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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.

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:*—The

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:* <http://www.astm.org/catalog/standards/sist/0e5d203f-69d2-47a7-8f2d-d8c09e9b82b1/astm-a957-a957m-11>

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 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

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

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 The substitution of a grade or composition different from that specified by the purchaser is prohibited.~~

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 ~~Fig. 1~~ Specification A1067, Fig. 2-1, Fig. 3-2, Fig. 3, or Fig. 4-4, except when Supplementary Requirement S15 is specified. The test coupon in Specification A1067, Fig. 4 shall be employed only

**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  $(1.40 + 0.09) = 1.49$ .

for austenitic alloy castings with cross sections less than 2½ in. [65 mm].<sup>4</sup>

NOTE 2—Test Coupons for Large and Heavy Steel Castings—The test coupons in A1067, Fig. 1 are to be used for large and heavy steel castings. However, at the option of the foundry the cross-sectional area and length of the standard coupon may be increased as desired.

NOTE 3—Bend Bar—If a bend bar is required, an alternate design (as shown by dotted lines in A1067, Fig. 1) is indicated.

NOTE 4—A1067, Fig 2 —pour through head; cover molten head with powdered charcoal, coke dust, and so forth, immediately after pouring, in order to keep head fluid as long as possible.

NOTE 5—A1067, Fig 4 —Coupons produced in this manner are suitable for austenitic alloys only. The mold may be preheated for pouring to produce a sound coupon.

6.3 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.

6.4 The specimens may be cast to shape or machined from coupons to dimensions in accordance with Test Methods and Definitions A370 or the ICI bar shown in Fig. 1, or the ICI-type bar shown in A1067, Fig. 3.

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

6.6 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.

## 7. Workmanship, Finish, and Appearance

7.1 All castings shall be made in a workmanlike manner and shall conform to the dimensions on drawings furnished by the purchaser before manufacture is started. If the pattern is supplied by the purchaser or is produced using a die supplied by the purchaser, the dimensions of the casting shall be as predicated by the pattern or die.

## 8. Quality

8.1 The surface of the casting shall be free of adhering ceramic, scale, cracks, and hot tears as determined by visual examination. Other surface discontinuities shall meet the visual acceptance standards specified in the order. Practice A997 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.

8.2 When additional inspection is desired, Supplementary Requirements S1, S2, S3, S4, or S5 may be specified.

## 9. Repair

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

## 10. Inspection

10.1 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 (5.3), are the responsibility of the manufacturer.

## 11. Rejection

11.1 Subsequent to acceptance at the manufacturer's works, material that is found to be unacceptable as determined by requirements specified in the order may be rejected by the purchaser. The manufacturer should be notified of such rejection. If the manufacturer is dissatisfied with the results of any tests performed by the purchaser, he may make claim for a rehearing.

## 12. Keywords

12.1 casting; investment casting; master heat; steel; sub-heat

## 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. Magnetic Particle Examination

S1.1 Castings shall be examined for surface and near-surface discontinuities by magnetic particle examination. The examination

<sup>4</sup> Information on the relationship of mechanical properties determined on test coupons obtained as specified in 6.2 with those obtained from the casting may be found in "The *The Steel Casting Handbook*," Fifth Edition, Steel Founders' Society of America, 1980, pp. 15–35 through 15–43.

shall be in accordance with Practice E709. The extent of examination and the basis for acceptance shall be agreed upon between the manufacturer and the purchaser. Specification A903/A903M may be used as a basis for such agreement.

## **S2. Radiographic Examination**

S2.1 Castings shall be examined for internal defects by means of X-rays or gamma rays. The procedure shall be in accordance with Guide E94, and types and degrees of discontinuities considered shall be judged by Reference Radiographs E186, E192, E280, or E446. Extent of examination and basis for examination shall be agreed upon between the manufacturer and purchaser.

## **S3. Liquid Penetrant Examination**

S3.1 Castings shall be examined for surface discontinuities by means of liquid penetrant examination. The examination shall be in accordance with Practice E165. Areas to be inspected, methods and types of liquid penetrants to be used, developing procedure, and basis for acceptance shall be agreed upon between the manufacturer and purchaser. Specification A903/A903M may be used as a basis for such agreement.

## **S4. Ultrasonic Examination**

S4.1 Castings shall be examined for internal defects by means of ultrasonic examination. The examination procedure shall be in accordance with Practice A609/A609M. Extent of examination, methods of testing, and basis for acceptance shall be agreed upon between the manufacturer and purchaser.

## **S5. Examination of Weld Preparation**

S5.1 Magnetic particle or liquid penetrant examination of cavities prepared for welding shall be performed to verify removal of those discontinuities found unacceptable by the examination method specified for the casting. Unless other degrees of shrinkage or types of discontinuities found in the cavities are specified, Type II, Internal Shrinkage, of Reference Photographs E125, of Degree 2 in sections up to 2 in. [50 mm] thick and of Degree 3 in sections over 2 in. [50 mm] thick shall be acceptable.

## **S6. Certification**

S6.1 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 date) and was found to meet the requirements.

## **S7. Prior Approval of Major Weld Repairs**

S7.1 Major weld repairs as defined and agreed upon between the manufacturer and purchaser shall be subject to the prior approval of the purchaser.

## **S8. Marking**

S8.1 The castings shall be marked for identification or traceability, or both. The content of the marking and the method of marking, including size, location, and style, shall be as agreed upon between the purchaser and the producer.

## **S9. Charpy Impact Test**

S9.1 Charpy impact test properties shall be determined from a set of three Charpy V-notch specimens made from a test coupon in accordance with Test Methods and Definitions A370, and tested at a test temperature agreed upon between the manufacturer and the purchaser. The sampling requirements shall be agreed upon between the manufacturer and purchaser (see 4.3). The acceptance requirements shall be energy absorbed, lateral expansion, or percent shear area, or any combination thereof, and shall be that agreed upon between the manufacturer and purchaser. Test specimens shall be prepared and tested in accordance with Test Methods and Definitions A370.

S9.2 *Absorbed Energy*—Average energy value of three specimens shall be not less than specified, with not more than one value permitted to fall below the minimum specified and no value permitted below the minimum specified for a single specimen.

S9.3 *Lateral Expansion*—Lateral expansion value shall be agreed upon between the manufacturer and purchaser.

S9.4 *Percent Shear Area*—Percent shear area shall be agreed upon between the manufacturer and purchaser.

## **S10. Hardness Test**

S10.1 Hardness measurements at specified locations on the castings shall be made in accordance with Test Methods and Definitions A370 and reported.

## **S11. Specified Ferrite Range**

S11.1 The chemical composition of the heat shall be controlled such that the ferrite content, as determined by the chemical composition procedure of Practice A800/A800M shall be in conformance with the specified ferrite content range.

S11.2 The specified ferrite content shall be as agreed upon between the manufacturer and the purchaser. If both minimum and maximum ferrite contents are specified, the minimum specified ferrite content range shall be 10 %. The minimum specified ferrite content shall be no lower than the percent necessary to achieve the minimum mechanical properties required for the alloy.