Designation: A 451/A 451M – 06

Standard Specification for Centrifugally Cast Austenitic Steel Pipe for High-Temperature Service[1]

This standard is issued under the fixed designation A 451/A 451M; 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 austenitic alloy steel pipe for use in high-temperature, corrosive, or nuclear pressure service.

1.2 Several grades of austenitic stainless steel are covered as indicated in Table 1.

1.3 Optional supplementary requirements are provided when additional testing may be 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 exactly equivalents; therefore, each system must be used independently of each other. Combining values from the two systems may result in nonconformance with the specification.

NOTE 1—This specification is not intended to cover centrifugal pipe made from alloys containing more than 0.20 % carbon, such as are covered by Specification A 297.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

A 297/A 297M Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application

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

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

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E 94 Guide for Radiographic Examination

E 165 Test Method for Liquid Penetrant Examination

E 186 Reference Radiographs for Heavy-Walled (2 to 412-in. [51 to 114-mm]) Steel Castings

E 280 Reference Radiographs for Heavy-Walled (412 to 12-in. [114 to 305-mm]) Steel Castings

E 446 Reference Radiographs for Steel Castings Up to 2 in. [51 mm] in Thickness

2.2 *ANSI Standard:*

B46.1 Surface Texture[4]

3. Ordering Information

3.1 Orders for material to this specification shall 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 (centrifugally cast pipe),

3.1.3 Grade (Table 1),

3.1.4 Size (outside or inside diameter and minimum wall thickness in inches or millimetres),

3.1.5 Length (specific or random, Specification A 999/A 999M),

3.1.6 End Finish of Specification A 999/A 999M,

3.1.7 Optional Requirements (9.4 and Supplementary Requirements S1 through S7),

3.1.8 Test Report Required (Section 14), and

3.1.9 Special Requirements or Additions to Specification.

4. Materials and Manufacture

4.1 *Heat-Treatment*—The pipe shall receive a heat-treatment at the temperature and time specified in Table 2, followed by a quench in water or rapid cool by other means.

4.2 *Machining*—The pipe shall be machined on the inner and outer surfaces to a roughness value no greater than 250-µin. [6.35-µm] arithmetical average deviation (AA) from the mean line, as defined in American National Standard B46.1.

5. Chemical Analysis

5.1 *Heat Analysis*—An analysis of each heat shall be made by the manufacturer to determine the percentages of elements specified in Table 1. The analysis shall be made on a test sample taken preferably during the pouring of the heat. The

[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 A01.18 on Castings.

Current edition approved Sept. 1, 2006. Published September 2006. Originally approved in 1961. Last previous edition approved in 2002 as A 451/A 451M – 02.

[2] For ASME Boiler and Pressure Vessel Code applications see related specification SA-451 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 National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

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

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TABLE 1 Chemical Requirements

Grade	Composition, %										
	Carbon, max	Manganese, max	Phosphorus, max	Sulfur, max	Silicon, max	Nickel	Chromium	Molybdenum	Columbium	Tantalum, max	Nitrogen
CPF3	0.03	1.50	0.040	0.040	2.00	8.0–12.0	17.0–21.0	...	...	...	...
CPF3A	0.03	1.50	0.040	0.040	2.00	8.0–12.0	17.0–21.0	...	...	...	...
CPF8	0.08	1.50	0.040	0.040	2.00	8.0–11.0	18.0–21.0	...	...	...	...
CPF8A	0.08	1.50	0.040	0.040	2.00	8.0–11.0	18.0–21.0	...	...	...	...
CPF3M	0.03	1.50	0.040	0.040	1.50	9.0–13.0	17.0–21.0	2.0–3.0	...	...	...
CPF8M	0.08	1.50	0.040	0.040	1.50	9.0–12.0	18.0–21.0	2.0–3.0	...	...	...
CPF10MC[A]	0.10	1.50	0.040	0.040	1.50	13.0–16.0	15.0–18.0	1.75–2.25	1.2 max, 10 × C min	...	...
CPF8C[A]	0.08	1.50	0.040	0.040	2.00	9.0–12.0	18.0–21.0	...	1 max, 8 × C min	...	...
CPF8C(Ta max)[B]	0.08	1.50	0.040	0.040	2.00	9.0–12.0	18.0–21.0	...	1 max, 8 × C min	0.10	...
CPH8	0.08	1.50	0.040	0.040	1.50	12.0–15.0	22.0–26.0	...	...	...	...
CPH20 or CPH10	0.20[C]	1.50	0.040	0.040	2.00	12.0–15.0	22.0–26.0	...	...	...	...
CPK20	0.20	1.50	0.040	0.040	1.75	19.0–22.0	23.0–27.0	...	...	...	...
CPE20N	0.20	1.50	0.040	0.040	1.50	8.0–11.0	23.0–26.0	...	...	...	0.08–0.20

[A] Grades CPF10MC and CPF8C may have a columbium plus tantalum content maximum of 1.35 %.
[B] No designation as yet assigned by ASTM International or Steel Founders' Society of America.
[C] By agreement between the manufacturer and the purchaser, the carbon content of Grade CPH20 may be restricted to 0.10 % max. When so agreed, the grade designation shall be CPH10.

