Designation: A 426/A 426M – 08

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

This standard is issued under the fixed designation A 426/A 426M; 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.

Note—Table 1 was editorially corrected and the year date was changed on Feb. 4, 2008.

1. Scope*

1.1 This specification[2] 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. 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 each other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

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

A 609/A 609M Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof

A 941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

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

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 208 Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels

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

E 709 Guide for Magnetic Particle Examination

2.2 *ANSI Standard:*[4]

B46.1 Surface Texture

2.3 *ASME Boiler and Pressure Vessel Code:*[5]

Section IX Welding Qualifications

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 A 999/A 999M),

3.1.7 End finish (Section on Ends of Specification A 999/A 999M),

3.1.8 Optional Requirements S1 through S12 and Section 14.1,

[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 SA-426 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.

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

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

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TABLE 1 Chemical Requirements[A]

Grade	UNS Number	Composition, %							
		Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon	Chromium	Molybdenum	Other
CP1	J12521	0.25 max	0.30-0.80	0.040	0.045	0.10-0.50	. . .	0.44-0.65	. . .
CP2	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	. . .
CP5	J42045	0.20 max	0.30-0.70	0.040	0.045	0.75 max	4.00-6.50	0.45-0.65	. . .
CP5b	J51545	0.15 max	0.30-0.60	0.040	0.045	1.00-2.00	4.00-6.00	0.45-0.65	. . .
CP9	J82090	0.20 max	0.30-0.65	0.040	0.045	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.
CP11	J12072	0.05–0.20	0.30-0.80	0.040	0.045	0.60 max	1.00-1.50	0.44-0.65	. . .
CP12	J11562	0.05–0.15	0.30-0.61	0.040	0.045	0.50 max	0.80-1.25	0.44-0.65	. . .
CP15	J11522	0.15 max	0.30-0.60	0.040	0.045	0.15-1.65	. . .	0.44-0.65	. . .
CP21	J31545	0.05–0.15	0.30-0.60	0.040	0.045	0.50 max	2.65-3.35	0.80-1.06	. . .
CP22	J21890	0.05–0.15	0.30-0.70	0.040	0.045	0.60 max	2.00-2.75	0.90-1.20	. . .
CPCA15	J91150	0.15 max	1.00 max	0.040	0.040	1.50 max	11.5-14.0	0.50 max	. . .

[A]Where ellipses appear in this table there is no requirement.

† Editorially corrected.

3.1.9 Test report required (Section on Certified Test Report of Specification A 999/A 999M),

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 A 999/A 999M 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 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 A 941.

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

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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.[6]

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 ⅛ 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.

[6] Viswanathan, R. and Bakker, W. T., Materials for Ultra Supercritical Fossil Power Plants, EPRI, Palo Alto, CA: 2000, TR-114750.

TABLE 2 Tensile Properties and Hardness Requirements

Tensile strength, min, psi [MPa]:	
Grade CP1	65 000 [450]
Grades CP11, CP22	70 000 [485]
Grades CP5, CP9, CPCA15	90 000 [620]
Grade CP91	85 000 [585] to 110 000 [760]
All other grades	60 000 [415]
Yield strength, min, psi [MPa]:	
Grade CP1	35 000 [240]
Grades CP11, CP22	40 000 [275]
Grades CP5, CP9	60 000 [415]
Grade CPCA15	65 000 [450]
Grade CP91	60 000 [415]
All other grades	30 000 [205]
Elongation, min, %:[A]	
Grade CP1	24
Grades CP11, CP22	20
Grades CP5, CP9, CP91, CPCA15	18
All other grades	22
Reduction of area, min, %:	
Grades CP1, CP2, CP11, CP12, CP15, CP21, CP22, CP5, CP5b, CP7, CP9	35
Grade CPCA15	30
Grade CP91	45
Hardness, max, HB:	
Grades CP5, CP5b, CP9, CP91, CPCA15	225
All other grades	201

[A] Elongation in 2 in. [50 mm] using a standard round specimen, in either the transverse or longitudinal direction.

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 A 370.

12. Hydrostatic Test

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

12.2 When agreed to between the manufacturer and the purchaser and so stated in the order, the hydrostatic test may be deferred and shall be performed later by the purchaser. Pipe furnished without the hydrostatic test shall include with the mandatory marking the letters "NH." The manufacturer is responsible for the satisfactory performance of the casting when it is tested.

12.3 When certification is required by the purchaser and the hydrostatic test has been omitted, the certification shall clearly state "not hydrostatically tested." The specification number and material grade shown on the certification shall be followed by the letters "NH."

