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

This standard is issued under the fixed designation A426/A426M; 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 centrifugally cast alloy steel pipe intended for use in high-temperature, high-pressure service.
- 1.2 Several grades of ferritic steels are covered. Their compositions are given in Table 1.
- 1.3 Supplementary Requirements S1 through S12 are provided. The supplementary requirements provide for additional tests of an optional nature and when desired shall be so stated in the order (Section 4).
- 1.4 The values stated in either inch-pound units or SI 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 non-conformance with the standard.
  - 1.4.1 Within the text, the SI units are shown in brackets.
- 1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

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

- A370 [Test Methods and Definitions for Mechanical Testing of Steel Products](#)
- A609/A609M [Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof](#)
- A941 [Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys](#)
- A999/A999M [Specification for General Requirements for Alloy and Stainless Steel Pipe](#)
- E94 [Guide for Radiographic Examination](#)
- E165 [Practice for Liquid Penetrant Examination for General Industry](#)
- E186 [Reference Radiographs for Heavy-Walled \(2 to 412-in. \(50.8 to 114-mm\)\) Steel Castings](#)
- E208 [Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels](#)
- E280 [Reference Radiographs for Heavy-Walled \(412 to 12-in. \(114 to 305-mm\)\) Steel Castings](#)
- E446 [Reference Radiographs for Steel Castings Up to 2 in. \(50.8 mm\) in Thickness](#)
- E709 [Guide for Magnetic Particle Testing](#)

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

B46.1 [Surface Texture](#)

#### 2.3 ASME Boiler and Pressure Vessel Code:<sup>5</sup>

Section IX [Welding and Brazing Qualifications](#)

#### 2.4 AWS Specifications<sup>6</sup>

[A5.5/A5.5M Low Alloy Steel Electrodes for Shielded Metal Arc Welding](#)

[A5.23/A5.23M Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding](#)

[A5.28/A5.28M Low Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding](#)

<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.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-426 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.

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

<sup>5</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

<sup>6</sup> [Viswanathan, R. and Bakker, W. T., Materials for Ultra-Supercritical Fossil Power Plants, EPRI, Palo Alto, CA: 2000, TR-114750.](#)

<sup>6</sup> Available from American Welding Society, 550 NW LeJeune Rd., Miami, FL 33126, <http://www.aws.org>

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

**TABLE 1 Chemical Requirements<sup>A</sup>**

Composition, %									
Grade	UNS Number	Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon	Chromium	Molybdenum	Other
GP4	J12521	0.25 max	0.30-0.80	0.040	0.045	0.10-0.50	...	0.44-0.65	...
CP1	J12521	0.25 max	0.30-0.80	0.030	0.025	0.10-0.50	...	0.44-0.65	...
GP2	J11547	0.10-0.20	0.30-0.61	0.040	0.045	0.10-0.50	0.50-0.81	0.44-0.65	...
CP2	J11547	0.10-0.20	0.30-0.61	0.030	0.025	0.10-0.50	0.50-0.81	0.44-0.65	...
GP5	J42045	0.20 max	0.30-0.70	0.040	0.045	0.75 max	4.00-6.50	0.45-0.65	...
CP5	J42045	0.20 max	0.30-0.70	0.030	0.025	0.75 max	4.00-6.50	0.45-0.65	...
GP5b	J51545	0.15 max	0.30-0.60	0.040	0.045	1.00-2.00	4.00-6.00	0.45-0.65	...
CP5b	J51545	0.15 max	0.30-0.60	0.030	0.025	1.00-2.00	4.00-6.00	0.45-0.65	...
GP9	J82090	0.20 max	0.30-0.65	0.040	0.045	0.25-1.00	8.00-10.00	0.90-1.20	...
CP9	J82090	0.20 max	0.30-0.65	0.030	0.025	0.25-1.00	8.00-10.00	0.90-1.20	...
CP91	J84090	0.08-0.12	0.30-0.60	0.030	0.010	0.20-0.50	8.0-9.5	0.85-1.05	nickel, 0.40 max.; columbium, 0.060-0.10; nitrogen, 0.030-0.070; vanadium, 0.18-0.25; aluminum, 0.02 max.; titanium, 0.01 max.; zirconium, 0.01 max.
GP11	J12072	0.05-0.20	0.30-0.80	0.040	0.045	0.60 max	1.00-1.50	0.44-0.65	...
CP11	J12072	0.05-0.20	0.30-0.80	0.030	0.025	0.60 max	1.00-1.50	0.44-0.65	...
GP12	J11562	0.05-0.15	0.30-0.61	0.040	0.045	0.50 max	0.80-1.25	0.44-0.65	...
CP12	J11562	0.05-0.15	0.30-0.61	0.030	0.025	0.50 max	0.80-1.25	0.44-0.65	...
GP15	J11522	0.15 max	0.30-0.60	0.040	0.045	1.15-1.65	...	0.44-0.65	...
CP15	J11522	0.15 max	0.30-0.60	0.030	0.025	1.15-1.65	...	0.44-0.65	...
GP21	J31545	0.05-0.15	0.30-0.60	0.040	0.045	0.50 max	2.65-3.35	0.80-1.06	...
CP21	J31545	0.05-0.15	0.30-0.60	0.030	0.025	0.50 max	2.65-3.35	0.80-1.06	...
GP22	J21890	0.05-0.15	0.30-0.70	0.040	0.045	0.60 max	2.00-2.75	0.90-1.20	...
CP22	J21890	0.05-0.15	0.30-0.70	0.030	0.025	0.60 max	2.00-2.75	0.90-1.20	...
GPCA15	J91150	0.15 max	1.00 max	0.040	0.040	1.50 max	11.5-14.0	0.50 max	...
CPCA15	J91150	0.15 max	1.00 max	0.030	0.025	1.50 max	11.5-14.0	0.50 max	...

