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Standard Specification for Steel Castings, General Requirements, for Pressure-Containing Parts¹

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

1. Scope*

1.1 This specification² covers a group of common requirements that, unless otherwise specified in an individual specification, shall apply to steel castings for pressure-containing parts under each of the following ASTM specifications:

| Title of Specification | ASTM Designation |
|---|--------------------|
| Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service | A216/A216M |
| Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service | A217/A217M |
| Castings, Austenitic, Austenitic-Ferritic (Duplex), Pressure-Containing Parts | A351/A351M |
| Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service | A352/A352M |
| Steel Castings, Alloy, Specially Heat-Treated, for Pressure-Containing Parts, Suitable for High-Temperature Service | A389/A389M |
| Steel Castings Suitable for Pressure Service | A487/A487M A990 |
| Castings, Iron-Nickel-Chromium and Nickel Alloys, Specially Controlled for Pressure Retaining Parts for Corrosive Service | A995/A995M |
| Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts | |

1.2 This specification also covers a group of supplementary requirements which may be applied to the above specifications as indicated therein. These are provided for use when additional testing or inspection is desired and apply only when specified individually by the purchaser in the order.

1.3 In case of conflict between the requirements of the individual specification and this general specification, the former shall prevail.

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 non-conformance with the standard.

2. Referenced Documents

2.1 ASTM Standards:³

- A216/A216M Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
- A217/A217M Specification for Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service
- A351/A351M Specification for Castings, Austenitic, for Pressure-Containing Parts

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-703/SA-703M 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.

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

- A352/A352M Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service
- A370 Test Methods and Definitions for Mechanical Testing of Steel Products
- A380 Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
- A389/A389M Specification for Steel Castings, Alloy, Specially Heat-Treated, for Pressure-Containing Parts, Suitable for High-Temperature Service
- A487/A487M Specification for Steel Castings Suitable for Pressure Service
- A488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel
- A609/A609M Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof
- A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
- A800/A800M Practice for Steel Casting, Austenitic Alloy, Estimating Ferrite Content Thereof
- A802/A802M Practice for Steel Castings, Surface Acceptance Standards, Visual Examination
- A903/A903M Specification for Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection
- A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys
- A967 Specification for Chemical Passivation Treatments for Stainless Steel Parts
- A990 Specification for Castings, Iron-Nickel-Chromium and Nickel Alloys, Specially Controlled for Pressure Retaining Parts for Corrosive Service
- A991/A991M Test Method for Conducting Temperature Uniformity Surveys of Furnaces Used to Heat Treat Steel Products
- A995/A995M Specification for Castings, Austenitic-Ferritic (Duplex) Stainless Steel, for Pressure-Containing Parts
- A1058 Test Methods for Mechanical Testing of Steel Products—Metric
- A1067/A1067M Specification for Test Coupons for Steel Castings
- A1080 Practice for Hot Isostatic Pressing of Steel, Stainless Steel, and Related Alloy Castings
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E94 Guide for Radiographic Examination
- E125 Reference Photographs for Magnetic Particle Indications on Ferrous Castings
- E165 Practice for Liquid Penetrant Examination for General Industry
- E186 Reference Radiographs for Heavy-Walled (2 to 4½-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 (4½ to 12-in. (114 to 305-mm)) Steel Castings
- E340 Test Method for Macroetching Metals and Alloys
- E353 Test Methods for Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
- E354 Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys
- 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*.⁴
- B16.5 Pipe Flanges and Flanged Fittings
- 2.3 *Standards of the Manufacturer's Standardization Society of the Valve and Fitting Industry*.⁵
- MSS SP 53 Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings and Other Piping Components (Magnetic Particle Exam Method)
- MSS SP 54 Quality Standard for Steel Castings for Valves, Flanges, and Fittings and Other Piping Components (Radiographic Examination Method)

3. Terminology

3.1 Definitions:

3.1.1 The definitions in Test Methods and Definitions A370 and Terminology A941 and Test Methods for Mechanical Testing of Steel Products – Metric A1058 are applicable to this specification and those listed in 1.1.

3.1.2 *chaplet, n*—a chaplet is a metallic support placed in a mold cavity to maintain the spacing between a core and the mold.

