



# Standard Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service<sup>1</sup>

This standard is issued under the fixed designation A217/A217M; 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.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope\*

1.1 This specification<sup>2</sup> covers martensitic stainless steel and alloy steel castings for valves, flanges, fittings, and other pressure-containing parts (**Note 1**) intended primarily for high-temperature and corrosive service (**Note 2**).

1.2 One grade of martensitic stainless steel and nine grades of ferritic alloy steel are covered. Selection will depend on design and service conditions, mechanical properties, and the high-temperature and corrosion-resistant characteristics (**Note 3**).

**NOTE 1**—Carbon steel castings for pressure-containing parts are covered by Specification **A216/A216M**. Low alloy quench-and-tempered grades equivalent to Specification A217/A217M grades may be found in both Specifications **A352/A352M** and **A487/A487M**.

**NOTE 2**—The grades covered by this specification represent materials that are generally suitable for assembly with other castings or wrought steel parts by fusion welding. It is not intended to imply that these grades possess equal degrees of weldability; therefore, it is the responsibility of the purchaser to establish for himself a suitable welding technique. Since these grades possess varying degrees of suitability for high-temperature and corrosion-resistant service, it is also the responsibility of the purchaser to determine which grade shall be furnished, due consideration being given to the requirements of the applicable construction codes.

**NOTE 3**—The committee formulating this specification has included nine grades of materials that are considered to represent basic types of ferritic alloy steels suitable for valves, flanges, fittings, and other pressure-containing parts. Additional alloy steels that may better fulfill certain types of service will be considered for inclusion in this specification by the committee as the need becomes apparent.

1.3 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 non-conformance with the standard.

## 2. Referenced Documents

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

**A216/A216M** Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service

**A352/A352M** Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service

**A487/A487M** Specification for Steel Castings Suitable for Pressure Service

**A488/A488M** Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel

**A703/A703M** Specification for Steel Castings, General Requirements, for Pressure-Containing Parts

**A802/A802M** Practice for Steel Castings, Surface Acceptance Standards, Visual Examination

**A985/A985M** Specification for Steel Investment Castings General Requirements, for Pressure-Containing Parts

**E165** Practice for Liquid Penetrant Examination for General Industry

**E709** Guide for Magnetic Particle Testing

### 2.2 AWS Specifications:<sup>4</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-217/SA 217M 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 Welding Society, 550 NW LeJuene Rd., Miami, FL 33126, <http://www.aws.org>.



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

### 3. General Conditions for Delivery

3.1 Except for investment castings, castings furnished to this specification shall conform to the requirements of Specification **A703/A703M** including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification **A703/A703M** constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification **A703/A703M**, this specification shall prevail.

3.2 Steel investment castings furnished to this specification shall conform to the requirements of Specification **A985/A985M**, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification **A985/A985M** constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification **A985/A985M**, Specification **A985/A985M** shall prevail.

### 4. Ordering Information

4.1 The inquiry and order should include or indicate the following:

4.1.1 A description of the casting by pattern number or drawing (dimensional tolerances shall be included on the casting drawing),

4.1.2 Grade of steel,

4.1.3 Options in the specification,

4.1.4 Whether the castings are to be produced using the investment casting process, and

4.1.5 The supplementary requirements desired including the standards of acceptance.

### 5. Heat Treatment

5.1 All castings shall receive a heat treatment proper to their design and chemical composition.

5.2 Castings shall be furnished in the normalized and tempered conditions; Grades WC1, WC4, WC5, WC6, and CA15 shall be tempered at 1100°F [595°C] min; Grades WC9, C5, C12, and WC11 shall be tempered at 1250°F [675°C] min; Grade C12A shall be thermally treated, either by normalizing-and-tempering or by accelerated cooling from the austenitizing temperature by air blasting or liquid quenching, followed by tempering. C12A castings shall be austenitized at 1900-1975°F [1040-1080°C] and tempered at 1350-1470°F [730-800°C].

5.3 Heat treatment shall be performed after castings have been allowed to cool below the transformation range.

### 6. Chemical Composition

6.1 The steel shall be in accordance with the requirements as to chemical composition prescribed in **Table 1 (Note 4)**.

NOTE 4—The role of alloying elements in the development of Grade C12A has been extensively investigated. V and Cb 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. The two elements are more effective in combination. Therefore, the addition of strong nitride-forming elements, those with a stronger affinity for nitrogen than Cb and V, as deoxidation agents, interferes with these high-temperature strengthening mechanisms.<sup>5</sup>

### 7. Mechanical Properties

7.1 Steel used for the castings shall conform to the requirements as to tensile properties given in **Table 2**.

7.2 C12A castings shall be hardness tested in accordance with Supplementary Requirement S13, and shall have a Brinell hardness of 185-248 HBW.