TABLE 2 Heat-Treatment Requirements

Grade	Temperature, min		Hold Time, h/in. of Thickness
	°F	°C	
CPF3, CPF3A, CPF8, CPF8A, CPF3M, CPF8M	1900	1040	1
CPF10MC, CPF8C, CPF8C (Ta max)	1950	1065	2
CPH8, CPH10, CPH20, CPK20	2100	1150	1
CPE20N	2225	1220	1

TABLE 3 Tensile Requirements

Grade	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa]	Elongation in 2 in. or 50 mm, min
CPF3	70 [485]	30 [205]	35
CPF3A[A]	77 [535]	35 [240]	35
CPF3M	70 [485]	30 [205]	30
CPF8	70 [485]	30 [205]	35
CPF8A[A]	77 [535]	35 [240]	35
CPF8M	70 [485]	30 [205]	30
CPF10MC	70 [485]	30 [205]	20
CPH10	70 [485]	30 [205]	30
CPF8C (Ta max), CPF8C	70 [485]	30 [205]	30
CPH8	65 [448]	28 [195]	30
CPK20	65 [448]	28 [195]	30
CPH20	70 [485]	30 [205]	30
CPE20N	80 [550]	40 [275]	30

[A] The properties shown are obtained by adjusting the composition within the limits shown in Table 1 to obtain a ferrite-austenite ratio that will result in the higher ultimate and yield strengths indicated. A lowering of impact values may develop in these materials when exposed to service temperature above 800°F [425°C].

chemical composition thus determined shall conform to the requirements specified in Table 1.

5.2 *Product Analysis*—A product analysis may be made by the purchaser. The sample for analysis shall be selected so as to be thoroughly representative of the pipe being analyzed. The chemical composition thus determined shall conform to the requirements specified in Table 1.

5.3 To determine conformance with the chemical analysis requirements, an observed value or calculated value shall be rounded in accordance with Practice E 29 to the nearest unit in the last right-hand place of values listed in Table 1.

6. Tensile Requirements

6.1 *Test Specimens*:

6.1.1 Test specimens shall be prepared in accordance with Test Methods and Definitions A 370. Test bars shall be poured in special blocks from the same heat as the castings represented. Test bars shall be supplied in sufficient number to furnish all specimens required in 6.2 and 6.3 (see Table 3).

6.1.2 Test specimens may be cut from heat-treated castings instead of from test bars when agreed upon between the manufacturer and the purchaser.

6.1.3 Tension test specimens shall be machined to the form and dimensions of the standard round 2-in. [50-mm] gage length specimens shown in Fig. 6 of Test Methods and Definitions A 370.

6.2 *Number of Tests*:

6.2.1 One tension test shall be made from each heat. The bar from which the test specimen is taken shall be heat-treated in the same manner as the castings represented.

6.2.2 If a specimen is machined improperly or flaws are revealed by machining or during testing, the specimen may be discarded and another substituted from the same heat.

6.3 *Retests*—If the results of the mechanical tests for any heat do not conform to the requirements specified, the castings may be reheat-treated and retested, but may not be solution-treated more than twice.

7. Hydrostatic Test

7.1 Each length of pipe shall be hydrostatically tested in accordance with Specification A 999/A 999M.

7.2 It is realized that the foundry may be unable to perform the hydrostatic test prior to shipment, or that the purchaser may wish to defer testing until additional work has been performed on the casting. In such cases, the foundry is responsible for the satisfactory performance of the casting when it is tested.

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8. Quality

8.1 The surface of the casting shall be examined visually and shall be free from cracks and hot tears. Other surface defects shall be judged in accordance with visual acceptance criteria which may be specified in the order.

9. Rework and Retreatment

9.1 Defects as defined in Section 8 shall be removed and their removal verified by visual inspection of the resultant cavities. Defects which are located by inspecting with Supplementary Requirement S6 or S7, or both, shall be removed or reduced to an acceptable size.