<sup>A</sup> Where ellipses appear in this table there is no requirement.

**A5.29/A5.29M Low-Alloy Steel Electrodes for Flux Cored Arc Welding**

**3. Ordering Information**

3.1 Orders for material under this specification shall 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 (centrifugally cast pipe),
- 3.1.3 Specification number,
- 3.1.4 Grade (Table 1),
- 3.1.5 Size (outside or inside diameter and minimum wall thickness),
- 3.1.6 Length (specific or random) (Section on Permissible Variations in Length of Specification A999/A999M),
- 3.1.7 End finish (Section on Ends of Specification A999/A999M),
- 3.1.8 Optional Requirements S1 through S12 and Section 14.15.1,
- 3.1.9 Test report required (Section on Certified Test Report of Specification A999/A999M),
- 3.1.10 Service temperature if over 1000°F [540°C] (Note 1), and

3.1.11 Special requirements or additions to specification.

#### 4. General Requirements for Delivery

4.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A999/A999M unless otherwise provided herein.

#### 5. Materials and Manufacture

5.1 *Heat-Treatment*—The pipe shall be furnished in the normalized and tempered or liquid-quenched and tempered condition (Note 1). The temperature for tempering shall not be less than 1250°F [675°C] except for Grades CP1, CP2, CP11, CP12, and CP15 for which the temperature for tempering shall not be less than 1100°F [595°C]. Grade CP91 shall be ~~normalized~~austenitized at 1900 – 1975 °F (1040 – 1080 °C) and tempered at 1350 – 1470 °F (730 – 800 °C).

5.1.1 Heat treatment shall be performed after the pipe has been allowed to cool below the transformation range. Definition of heat-treatment terms shall be as given in Terminology A941.

NOTE 1—Except for Grade CP91, it is recommended that the temperature for tempering should be at least 100°F [55°C] above the intended service temperature. The purchaser shall advise the manufacturer of the service temperature when it is over 1000°F [540°C].

5.2 *Machining*—The pipe shall be machined on the inner and outer surfaces to a roughness value no greater than 250 μ in. [6.35 μm] arithmetical average deviation (AA) from the mean line unless otherwise specified as in ANSI B46.1.

#### 6. Chemical Analysis

6.1 *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 preferable during the pouring of the heat. The chemical composition thus determined shall conform to the requirements specified in Table 1 (Note 2).

NOTE 2—The role of alloying elements in the development of Grade CP91 has been extensively investigated. V and Nb contribute to precipitation strengthening by forming fine and coherent precipitation of M(C,N)X carbo-nitrides in the ferrite matrix. V also precipitates as VN during tempering or during creep. Therefore, the addition of strong nitride forming elements, those with a stronger affinity for nitrogen than Nb and V, as deoxidation agents, interferes with these high-temperature strengthening mechanisms.<sup>7</sup>

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

#### 7. Tensile and Hardness Requirements

7.1 Steel used for the castings shall conform to the tensile and hardness requirements specified in Table 2.

#### 8. Permissible Variations in Dimensions

8.1 *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.

#### 9. Number of Tests

9.1 One tension and one hardness test shall be made from each heat.

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

#### 10. Retests

10.1 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 re-austenitized more than twice.

#### 11. Test Specimens

11.1 Test coupons from which tension test specimens are prepared shall be removed from heat-treated casting prolongations.

11.2 When agreed upon between the manufacturer and the purchaser, test coupons from which test specimens are prepared shall be cast attached to separate blocks from the same heat as the casting represented. The test blocks shall be heat treated in the same manner as the casting represented.

11.3 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 A370.

#### 12. Hydrostatic Test

~~12.1 Each length of pipe shall be hydrostatically tested in accordance with Specification~~

<sup>7</sup> Viswanathan, R. and Bakker, W. T., Materials for Ultra Supercritical Fossil Power Plants, EPRI, Palo Alto, CA: 2000, TR-114750.