relieving treatment at 1200 to 1300 °F [650 to 705 °C].

NOTE 5—Certain of the ferritic steels covered by this specification tend to 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, hot-bending and other forming operations, should be followed by suitable heat treatment.

5.4.3 Except when Supplementary Requirement S6 is specified by the purchaser, Grade FP91 shall be normalized and tempered by reheating within the temperature range from 1900 to 1975 °F [1040 to 1080 °C], followed by air cooling and tempering in the temperature range of 1350 to 1470 °F [730 to 800 °C].

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5.4.4 Except when Supplementary Requirement S6 is specified by the purchaser, Grade FP92 shall be normalized and tempered by reheating within the temperature range of 1900 to 1975 °F [1040 to 1080 °C], followed by air cooling and tempering in the temperature range of 1350 to 1470 °F [730 to 800 °C].

6. Chemical Composition

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

7. Heat Analysis

7.1 An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of the elements specified. If secondary melting processes are employed, the heat analysis shall be obtained from one remelted ingot or the product of one remelted ingot of each primary melt. The chemical composition thus determined, or that determined from a product analysis made by the tubular product manufacturer, shall conform to the requirements specified.

7.2 In the case of large ingots poured from two or more heats, the weighted average of the chemical determinations of the several heats, made in accordance with 7.1, shall conform to the requirements specified in Section 6.

8. Product Analysis

8.1 At the request of the purchaser, a product analysis shall be made by the manufacturer on every heat.

8.2 The results of these analyses shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 6.

8.3 If the analysis of one of the tests specified in Section 7 or Section 8 does not conform to the requirements specified in Section 6 an analysis of each billet or pipe from the same heat may be made, and all billets or pipes conforming to the requirements shall be accepted.

9. Tensile Requirements

9.1 The material shall conform to the requirements as to tensile properties prescribed in Table 2. Tests for acceptance shall be made after final heat treatment of the forging.

10. Mechanical Tests Required

10.1 *Transverse or Longitudinal Tension Test*—One test shall be made on a specimen from one end of one length of pipe representing each heat in each heat-treatment lot.

10.2 *Flattening Test*—For pipe NPS 14 or less, and diameter to wall thickness ratios of more than 7.0, a flattening test shall be carried out in accordance with Specification A 999/A 999M. A test shall be carried out on a specimen taken from one end of each length of pipe.

10.3 *Bend Test*—For pipe larger than NPS 14 or NPS where diameters to wall thickness ratio is 7.0 or less, a bend test shall be carried out in accordance with Test Methods E 290. Unless otherwise specified, the test specimens shall be taken in a transverse direction. The diameter of the pin shall be ⅔ *t* for longitudinal specimens or 1⅓ *t* for transverse specimens, where *t* is the specimen thickness. The bend test specimens shall be bent at room temperature through 180° without cracking. One bend test shall be taken from one end of each length of pipe.

11. Workmanship

11.1 The pipe shall conform to the sizes and shapes specified by the purchaser.

12. Ends

12.1 Pipe ends shall be machined as specified in the purchase order.

13. Finish

13.1 The finished pipe shall be reasonably straight and shall have a workmanlike finish.

13.2 Repair of defects by welding shall be permitted only subject to the approval of the purchaser. Defects shall be thoroughly chipped or ground out before welding. Only qualified operators and procedures in accordance with the ASME Boiler and Pressure Vessel Code, Section IX, shall be used. Local or full heat treatment in accordance with 5.4 shall follow welding. Local grinding following welding and retreating shall be considered as meeting the requirements of 5.3.

14. Product Marking

14.1 In addition to the marking prescribed in Specification A 999/A 999M, the marking shall include the wall thickness, piece mark, length, and additional symbol "S" if the pipe conforms to the supplementary requirements specified in Supplementary Requirements S1 to S5, and the heat number or the manufacturer's number by which the heat can be identified. Indentation stamping, instead of stenciling, will be permitted only with the written approval of the purchaser.

TABLE 2 Tensile Requirements

Grade	FPA	FPB	FP1, FP2	FP12	FP91	FP92	All Others
Tensile strength, min; ksi [MPa]	48 [330]	60 [415]	55 [380]	60 [415]	85 [585]	90 [620]	60 [415]
Yield strength, min; ksi [MPa]	30 [210]	35 [240]	30 [210]	32 [220]	60 [415]	64 [440]	30 [210]

Grade	Elongation Requirements							
	FPA		FPB		FP91 and FP92		All Others	
	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
Elongation in 2 in. or 50 mm, 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	35	25	30	17	27	18	30	20
When standard round 2-in. or 50-mm gage length test specimen is used	28	20	22	12	20	13	22	14

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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. Additional Tension Test

S1.1 An additional tension test shall be made on a specimen from one or each end of each pipe. If this supplementary requirement is specified, the number of tests per pipe required shall 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.

S2. Additional Flattening or Bend Tests

S2.1 The appropriate flattening or bend test may be made on specimens from both ends of each length of pipe. Crop ends may be used. If the specimen from either end of any length fails to conform to the specific requirement, that length shall be rejected.

S3. Ultrasonic Tests

S3.1 Each pipe shall be ultrasonically tested to determine its soundness throughout the entire length of the pipe. Until suitable standards are established, the basis for rejection of material shall be a matter of agreement between the manufacturer and purchaser.

S4. Hydrostatic Test

S4.1 A hydrostatic pressure test shall be applied as agreed upon by the manufacturer and purchaser.

S5. Metal Structure and Etching Tests

S5.1 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 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.

S6. Alternative Heat Treatment—Grades FP91 and FP92

S6.1 Grades FP91 and FP92 shall be normalized in accordance with 5.4.3 or 5.4.4, respectively, and tempered at a temperature, to be specified by the purchaser, less than 1350 °F [730 °C]. It shall be the purchaser's responsibility to subsequently temper in the range of 1350 to 1470 °F [730 to 800 °C]. All mechanical tests shall be made on material heat treated in accordance with 5.4.3 or 5.4.4, respectively. The certification shall reference this supplementary requirement indicating the tempering temperature applied. The notation "S6'' 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 369/A 369M – 02, that may impact the use of this specification. (Approved September 1, 2006)

(*1*) Revised 5.4.3, 5.4.4, and Supplementary Requirement S6 to reduce the maximum normalizing termperatures and to establish temperature ranges for tempering of Grades FP91 and FP92.

(*2*) Revised Table 1 to reduce maximum Al and establish maximums for Ti and Zr for Grades FP91 and FP92.

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