### 8. Quality

8.1 The surface of the casting shall be examined visually and shall be free of adhering sand, scale, cracks, and hot tears. Other surface discontinuities shall meet the visual acceptance standards specified in the order. Practice **A802/A802M** or other visual standards may be used to define acceptable surface discontinuities and finish. Unacceptable visual surface discontinuities shall be removed and their removal verified by visual examination of the resultant cavities. When methods involving high temperature are used in the removal of discontinuities, castings shall be preheated to at least the minimum temperatures in **Table 3**.

8.2 Hollow castings of Grade C12A, larger than NPS 4 [DN 100], and whose internal surfaces are not accessible to the visual examination in 8.1, shall be examined by the ultrasonic examination prescribed in Supplementary Requirement S7. Castings producing a signal equal to or greater than the lowest signal produced by the referenced discontinuities shall be identified and separated from the acceptable castings. The area producing the signal may be re-examined. Such castings shall be rejected if the test signals were produced by imperfections that cannot be identified or were produced by cracks or crack-like imperfections. Such castings may be repaired. To be accepted, a repaired casting shall pass the ultrasonic examination and shall meet the minimum wall thickness requirements of the purchase order.

8.3 When additional inspection is desired, Supplementary Requirements S4, S5, and S10 may be ordered.

8.4 The castings shall not be peened, plugged, or impregnated to stop leaks.

### 9. Repair by Welding

9.1 Repairs shall be made using procedures and welders qualified under Practice **A488/A488M**.

9.2 All repair welds in C12A castings shall be made with one of the following welding processes and consumables: SMAW, A5.5/A5.5M E90XX-B9; SAW, A5.23/A5.23M EB9 + Neutral Flux; GTAW, A5.28/A5.28M ER90S-B9, and FCAW, A5.29/A5.29M E91T1-B9. In addition, the sum of the Ni+Mn content, in all welding consumables used to weld repair C12A

<sup>5</sup> Viswanathan, R. and Bakker, W. T., *Materials for Ultra Supercritical Fossil Power Plants*, EPRI, Palo Alto, CA, 2000. TR-114750.

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

NOTE 1—All values are maximum unless otherwise indicated.

|                                          | Composition, %    |                            |                            |                     |                     |                     |                     |                     |                              |                    |
|------------------------------------------|-------------------|----------------------------|----------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|------------------------------|--------------------|
|                                          | Carbon Molybdenum | Nickel Chromium Molybdenum | Nickel Chromium Molybdenum | Chromium Molybdenum | Chromium Molybdenum | Chromium Molybdenum | Chromium Molybdenum | Chromium Molybdenum | Chromium Molybdenum Vanadium | Chromium           |
| Grade Identification Symbol              | WC1               | WC4                        | WC5                        | WC6                 | WC9                 | WC11                | C5                  | C12                 | C12A                         | CA15               |
| UNS Number                               | J12524            | J12082                     | J22000                     | J12072              | J21890              | J11872              | J42045              | J82090              | J84090                       | J91150             |
| Carbon                                   | 0.25              | 0.05–0.20                  | 0.05–0.20                  | 0.05–0.20           | 0.05–0.18           | 0.15–0.21           | 0.20                | 0.20                | 0.08–0.12                    | 0.15               |
| Manganese                                | 0.50–0.80         | 0.50–0.80                  | 0.40–0.70                  | 0.50–0.80           | 0.40–0.70           | 0.50–0.80           | 0.40–0.70           | 0.35–0.65           | 0.30–0.60                    | 1.00               |
| Phosphorus                               | 0.04              | 0.04                       | 0.04                       | 0.035 <sup>B</sup>  | 0.035               | 0.020               | 0.04 <sup>B</sup>   | 0.035 <sup>B</sup>  | 0.025                        | 0.040 <sup>B</sup> |
| Sulfur                                   | 0.045             | 0.045                      | 0.045                      | 0.035 <sup>B</sup>  | 0.035 <sup>B</sup>  | 0.015               | 0.045 <sup>B</sup>  | 0.035 <sup>B</sup>  | 0.010                        | 0.025 <sup>B</sup> |
| Silicon                                  | 0.60              | 0.60                       | 0.60                       | 0.60                | 0.60                | 0.30–0.60           | 0.75                | 1.00                | 0.20–0.50                    | 1.50               |
| Nickel                                   | ...               | 0.70–1.10                  | 0.60–1.00                  | ...                 | ...                 | ...                 | ...                 | ...                 | 0.40                         | 1.00               |
| Chromium                                 | ...               | 0.50–0.80                  | 0.50–0.90                  | 1.00–1.50           | 2.00–2.75           | 1.00–1.50           | 4.00–6.50           | 8.00–10.00          | 8.0–9.5                      | 11.5–14.0          |
| Molybdenum                               | 0.45–0.65         | 0.45–0.65                  | 0.90–1.20                  | 0.45–0.65           | 0.90–1.20           | 0.45–0.65           | 0.45–0.65           | 0.90–1.20           | 0.85–1.05                    | 0.50               |
| Columbium                                | ...               | ...                        | ...                        | ...                 | ...                 | ...                 | ...                 | 0.03                | 0.060–0.10                   | ...                |
| Nitrogen                                 | ...               | ...                        | ...                        | ...                 | ...                 | ...                 | ...                 | ...                 | 0.030–0.070                  | ...                |
| Vanadium                                 | ...               | ...                        | ...                        | ...                 | ...                 | ...                 | ...                 | 0.06                | 0.18–0.25                    | ...                |
| Specified Residual Elements              |                   |                            |                            |                     |                     |                     |                     |                     |                              |                    |
| Aluminum                                 | ...               | ...                        | ...                        | ...                 | ...                 | 0.01                | ...                 | ...                 | 0.02                         | ...                |
| Copper                                   | 0.50              | 0.50                       | 0.50                       | 0.50                | 0.50                | 0.35                | 0.50                | 0.50                | ...                          | ...                |
| Nickel                                   | 0.50              | ...                        | ...                        | 0.50                | 0.50                | 0.50                | 0.50                | 0.50                | ...                          | ...                |
| Chromium                                 | 0.35              | ...                        | ...                        | ...                 | ...                 | ...                 | ...                 | ...                 | ...                          | ...                |
| Titanium                                 | ...               | ...                        | ...                        | ...                 | ...                 | ...                 | ...                 | ...                 | 0.01                         | ...                |
| Tungsten                                 | 0.10              | 0.10                       | 0.10                       | 0.10                | 0.10                | ...                 | 0.10                | 0.10                | ...                          | ...                |
| Vanadium                                 | ...               | ...                        | ...                        | ...                 | ...                 | 0.03                | ...                 | ...                 | ...                          | ...                |
| Zirconium                                | ...               | ...                        | ...                        | ...                 | ...                 | ...                 | ...                 | ...                 | 0.01                         | ...                |
| Total content of these residual elements | 1.00              | 0.60                       | 0.60                       | 1.00                | 1.00                | 1.00                | 1.00                | 1.00                | ...                          | ...                |

