



# 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

*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 nonconformance with the standard.

1.4 *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>

- 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

### 2.2 AWS Specifications:<sup>4</sup>

- A5.5/A5.5M** Low-Alloy Steel Electrodes for Shielded Metal 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 LeJeune Rd., Miami, FL 33126, <http://www.aws.org>.

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

**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

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

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 to 1975 °F [1040 to 1080 °C] and tempered at 1350 to 1470 °F [730 to 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)**.

### 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:

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

Element, %	Grade									
	WC1 J12524 C-Mo	WC4 J12082 Ni-Cr-Mo	WC5 J22000 Ni-Cr-Mo	WC6 J12072 Cr-Mo	WC9 J21890 Cr-Mo	WC11 J11872 Cr-Mo	C5 J42045 Cr-Mo	C12 J82090 Cr-Mo	C12A J84090 Cr-Mo-V	CA15 J91150 Cr
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>C</sup>	0.035	0.020	0.04 <sup>C</sup>	0.035 <sup>C</sup>	0.025	0.040 <sup>C</sup>
Sulfur	0.045	0.045	0.045	0.035 <sup>C</sup>	0.035 <sup>C</sup>	0.015	0.045 <sup>C</sup>	0.035 <sup>C</sup>	0.010	0.025 <sup>C</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
Niobium <sup>D</sup>	...	...	...	...	...	...	...	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 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> All values are maximums unless a range is provided.

<sup>C</sup> For lower maximum phosphorus or sulfur contents, see Supplementary Requirement S52.

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

NOTE 4—The role of alloying elements in the development of Grade C12A 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. The two elements are more effective in combination. 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>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 temperatures 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

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

**TABLE 2 Tensile Requirements<sup>A</sup>**

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

<sup>A</sup> All values are minimums unless a range is provided.

<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.

**TABLE 3 Minimum Preheat Temperatures**

Grade	Thickness, in. [mm]	Minimum Preheat Temperature, °F [°C]
WC1	½ and under	50 [10]
	Over ½ [15.9]	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]

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 castings shall not exceed 1.0 %. Weld-repaired Grade C12A castings shall be post-weld heat treated at 1350 to 1470 °F [730 to 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 examination 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