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## Standard Specification for Investment Castings, Steel and Alloy, Common Requirements, for General Industrial Use<sup>1</sup>

This standard is issued under the fixed designation A957/A957M; 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 covers a group of requirements that are mandatory for castings produced by the investment casting process to meet the metallurgical requirements of the following steel casting specifications issued by ASTM.

ASTM Designation	Title of Specification
A27/A27M	Steel Castings, Carbon, for General Application
A148/A148M	Steel Castings, High-Strength, for Structural Purposes
A297/A297M	Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat-Resistant, for General Application
A447/A447M	Steel Castings, Chromium-Nickel-Iron Alloy (25-12 Class), for High-Temperature Service
A494/A494M	Castings, Nickel and Nickel Alloy
A560/A560M	Castings, Chromium-Nickel Alloy
A732/A732M	Castings, Investment, Carbon and Low Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures
A743/A743M	Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion-Resistant, for General Application
A744/A744M	Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service
A747/A747M	Steel Castings, Stainless, Precipitation Hardening
A890/A890M	Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
A915/A915M	Steel Castings, Carbon and Alloy, Chemical Requirements Similar to Standard Wrought Grades
A958	Steel Castings, Carbon and Alloy, with Tensile Requirements, Chemical Requirements Similar to Standard Wrought Grades

1.2 This specification also covers a group of supplementary requirements that 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 When investment castings are ordered, the requirements stated in this specification form an integral part of the material specification. In cases of conflict, the requirements of this specification shall take precedence over the individual material specification requirements.

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.

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

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- A27/A27M [Specification for Steel Castings, Carbon, for General Application](#)
- A148/A148M [Specification for Steel Castings, High Strength, for Structural Purposes](#)
- A297/A297M [Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application](#)
- 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](#)
- A447/A447M [Specification for Steel Castings, Chromium-Nickel-Iron Alloy \(25-12 Class\), for High-Temperature Service](#)
- A488/A488M [Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel](#)
- A494/A494M [Specification for Castings, Nickel and Nickel Alloy](#)
- A560/A560M [Specification for Castings, Chromium-Nickel Alloy](#)
- A609/A609M [Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof](#)
- A732/A732M [Specification for Castings, Investment, Carbon and Low Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures](#)
- A743/A743M [Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application](#)
- A744/A744M [Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service](#)
- A747/A747M [Specification for Steel Castings, Stainless, Precipitation Hardening](#)
- A751 [Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products](#)
- A800/A800M [Practice for Steel Casting, Austenitic Alloy, Estimating Ferrite Content Thereof](#)
- A890/A890M [Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex \(Austenitic/Ferritic\) for General Application](#)
- A903/A903M [Specification for Steel Castings, Surface Acceptance Standards, Magnetic Particle and Liquid Penetrant Inspection](#)
- A915/A915M [Specification for Steel Castings, Carbon, and Alloy, Chemical Requirements Similar to Standard Wrought Grades](#)
- A941 [Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferrous Alloys](#)
- A958 [Specification for Steel Castings, Carbon and Alloy, with Tensile Requirements, Chemical Requirements Similar to Standard Wrought Grades](#)
- A967 [Specification for Chemical Passivation Treatments for Stainless Steel Parts](#)
- A991/A991M [Test Method for Conducting Temperature Uniformity Surveys of Furnaces Used to Heat Treat Steel Products](#)
- A997 [Practice for Investment Castings, Surface Acceptance Standards, Visual Examination](#)
- A1067 [Specification for Test Coupons for Steel 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 412-in. \(50.8 to 114-mm\)\) Steel Castings](#)
- E192 [Reference Radiographs of Investment Steel Castings for Aerospace Applications](#)
- E280 [Reference Radiographs for Heavy-Walled \(412 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](#)

<sup>2</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.

Guide for Magnetic Particle Testing

E2660 [Digital Reference Images for Investment Steel Castings for Aerospace Applications](#)

2.2 *SAE Aerospace Recommended Practice*:<sup>3</sup>

ARP 1341 Determining Decarburization and Carburization in Finished Parts of Carbon and Low-Alloy Steel

### 3. Terminology

#### 3.1 Definitions:

3.1.1 The definitions in Test Methods and Definitions A370, Test Methods, Practices, and Terminology A751, and Terminology A941 are applicable to this specification and to those listed in 1.1.

#### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *investment casting, n*—a metal casting that is produced in a mold obtained by investing (surrounding) an expendable pattern with a ceramic slurry that is allowed to solidify. The expendable pattern may consist of wax, plastic, or other material and is removed prior to filling the mold with liquid metal.

3.2.2 *master heat, n*—a quantity of metal processed in a single furnace or refining vessel at one time in such a manner as to produce the desired composition and properties.

3.2.3 *sub-heat, n*—a portion of a master heat remelted without additional processing for pouring into castings. Synonyms: melt, production heat.