9.2 If removal of the defect does not infringe upon the minimum wall thickness, the depression may be blended uniformly into the surrounding surface.

9.3 If the cavity resulting from defect removal infringes upon the minimum wall thickness, weld repair is permitted subject to the purchasers' approval. The composition of the weld rod used shall be suitable for the composition of the metal being welded.

9.3.1 Only operators and procedures qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, shall be used. All repair welds will be inspected to the same quality standards used to inspect the casting.

9.4 Postweld heat-treatment of the repaired casting is neither required nor prohibited.

10. Permissible Variations in Dimensions

10.1 *Thickness*—The wall thickness shall not vary over that specified by more than ⅛ in. (3 mm). There shall be no variation under the specified wall thickness.

11. General Requirements

11.1 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.

12. Rejection

12.1 Each length of pipe received from the manufacturer may be inspected by the purchaser and, if it does not meet the requirements of the specification based on the inspection and test method as outlined in the specification, the pipe may be rejected and the manufacturer shall be notified. Disposition of rejected pipe shall be a matter of agreement between the manufacturer and the purchaser.

13. Rehearing

13.1 Samples that represent rejected material shall be preserved for 2 weeks from the date of transmission of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

14. Certification

14.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

15. Product Marking

15.1 Each length of pipe shall be legibly marked with the manufacturer's name or brand, the letters ASTM, the specification number, and grade. In addition, heat numbers, or serial numbers that are traceable to heat numbers, shall be marked on each length of pipe.

16. Keywords

16.1 austenitic; centrifugally cast; height; high-temperature service; stainless steel; steel castings

SUPPLEMENTARY REQUIREMENTS

Supplementary requirements shall be applied only when specified by the purchaser. Details of the supplementary requirements shall be agreed upon by the manufacturer and purchaser. The specified tests shall be performed by the manufacturer prior to shipment of the castings.

S1. Additional Tension Tests

S1.1 Additional tension tests shall be made at a temperature to be specified by the customer, and the properties to be met are a matter of agreement between purchaser and manufacturer.

S2. Flattening Test

S2.1 The flattening test shall be made on specimens from one or both ends of each length of pipe. If the specimen from any end of any length fails to conform to the requirements of Specification A 999/A 999M, that length shall be rejected.

S3. Photomicrographs

S3.1 The manufacturer shall furnish one photomicrograph at 100 diameters from one specimen of as-finished pipe from each heat in each heat-treatment lot. Such photomicrographs shall be suitably identified as to pipe size, wall thickness, and heat. Such photomicrographs are for information only, to show the actual metal structure of the pipe as furnished. No photomicrographs for the individual pieces purchased shall be required except as specified in Supplementary Requirement S4.

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S4. Photomicrographs for Individual Pieces

S4.1 The manufacturer shall furnish photomicrographs from one or both ends of each pipe. All photomicrographs 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.

S5. Metal Structure and Etching Tests

S5.1 Etching tests (Note S1) shall be made on transverse sections from the pipe and shall reveal the macrostructure of the material. Such tests are for information only.

NOTE S1—Pending development of etching methods applicable to the product covered by this specification, it is recommended that the Recommended Practice for a Standard Macroetch Test for Routine Inspection of Iron and Steel be followed.[5]

[5] *Metals Handbook*, American Society for Metals, Vol 8, 8th ed., 1973, pp. 70-77.

S6. Radiographic Examination

S6.1 The castings shall be examined for internal defects by means of X rays or gamma rays. The inspection procedure shall be in accordance with Guide E 94 and the types and degrees of discontinuities considered shall be judged by Reference Radiographs E 446, E 186, or E 280. The extent of examination and the basis for acceptance shall be subject to agreement between the manufacturer and the purchaser.

S7. Liquid Penetrant Examination

S7.1 The castings shall be examined for surface discontinuities by means of liquid penetrant inspection. The method of performing the liquid penetrant test shall be in accordance with Test Method E 165. The areas to be inspected, the methods and types of liquid penetrants to be used, the developing procedure, and the basis for acceptance shall be as specified on the inquiry or invitation to bid and on the purchase order or contract or both, or as agreed upon between the manufacturer and the purchaser.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 451/A 451M (2002)) that may impact the use of this standard (Approved Sept. 1, 2006).

(1) Replaced reference to A 530/A 530M with reference to A 999/A 999M in Section 2.

(2) In sections 3.1.5, 3.1.6, 7.1, and 11.1, replaced reference to A 530/A 530M with reference to A 999/A 999M.

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