



Designation: A451/A451M – 20

# Standard Specification for Centrifugally Cast Austenitic Steel Pipe for High-Temperature Service<sup>1</sup>

This standard is issued under the fixed designation A451/A451M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This specification<sup>2</sup> covers 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 SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.4.1 Within the text, the SI units are shown in brackets.

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 [A297/A297M](#).

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

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

[A297/A297M](#) Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.18 on Castings.

Current edition approved July 1, 2020. Published August 2020. Originally approved in 1961. Last previous edition approved in 2019 as A451/A451M – 19. DOI: 10.1520/A0451\_A0451M-20.

<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-451 in Section II of that Code.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[A999/A999M](#) Specification for General Requirements for Alloy and Stainless Steel Pipe

[E29](#) Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

[E94/E94M](#) Guide for Radiographic Examination Using Industrial Radiographic Film

[E165/E165M](#) Practice for Liquid Penetrant Testing for General Industry

[E186](#) Reference Radiographs for Heavy-Walled (2 to 4½ in. (50.8 to 114 mm)) Steel Castings

[E280](#) Reference Radiographs for Heavy-Walled (4½ to 12 in. (114 to 305 mm)) Steel Castings

[E446](#) Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness

2.2 *ANSI Standard:*<sup>4</sup>

[B46.1](#) Surface Texture

## 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, meters, 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 millimeters),

3.1.5 Length (specific or random, Specification [A999/A999M](#)),

3.1.6 End finish of Specification [A999/A999M](#),

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.

<sup>4</sup> 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

**TABLE 1 Composition Requirements<sup>A,B</sup>**

Grade (UNS Number)	Element, %										
	Carbon	Manga- nese	Phospho- rus	Sulfur	Silicon	Chromium	Nickel	Molybde- num	Nitrogen	Niobium <sup>C</sup>	Tantalum
CPF3 (J92500)	0.03	1.50	0.040	0.040	2.00	17.0–21.0	8.0–12.0	...	...	...	...
CPF3A (J92500)	0.03	1.50	0.040	0.040	2.00	17.0–21.0	8.0–12.0	...	...	...	...
CPF8 (J92600)	0.08	1.50	0.040	0.040	2.00	18.0–21.0	8.0–11.0	...	...	...	...
CPF8A (J92600)	0.08	1.50	0.040	0.040	2.00	18.0–21.0	8.0–11.0	...	...	...	...
CPF3M (J92800)	0.03	1.50	0.040	0.040	1.50	17.0–21.0	9.0–13.0	2.0–3.0	...	...	...
CPF8M (J92804)	0.08	1.50	0.040	0.040	1.50	18.0–21.0	9.0–12.0	2.0–3.0	...	...	...
CPF10MC <sup>D</sup>	0.10	1.50	0.040	0.040	1.50	15.0–18.0	13.0–16.0	1.75–2.25	...	1.2 max, 10 × C min	...
CPF8C <sup>D</sup> (J92710)	0.08	1.50	0.040	0.040	2.00	18.0–21.0	9.0–12.0	...	...	1 max, 8 × C min	...
CPF8C (Ta max) <sup>E</sup>	0.08	1.50	0.040	0.040	2.00	18.0–21.0	9.0–12.0	...	...	1 max, 8 × C min	0.10
CPH8 (J93400)	0.08	1.50	0.040	0.040	1.50	22.0–26.0	12.0–15.0	...	...	...	...
CPH10 (J93401)	0.10	1.50	0.040	0.040	2.00	22.0–26.0	12.0–15.0	...	...	...	...
CPH20 (J93402)	0.20	1.50	0.040	0.040	2.00	22.0–26.0	12.0–15.0	...	...	...	...
CPK20 (J94202)	0.20	1.50	0.040	0.040	1.75	23.0–27.0	19.0–22.0	...	...	...	...
CPE20N (J92802)	0.20	1.50	0.040	0.040	1.50	23.0–26.0	8.0–11.0	...	0.08–0.20	...	...

<sup>A</sup> Where ellipses (. . .) appear in this table there is no requirement, and the element need not be analyzed or reported.

<sup>B</sup> Values are maximums unless a range or a minimum is provided.

<sup>C</sup> Columbium (Cb) and Niobium (Nb) are interchangeable names for the same element 41.

<sup>D</sup> Grades CPF10MC and CPF8C may have a columbium plus tantalum content maximum of 1.35 %.

<sup>E</sup> No designation as yet assigned by ASTM International or Steel Founders' Society of America.

**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

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

## 5. Chemical Composition

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 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 **E29** 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 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 specimen.

### 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 heat treated more than twice.

## 7. Hydrostatic Test

7.1 Each length of pipe shall be hydrostatically tested in accordance with Specification A999/A999M.

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.

## 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 purchaser's 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 Post-weld 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 1/8 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 A999/A999M, 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 two 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.

**TABLE 3 Tensile Requirements**

Grade	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa]	Elongation, min %, in 2 in. [50 mm]
CPF3	70 [485]	30 [205]	35
CPF3A <sup>A</sup>	77 [535]	35 [240]	35
CPF3M	70 [485]	30 [205]	30
CPF8	70 [485]	30 [205]	35
CPF8A <sup>A</sup>	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

<sup>A</sup> 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].