### 4. Materials and Manufacture

4.1 *Melting Process*—Master heats shall be made by the electric furnace process with or without separate refining such as argon-oxygen-decarburization (AOD), vacuum-oxygen-degassing (VOD), vacuum-induction-melting (VIM), and so forth, unless otherwise specified in the individual specification or agreed upon between the customer and producer. Master heats may be used directly for producing castings or converted into ingot, bar, shot, or other suitable form, not including gates and risers from casting production, for later remelting as a sub-heat.

4.2 *Re-Melting Process*—Sub-heats shall be produced from master heat metal in suitable batch sizes by electric induction furnace with or without atmosphere protection such as vacuum or inert gas unless otherwise specified in the individual specification or agreed upon between the customer and producer. Revert (gates, sprues, risers, and rejected castings) shall not be re-melted except in master heats.

#### 4.3 Sampling:

4.3.1 If castings are poured directly from one or more master heats, then the samples for chemical and other required testing shall also be poured directly from each of the master heats.

4.3.2 If castings are poured from a sub-heat, then the samples for chemical and other required testing shall also be poured from a sub-heat of that same master heat, but not necessarily from the same sub-heat as the castings. The sub-heat used for the test samples shall be produced using the same practices and additions as used for the castings.

4.3.3 Unless otherwise specified by the purchaser, test specimens may be taken from castings or from coupons cast integrally with the castings, in the same molds as the castings, or in separate molds.

#### 4.4 Heat Treatment:

4.4.1 Castings shall be heat treated in the working zone of a furnace that has been surveyed in accordance with Test Method A991/A991M.

4.4.2 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.

4.4.3 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, Practices, and Terminology A751.

5.2 *Heat Analysis*—An analysis of samples obtained in accordance with 4.3 or Supplementary Requirement S17 as appropriate, shall be made by the manufacturer to determine the percentages of the elements specified in the individual specification for the grade being poured. When drillings are used, they shall be taken not less than 1/16 in. [1.6 mm] beneath the surface. The chemical composition thus determined 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 master heat, sub-heat, lot, or casting. The analysis shall be made on representative material. Samples for carbon analysis of carbon and alloy steel shall

<sup>3</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

be taken no closer than 1/16 in. [1.6 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 castings may vary from the specified limits by the amounts shown in Table 1. The product analysis tolerances of Table 1 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, the reproducibility Data R2, 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 S13 may be specified.

NOTE 1—All commercial metals contain small amounts of various elements in addition to those that are specified. It is neither practical nor necessary to specify limits for every unspecified element that might be present, despite the fact that the presence of many of these elements is often routinely determined by the producer.

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.

## 6. Mechanical Requirements

6.1 The individual product specifications vary as to whether mechanical tests are required; for this reason, and to determine specific test requirements, the individual product specification should be reviewed. If mechanical testing is required by the product specification, sampling shall be in accordance with 4.3 or with Supplementary Requirement S18 as appropriate.

6.2 Unless otherwise specified by the purchaser, when mechanical properties are required by the product specification, test coupons may be taken from castings, may be cast integrally with the castings, or may be cast in separate molds of the same type and material as those used for the castings, in accordance with Specification A1067, Fig. 1, Fig. 2, Fig. 3, or Fig. 4, except when Supplementary Requirement S15 is specified. The test coupon in Specification A1067, Fig. 4 shall be employed only for austenitic

**TABLE 1 Product Analysis Tolerances**

Element	Range, % <sup>A</sup>	Tolerances <sup>B, C</sup> Over Maximum or Under Minimum Limit, %
C	up to 0.65 above 0.65	$0.03 \times \% C_L + 0.02$ 0.04
Mn	up to 1 above 1	$0.08 \times \% Mn_L + 0.01$ 0.09
Si	up to 0.60 above 0.60	$0.22 \times \% Si_L - 0.01$ 0.15
P	all	$0.13 \times \% P_L + 0.005$
S	all	$0.36 \times \% S_L + 0.001$
Ni	up to 2 above 2	$0.10 \times \% Ni_L + 0.03$ 0.25
Cr	up to 2 above 2	$0.07 \times \% Cr_L + 0.04$ 0.18
Mo	up to 0.6 above 0.6	$0.04 \times \% Mo_L + 0.03$ 0.06
V	up to 0.25 above 0.25	$0.23 \times \% V_L + 0.004$ 0.06
W	up to 0.10 above 0.10	$0.08 \times \% W_L + 0.02$ 0.02
Cu	up to 0.15 above 0.15	$0.18 \times \% Cu_L + 0.02$ 0.05
Al	up to 0.10 above 0.10	$0.08 \times \% Al_L + 0.02$ 0.03

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

<sup>B</sup> 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 footnote C.

<sup>C</sup> To illustrate the computation of the tolerance, consider the manganese maximum of 0.70 for an 0.30 carbon grade 65-35 in Specification A27/A27M. The maximum permissible deviation is  $(0.08 \times 0.70 + 0.01) = 0.066$ . Therefore, the highest acceptable product analysis is 0.766. Similarly, for an 0.20 carbon grade 70-40 in Specification A27/A27M, the maximum manganese content is 1.40; thus, the highest acceptable product analysis is  $(1.40 + 0.09) = 1.49$ .