<sup>A</sup> Where ellipses (–) appear in this table, there is no requirement, and the element need not be analyzed for or reported.<sup>B</sup> For lower maximum phosphorus or sulfur contents, see Supplementary Requirement S52.TABLE 2 Tensile Requirements<sup>A</sup>

| Grade              | Tensile Strength, ksi [MPa] | Yield Strength, min, ksi [MPa] | Elongation in 2 in. [50 mm] min, % <sup>C</sup> | Reduction of Area, min, % |
|--------------------|-----------------------------|--------------------------------|-------------------------------------------------|---------------------------|
| WC1                | 65 [450] to 90 [620]        | 35 [240]                       | 24                                              | 35                        |
| WC4, WC5, WC6, WC9 | 70 [485] to 95 [655]        | 40 [275]                       | 20                                              | 35                        |
| WC11               | 80 [550] to 105 [725]       | 50 [345]                       | 18                                              | 45                        |
| C5, C12            | 90 [620] to 115 [795]       | 60 [415]                       | 18                                              | 35                        |
| C12A               | 85 [585] to 110 [760]       | 60 [415]                       | 18                                              | 45                        |
| CA15               | 90 [620] to 115 [795]       | 65 [450]                       | 18                                              | 30                        |

<sup>A</sup> Where ellipses (–) appear in this table, there is no requirement.<sup>B</sup> Determine by either 0.2 % offset method or 0.5 % extension-under-load method.<sup>C</sup> When ICI test bars are used in tensile testing as provided for in Specification A703/A703M, the gage length to reduced section diameter ratio shall be 4 to 1.

castings, shall not exceed 1.0%. Weld repaired Grade C12A castings shall be post-weld heat treated at 1350–1470°F [730–800°C].

9.3 Weld repairs shall be inspected to the same quality standards that are used to inspect the castings. When castings are produced with Supplementary Requirement S4 specified, weld repairs shall be inspected by magnetic particle examina-

TABLE 3 Minimum Preheat Temperatures

| Grade | Thickness, in. [mm]              | Minimum Preheat Temperature, °F [°C] |
|-------|----------------------------------|--------------------------------------|
| WC1   | 5/8 and under<br>Over 5/8 [15.9] | 50 [10]<br>250 [120]                 |
| WC4   | All                              | 300 [150]                            |
| WC5   | All                              | 300 [150]                            |
| WC6   | All                              | 300 [150]                            |
| WC9   | All                              | 400 [200]                            |
| WC11  | All                              | 300 [150]                            |
| C5    | All                              | 400 [200]                            |
| C12   | All                              | 400 [200]                            |
| C12A  | All                              | 400 [200]                            |
| CA15  | All                              | 400 [200]                            |

tion to the same standards that are used to inspect the castings. When castings are produced with Supplementary Requirement S5 specified, weld repairs on castings that have leaked on hydrostatic test, or on castings in which the depth of any cavity prepared for repair welding exceeds 20 % of the wall thickness or 1 in. [25 mm], whichever is smaller, or on castings in which any cavity prepared for welding is greater than approximately 10 in.<sup>2</sup> [65 cm<sup>2</sup>], shall be radiographed to the same standards that are used to inspect the castings.