3.1.3 *electronic data interchange (EDI), n*—the computer-to-computer exchange of business information in a standard format such as ANSI ASC X12.

3.1.4 *heat, n*—all the molten metal poured from a single furnace or all the molten metal from two or more furnaces poured into a single ladle or casting prior to the replenishing of the furnace(s).

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 Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park St., NE, Vienna, VA 22180-4602, <http://www.mss-hq.org>.

3.1.5 *internal chill, n*—an internal chill is a metallic device placed in a mold cavity to increase the rate of heat removal at that location.

3.1.6 *test coupon, n*—the part from which the test specimen will be extracted.

3.1.7 *test specimen, n*—the part that will be acted upon in a mechanical test.

4. Materials and Manufacture

4.1 *Melting Process*—The steel shall be made by open-hearth or electric-furnace process, with or without separate refining such as argon-oxygen-decarburization (AOD), unless otherwise designated by the individual specification.

4.2 *Heat Treatment:*

4.2.1 Ferritic and martensitic steel shall be cooled after pouring to provide substantially complete transformation of austenite prior to heat treatment to enhance mechanical properties.

4.2.2 Castings shall be heat treated in the working zone of a furnace that has been surveyed in accordance with Test Method [A991/A991M](#).

4.2.2.1 When castings are heat treated at temperatures above 2000°F [1100°C], then the working zone shall have been established by a survey performed at not more than 25°F [15°C] below nor more than 200°F [110°C] above the minimum heat treatment temperature specified for the grade. If a minimum heat treatment temperature is not specified for the grade, then the survey temperature shall be not more than 50°F [30°C] below nor more than 175°F [100°C] above the furnace set point used.

4.2.2.2 The maximum variation in measured temperature as determined by the difference between the highest temperature and the lowest temperature shall be as agreed between the purchaser and producer except that during production heat treatment, no portion of the furnace shall be below the minimum specified temperature nor above the maximum specified temperature for the grade being processed.

5. Chemical Composition

5.1 *Chemical Analysis*—Chemical analysis of materials covered by this specification shall be in accordance with Test Methods [A751](#).

5.2 *Heat Analysis*—An analysis of each heat shall be made by the manufacturer to determine the percentages of the elements specified. The analysis shall be made from a test sample preferably taken during the pouring of the heat. When drillings are used, they shall be taken not less than ¼ in. [6.4 mm] beneath the surface. The chemical composition thus determined shall be reported to the purchaser, or his representative, and shall conform to the requirements in the individual specification for the grade being poured.

5.3 *Product Analysis*—A product analysis may be made by the purchaser from material representing each heat, lot, or casting. The analysis shall be made on representative material. Due to the possibility of decarburization, samples for carbon analysis shall be taken no closer than ¼ in. [6.4 mm] to a cast surface except that castings too thin for this shall be analyzed on representative material. The chemical composition thus determined shall meet the requirements specified in the applicable specification for the grade involved, or shall be subject to rejection by the purchaser, except that the chemical composition determined for carbon and low-alloy steel and stainless steel castings may vary from the specified limits by the amounts shown in [Table 1](#) and [Table 2](#) respectively. The product analysis tolerances of [Table 1](#) and [Table 2](#) are not applicable as acceptance criteria for heat analysis by the casting manufacturer. When comparing product and heat analysis for other than carbon and low alloy steels and stainless steels, the reproducibility Data R_2 , in Test Methods [E353](#) or [E354](#), as applicable, shall be taken into consideration.

5.4 *Unspecified Elements*—When chemical analysis for elements not specified for the grade ordered is desired, Supplementary Requirement S1 may be specified.

5.5 *Grade substitution*—Grade substitution is not permitted. Grade substitution occurs when the material being supplied contains one or more elements that are not specified for the supplied material such that the material conforms to the requirements of a different grade.

5.6 Where more than one ladle is poured into a single casting, the molten metal in each ladle must conform to the specified chemical requirements.

6. Mechanical Test Methods

6.1 All mechanical tests shall be conducted in accordance with Test Methods and Definitions [A370](#). When material is ordered to an M-suffix (SI units) standard, then in accordance with Test Methods [A1058](#).

6.2 Choice of testing track from the options listed in Test Methods [A1058](#) when material is ordered to an M suffix (SI units) product standard, should be identified by the purchaser in the ordering information. If the choice of test track is not specified in the order, then the default ASTM track shall be used as noted in Test Methods [A1058](#).