13. Visual Inspection

13.1 The surface of the casting shall be free from cracks and hot tears as determined by visual examination. Other surface imperfections shall be judged in accordance with visual acceptance criteria which may be specified in the order.

14. Rework and Retreatment

14.1 Defects as defined in Section 14 shall be removed and their removal verified by visual inspection of the resultant cavities. Defects that are located by inspecting with supplementary requirements S6, S7, S8, or S9 shall be removed or reduced to an acceptable size.

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

14.3 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.

14.3.1 Only welders 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.

14.4 Local or full heat treatment in accordance with tempering temperatures specified in 5.1 shall follow welding.

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15. Rejection

15.1 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.

16. Product Marking

16.1 Each length of pipe shall be legibly marked with the manufacturer's name or brand, 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.

17. Keywords

17.1 alloy steel; centrifugal; ferritic; high-temperature service; pipe; 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 between 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 the 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 suitable 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 Section S4.

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 shall be made on transverse sections from the pipe and shall reveal the macrostructure of the material. Such tests are for information only.

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 186, E 280, or E 446. The extent of the 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 Practice 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 purchaser.

S8. Magnetic Particle Inspection

S8.1 The castings shall be examined by magnetic particle inspection. The inspection procedure used shall be in accordance with Practice E 709. The extent of examination and the basis for acceptance shall be subject to agreement between the manufacturer and the purchaser.

S9. Ultrasonic Inspection

S9.1 The castings shall be examined ultrasonically in accordance with Practice A 609/A 609M. The extent of the examination and the basis of acceptance shall be subject to agreement between the manufacturer and the purchaser.

S10. Residual Elements

S10.1 An analysis for the elements specified in Table S1 shall be included in those analyses specified in Section 6. The chemical composition thus determined shall conform to the requirements of Table S1.

S11. Charpy Impact Test

S11.1 Charpy impact test properties shall be determined on each heat from a set of three Charpy V-notch specimens. The

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TABLE S1 Residual Elements

Grade	Copper, max	Nickel, max	Chromium, max	Tungsten, max	Total Contents of These Unspecified Elements, max, %
CP1	0.50	0.50	0.35	0.10	1.00
CP2	0.50	0.50	. . .	0.10	1.00
CP5	0.50	0.50	. . .	0.10	1.00
CP5b	0.50	0.50	. . .	0.10	1.00
CP7	0.50	0.50	. . .	0.10	1.00
CP9	0.50	0.50	. . .	0.10	1.00
CP11	0.50	0.50	. . .	0.10	1.00
CP12	0.50	0.50	. . .	0.10	1.00
CP15	0.50	0.50	0.35	0.10	1.00
CP21	0.50	0.50	. . .	0.10	1.00
CP22	0.50	0.50	. . .	0.10	1.00
CPCA15	0.50	1.00	. . .	0.10	1.50

test coupons shall be taken as specified for tension specimens in Section 11 and tested at a test temperature agreed upon by the manufacturer and purchaser. The acceptance requirements shall be either energy absorbed or lateral expansion or percent shear area, and shall be that agreed upon by the manufacturer and purchaser. Test specimens shall be prepared as Type A and tested in accordance with Test Methods and Definitions A 370.

S11.2 *Absorbed Energy Value*, of three specimens shall not be less than that agreed upon by the manufacturer and purchaser, with no more than one value permitted below the minimum average specified and no value permitted below the minimum specified for a single specimen.

S11.3 *Lateral Expansion Value*, shall be agreed upon by the manufacturer and purchaser.

S11.4 *Percent Shear Area*, shall be agreed upon by the manufacturer and purchaser.

S12. Drop Weight Test

S12.1 Drop weight test properties shall be determined by preparing and testing either Type P1, P2, or P3 specimens in accordance with Test Method E 208. The test coupons shall be taken as specified for tension specimens in Section 11. The crack starter weld shall be deposited on the surface of the specimen which was nearest to the casting surface. Each test shall consist of at least two specimens tested at a temperature agreed upon by the manufacturer and purchaser. Each specimen shall exhibit a “no break” performance.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue, A 426/A 426M - 07, that may impact the use of this standard. (Approved February 4, 2008)

(*1*) Table 1–Molybdenum content in CP91 corrected.

(*2*) Table 1–Included ellipses description as footnote.

Committee A01 has identified the location of selected changes to this standard since the last issue, A 426/A 426M - 05, that may impact the use of this standard. (Approved May 1, 2007)

(*1*) Added Grade CP91 to 5.1 and 6.1 and to Tables 1 and 2.

(*2*) Added UNS numbers to Table 1.

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