9.4 Weld repairs shall be considered major in the case of a casting that has leaked on hydrostatic test, or when the depth of the cavity prepared for welding exceeds 20 % of the wall

thickness or 1 in. [25 mm], whichever is smaller, or when the extent of the cavity exceeds approximately 10 in.<sup>2</sup> [65 cm<sup>2</sup>]. All castings with major repair welds shall be thermally stress relieved or completely reheat-treated. This mandatory stress relief or reheat-treatment shall be in accordance with the qualified procedure used. Major repairs shall be inspected to the same quality standards that are used to inspect the castings.

## 10. Keywords

10.1 alloy steel; high temperature; martensitic stainless steel; pressure containing; steel castings

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall not apply unless specified in the purchase order. Lists of standardized supplementary requirements for use at the option of the purchaser are included in Specifications **A703/A703M** and **A985/A985M**. Those which are ordinarily considered suitable for use with this specification are given below. Others enumerated in Specifications **A703/A703M** and **A985/A985M** may be used with this specification upon agreement between the manufacturer and purchaser.

### S1. Unspecified Elements

### S2. Destruction Tests

### S3. Bend Tests

### S4. Magnetic Particle Inspection

### S5. Radiographic Inspection

### S7. Ultrasonic Inspection

### S10. Examination of Weld Preparation

### S13. Hardness Test

### S21. Heat Treatment Furnace Record

### S22. Heat Treatment

### S51. Mandatory Postweld Heat Treatment

S51.1 All castings with repair welds shall receive a mandatory thermal stress relief or complete reheat treatment in accordance with the qualified procedure after all weld repairs.

### S52. Lower Maximum Phosphorus or Sulfur Contents

S52.1 When specified in the order, the maximum phosphorus or sulfur contents shall be as follows:

S52.2 For WC6, the maximum phosphorus content shall not exceed 0.030% and the maximum sulfur content shall not exceed 0.025%.

S52.3 For WC9, the maximum sulfur content shall not exceed 0.030%.

S52.4 For C5, the maximum phosphorous content shall not exceed 0.035% and the maximum sulfur content shall not exceed 0.030%.

S52.5 For C12, the maximum phosphorus content shall not exceed 0.035% and the maximum sulfur content shall not exceed 0.025%.

S52.6 For CA15, the maximum phosphorus content shall not exceed 0.025% and the maximum sulfur content shall not exceed 0.020%.

### S53. Temper Embrittlement Factor

S53.1 When specified by the purchaser, the composition of Grade WC9, based on heat analysis, shall be restricted in accordance with the following equations:

$$J = (Si + Mn) \times (P + Sn) \times 10^4 \leq 180 (Si, Mn, P, \text{ and } Sn \text{ in wt\%})$$

$$Cu \leq 0.20\%$$

$$Ni \leq 0.30\%$$

S53.1.1 Lower values of J, Cu, and Ni can be specified by agreement between the purchaser and the supplier.

S53.1.2 The values of J shall be reported.

S53.1.3 If WC9 castings are repaired by welding, the composition of the weld deposit shall be restricted in accordance with the following equations:

$$X = (10P + 5Sb + 4Sn + As)/100 \leq 15 (P, Sb, Sn, \text{ and } As \text{ in ppm})$$

$$Cu \leq 0.20\%$$

$$Ni \leq 0.30\%$$



## SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A217/A217M – 12) that may impact the use of this standard. (Approved May 1, 2014.)

- |                                                                                                                                                                   |                                                                                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| (1) Table 1 has been revised to provide for a Supplementary Requirement for reduced maximum Phosphorus and Sulfur contents of Grades WC6, WC9, C5, C12, and CA15. | (2) Added Supplementary Requirement S52.<br>(3) Added Supplementary Requirement S53. |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|

Committee A01 has identified the location of selected changes to this standard since the last issue (A217/A217M – 11) that may impact the use of this standard. (Approved Nov. 1, 2012.)

- |                                                                                                                                   |                                           |
|-----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|
| (1) <b>Table 1</b> has been revised to reduce the maximum Phosphorus and Sulfur contents of Grades WC6, WC9, C12, C12A, and CA15. | (2) S10 has been revised to delete S10.1. |
|-----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|

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