TABLE 1 Product Analysis Tolerances – Carbon and Low-Alloy Steels

| Element | Range ^A | Tolerances ^{B,C} over max or under min, Limit, % |
|-----------------|-----------------------|---|
| Carbon (C) | up to 0.65 % | $0.03 \times \% C_L + 0.02$ |
| | above 0.65 % | 0.04 % |
| Manganese (Mn) | up to 1 % | $0.08 \times \% Mn_L + 0.01$ |
| | above 1 % | 0.09 |
| Silicon (Si) | up to 0.60 % | $0.22 \times \% Si_L - 0.01$ |
| | above 0.60 % | 0.15 % |
| Phosphorus (P) | all | $0.13 \times \% P_L + 0.005$ |
| Sulfur (S) | all | $0.36 \times \% S_L + 0.001$ |
| Nickel (Ni) | up to 2 % | $0.10 \times \% Ni_L + 0.03$ |
| | above 2 % | 0.25 % |
| Chromium (Cr) | up to 2 % | $0.07 \times \% Cr_L + 0.04$ |
| | above 2 % | 0.18 % |
| Molybdenum (Mo) | up to 0.6 % | $0.04 \times \% Mo_L + 0.03$ |
| | above 0.6 % | 0.06 % |
| Vanadium (V) | up to 0.25 % | $0.23 \times \% V_L + 0.004$ |
| | above 0.25 % | 0.06 % |
| Tungsten (W) | up to 0.10 % | $0.08 \times \% W_L + 0.02$ |
| | above 0.10 % | 0.02 % |
| Copper (Cu) | up to 0.15 % | $0.18 \times \% Cu_L + 0.02$ |
| | above 0.15 % | 0.05 % |
| Aluminum (Al) | up to 0.03 % | 0.01 % |
| | 0.03 to 0.10 %, incl. | $0.08 \times \% Al + 0.02$ |
| | above 0.10 % | 0.03 % |

^A The range denotes the composition limits up to which the tolerances are computed by the equation, and above which the tolerances are given by a constant.

^B The subscript _L for the elements in each equation indicates that the limits of the element specified by the applicable specification are to be inserted into the equation to calculate the tolerance for the upper limit and the lower limit, if applicable, respectively. Examples of computing tolerances are presented in the footnote C.

^C To compute the tolerances, consider the manganese limits 0.50 – 80 % of Grade WC4 of Specification A217/A217M. In accordance with Table 1, the maximum permissible deviation of a product analysis below the lower limit 0.50 is $0.05 \% = (0.08 \times 0.50 + 0.01)$. The lowest acceptable product analysis of Grade WC4, therefore, is 0.45 %. Similarly, the maximum permissible deviation above the upper limit of 0.80 % is $0.074 \% = (0.08 \times 0.80 + 0.01)$. The highest acceptable product analysis of Grade WC4, therefore, is 0.874. For Grade WCC of Specification A216/A216M, the maximum manganese content is 1.40 % if the carbon content is 0.20 %. In this case, the highest acceptable product analysis is $1.49 \% = (1.40 + 0.09)$.

<https://standards.iteh.ai/catalog/standards/sist/875b28e9-2e50-412b-b0a2-dda11187aef0/astm-a703-a703m-15>

7. Tensile Requirements

7.1 One tension test shall be made from each heat, and shall conform to the tensile requirements specified. Test coupons shall be cast from the same heat as the castings represented, except that for investment castings, the test coupons shall be cast in the same type of mold as the castings.⁶

7.2 The coupon from which the test specimen is taken shall be heat treated in production furnaces to the same procedure as the castings it represents.

7.3 Test specimens may be cut from heat-treated castings, at the producer's option, instead of from test coupons.

7.4 *Investment Castings*—For investment castings, the coupons may be cast to shape or machined from coupons to dimensions in accordance with Test Methods and Definitions A370 or the ICI coupon shown in A1067/A1067M, Fig. 1.

