Designation: ~~A451/A451M – 19~~ A451/A451M – 20

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

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 (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 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.

~~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.~~

1.4.1 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:*[3]

A297/A297M Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application

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:*[4]

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),

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[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.

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[2] For ASME Boiler and Pressure Vessel Code applications, see related ~~specification~~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, http://www.ansi.org.

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

TABLE 1 Composition Requirements[A,B]

Grade (UNS Number)	Element, %											
	Carbon	Manganese	Phosphorus	Sulfur	Silicon	~~Nickel~~ ~~Chromium~~Nickel Chromium		Molybdenum	Nitrogen	Niobium[C]	Tantalum	~~Nitrogen~~
~~CPF3 (J92500)~~	~~0.03~~	~~1.50~~	~~0.040~~	~~0.040~~	~~2.00~~	~~8.0–12.0~~	~~17.0–21.0~~	...	...	...	...	
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~~	~~8.0–12.0~~	~~17.0–21.0~~	...	...	...	...	
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~~	~~8.0–11.0~~	~~18.0–21.0~~	...	...	...	...	
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~~	~~8.0–11.0~~	~~18.0–21.0~~	...	...	...	...	
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~~	~~9.0–13.0~~	~~17.0–21.0~~	~~2.0–3.0~~	...	...	...	
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~~	~~9.0–12.0~~	~~18.0–21.0~~	~~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~~[D]	~~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~~	...	...	
CPF10MC[D]	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~~[D] ~~(J92710)~~	~~0.08~~	~~1.50~~	~~0.040~~	~~0.040~~	~~2.00~~	~~9.0–12.0~~	~~18.0–21.0~~	...	~~1 max, 8 × C min~~	...	...	
CPF8C[D] (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)~~[E]	~~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~~	...	
CPF8C (Ta max)[E]	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	...	...	...	...	
~~CPH8 (J93400)~~	~~0.08~~	~~1.50~~	~~0.040~~	~~0.040~~	~~1.50~~	~~12.0–15.0~~	~~22.0–26.0~~	...	...	...	...	
CPH10 (J93401)	0.10	1.50	0.040	0.040	2.00	22.0–26.0	12.0–15.0	...	...	...	...	
~~CPH20 or CPH10 (J93402)~~	~~0.20~~[F]	~~1.50~~	~~0.040~~	~~0.040~~	~~2.00~~	~~12.0–15.0~~	~~22.0–26.0~~	...	...	...	...	
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~~	~~19.0–22.0~~	~~23.0–27.0~~	...	...	...	...	
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~~	~~8.0–11.0~~	~~23.0–26.0~~	...	...	...	~~0.08–0.20~~	
CPE20N (J92802)	0.20	1.50	0.040	0.040	1.50	23.0–26.0	8.0–11.0	...	0.08–0.20	...	...	

[A] Where ellipses ~~(...)~~ (. . .) appear in this table there is no requirement, and the element need not be analyzed or reported.
[B] Values are maximums unless a range or a minimum is provided.
[C] Columbium (Cb) and Niobium (Nb) are interchangeable names for the same element 41.
[D] Grades CPF10MC and CPF8C may have a columbium plus tantalum content maximum of 1.35 %.
[E] No designation as yet assigned by ASTM International or Steel Founders' Society of America.
~~[F] 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.~~

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.

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 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.

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

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.

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[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].