7.5 *Other Castings*—Unless otherwise specified by the purchaser, test coupons may be cast integrally with the castings or as separately in accordance with A1067/A1067M, Fig. 1 and Table 1, with Fig. 2, or with Fig. 4, except when Supplementary Requirement S26 is specified. The test coupon in A1067/A1067M, Fig. 4 shall be employed only for austenitic alloy castings with cross sections less than 2½ in. [63.5 mm]. Tension test specimens shall be prepared in accordance with Test Methods and Definitions A370 or Test Methods A1058 as applicable.

7.6 If any specimen shows defective machining or develops flaws, it may be discarded and another substituted from the same heat.

⁶ Information on the relationship of mechanical properties determined on test coupons obtained as specified in 7.1 and 7.4 with those obtained from the casting may be found in *The Steel Castings Handbook*, Fifth Edition, Steel Founders' Society of America, 1980, pp. 15-35 through 15-43.



TABLE 2 Product Analysis Tolerances – Stainless Steels

| Elements | Limit or Maximum of Specified Range, % | Tolerance Over the Maximum Limit or Under the Maximum Limit | Elements | Limit or Maximum of Specified Range, % | Tolerance Over the Maximum Limit or Under the Minimum Limit |
|------------|--|---|-------------------------|--|---|
| Carbon | to 0.010, incl | 0.002 | Titanium | to 1.00, incl | 0.05 |
| | over 0.010 to 0.030, incl | 0.005 | | over 1.00 to 3.00, incl | 0.07 |
| | over 0.030 to 0.20, incl | 0.01 | Cobalt | over 0.05 to 0.50, incl | 0.01 ^A |
| | over 0.20 to 0.60, incl | 0.02 | | over 0.50 to 2.00, incl | 0.02 |
| | over 0.60 to 1.20, incl | 0.03 | | over 2.00 to 5.00, incl | 0.05 |
| Manganese | to 1.00, incl | 0.03 | Columbium plus tantalum | to 1.50, incl | 0.05 |
| | over 1.00 to 3.00, incl | 0.04 | | | |
| | over 3.00 to 6.00, incl | 0.05 | | | |
| | over 6.00 to 10.00, incl | 0.06 | | | |
| | over 10.00 to 15.00, incl | 0.10 | | | |
| | over 15.00 to 20.00, incl | 0.15 | Tantalum | to 0.10, incl | 0.02 |
| Phosphorus | to 0.040, incl | 0.005 | Copper | to 0.50, incl | 0.03 |
| | over 0.040 to 0.20, incl | 0.010 | | over 0.50 to 1.00, incl | 0.05 |
| | | | | over 1.00 to 3.00, incl | 0.10 |
| Sulfur | to 0.040, incl | 0.005 | Aluminum | to 0.15, incl | -0.005, +0.01 |
| | over 0.040 to 0.20, incl | 0.010 | | over 0.15 to 0.50, incl | 0.05 |
| | over 0.20 to 0.50, incl | 0.020 | | over 0.50 to 2.00, incl | 0.10 |
| Silicon | to 1.00, incl | 0.05 | Nitrogen | to 0.02, incl | 0.005 |
| | over 1.00 to 3.00, incl | 0.10 | | over 0.02 to 0.19, incl | 0.01 |
| | over 3.00 to 6.00, incl | 0.15 | | over 0.19 to 0.25, incl | 0.02 |
| Chromium | over 4.00 to 10.00, incl | 0.10 | | over 0.25 to 0.35, incl | 0.03 |
| | over 10.00 to 15.00, incl | 0.15 | | over 0.35 to 0.45, incl | 0.04 |
| | over 15.00 to 20.00, incl | 0.20 | Tungsten | over 0.45 to 0.55, incl | 0.05 |
| | over 20.00 to 30.00, incl | 0.25 | | to 1.00, incl | 0.03 |
| Nickel | to 1.00, incl | 0.03 | | over 1.00 to 2.00, incl | 0.05 |
| | over 1.00 to 5.00, incl | 0.07 | Vanadium | to 0.50, incl | 0.03 |
| | over 5.00 to 10.00, incl | 0.10 | | over 0.50 to 1.50, incl | 0.05 |
| | over 10.00 to 20.00, incl | 0.15 | | all | 0.03 |
| | over 20.00 to 30.00, incl | 0.20 | Selenium | | |
| Molybdenum | over 0.20 to 0.60, incl | 0.03 | | | |
| | over 0.60 to 2.00, incl | 0.05 | | | |
| | over 2.00 to 8.00, incl | 0.10 | | | |

^A Product analysis limits for cobalt under 0.05 % have not been established, and the manufacturer should be consulted for those limits.

7.7 To determine conformance with the tension test requirements, an observed value or calculated value shall be rounded off in accordance with Practice E29 to the nearest 500 psi [5 MPa] for yield and tensile strength and to the nearest 1 % for elongation and reduction of area.

8. Repair by Welding

8.1 Repair by welding shall be in accordance with the requirements of individual specification using procedures and welders qualified in accordance with Practice A488/A488M.

9. Flanges

9.1 When a flange from a flanged casting is removed to make a weld end casting, discontinuities may be observed that would not have been detrimental in a flanged casting. The disposition of the casting shall be subject to agreement between the purchaser and manufacturer.

10. Quality

10.1 The surface of the casting shall be free of adhering sand, scale, cracks, and hot tears as determined by visual examination. 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.

10.2 The castings shall not be peened, plugged, or impregnated to stop leaks or disguise rejectable indications.

10.3 Internal chills and chaplets may be used in the manufacture of castings. However, the chills, chaplets, and affected cast material must be completely removed.

11. Hydrostatic Tests

11.1 Each casting shall be tested after machining to the hydrostatic shell test pressures prescribed in ANSI B16.5 for the applicable steel rating for which the casting is designed. Casting shall show no leaks. Castings ordered for working pressures other than those in the standard ANSI ratings, or those listed for which test pressures are not specified by ANSI B16.5, shall be tested at a pressure agreed upon between manufacturer and the purchaser.

11.2 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 or machining has been performed on the casting. Castings ordered in the rough state for final machining by the purchaser may be tested hydrostatically prior to shipment by the manufacturer at pressures to be agreed upon with the purchaser. However, the foundry is responsible for the satisfactory performance of the castings under the final test required in 11.1.

12. Workmanship, Finish, and Appearance

12.1 All castings shall be made in a workmanlike manner and shall conform to the dimensions on drawings furnished by the purchaser. When the pattern is supplied by the purchaser, the dimensions of the casting shall be as predicated by the pattern unless otherwise agreed upon.

12.2 Machined welding ends shall be suitably protected against damage during shipping.

13. Retests

13.1 If the results of the mechanical tests for any heat, lot, or casting do not conform to the requirements specified, retests are permitted as outlined in Test Methods and Definitions A370 or Test Methods A1058 as applicable. At the manufacturer's option, castings may be reheat-treated and retested. When castings are reheat-treated, they may not be re-austenitized more than three times without the approval of the purchaser. Testing after reheat treatment shall consist of the full number of specimens taken from locations complying with the specification or order.

14. Inspection

14.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities necessary to satisfy that the material is being produced and furnished in accordance with the applicable specification. Foundry inspection by the purchaser shall not interfere unnecessarily with the manufacturer's operations. All tests and inspections, with the exception of product analysis (5.2), shall be made at the place of manufacture unless otherwise agreed.

15. Rejection and Rehearing

15.1 Any rejection based on test reports shall be reported to the manufacturer within 30 days from the receipt of the test reports by the purchaser.

15.2 Material that shows unacceptable discontinuities as determined by the acceptance standards specified in the order subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified within 30 days after discovery of the rejectable condition.

15.3 Samples that represent rejected material shall be preserved for two weeks from the date of transmission of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

16. Certification

16.1 The manufacturer's certification shall be furnished to the purchaser stating that the material was manufactured, sampled, tested, and inspected in accordance with the material specification (including year of issue) and was found to meet the requirements. When the purchaser imposes the requirements of this specification, the manufacturer is responsible for compliance with the specification requirements during the production and processing of the casting by themselves and any of their subcontractors.

16.2 As applicable, the certification shall also include:

16.2.1 Material specification and grade,

16.2.2 Pattern number,

16.2.3 Heat number or serial number traceable to a heat number,

16.2.4 Chemical analysis of the heat,

16.2.5 Mechanical property results required by the specification and supplementary requirements specified in the purchase order,

16.2.6 Statement of satisfactory inspection, visual, and nondestructive testing specified in the purchase order,