

Issued 15 JAN 1961

Revised 1 APR 1991

Superseding AMS 4215D

Submitted for recognition as an American National Standard

ALUMINUM ALLOY CASTINGS
5.0Si - 1.2Cu - 0.50Mg (C355.0-T6P)
Solution and Precipitation Heat Treated

UNS A33550

1. SCOPE:

1.1 Form: This specification covers an aluminum alloy in the form of sand, permanent mold, composite mold, and investment castings.

1.2 Application: Primarily for components requiring high strength at room and elevated temperatures.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

2.1.1 Aerospace Material Specifications:

- AMS 2360 - Room Temperature Tensile Properties of Castings
- AMS 2635 - Radiographic Inspection
- AMS 2645 - Fluorescent Penetrant Inspection
- AMS 2646 - Contrast Dye Penetrant Inspection
- AMS 2694 - Repair Welding of Aerospace Castings
- AMS 2804 - Identification, Castings

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2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM B 557 - Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products

ASTM B 557M - Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products (Metric)

ASTM B 660 - Packaging/Packing of Aluminum and Magnesium Products

ASTM E 10 - Brinell Hardness of Metallic Materials

ASTM E 34 - Chemical Analysis of Aluminum and Aluminum Alloys

ASTM E 155 - Reference Radiographs for Inspection of Aluminum and Magnesium Castings

2.3 U.S. Government Publications: Available from Naval Publications and Forms Center, Attn: NPODS, 5801 Tabor Avenue, Philadelphia, PA 19120-5099.

2.3.1 Military Specifications:

MIL-H-6088 - Heat Treatment of Aluminum Alloys

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E 34, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	min	max
Silicon	4.5	5.5
Copper	1.0	1.5
Magnesium	0.40	0.6
Iron	--	0.20
Titanium	--	0.20
Manganese	--	0.10
Zinc	--	0.10
Other Impurities, each	--	0.05
Other Impurities, total	--	0.15
Aluminum	remainder	

3.2 Condition: Solution and precipitation heat treated.

3.3 Casting: Castings shall be produced in lots from metal conforming to 3.1. Metal remelted from previously analyzed ingot may be poured directly into castings. Furnace or ladle additions of grain-refining elements or alloys are permissible. Molten metal taken from alloying furnaces, with or without additions of foundry operating scrap (gates, sprues, risers, and rejected castings), shall not be poured into castings unless first converted to ingot, analyzed, and remelted or unless the composition of a sample taken after the last addition to the melt conforms to 3.1. The type of mold for castings is not restricted.

- 3.3.1 A melt shall be the metal withdrawn from a batch-furnace charge of 2000 pounds (907 kg) or less as melted for pouring castings or, when permitted by purchaser, a melt shall be 4000 pounds (1814 kg) or less of metal withdrawn from one continuous furnace in not more than eight consecutive hours.
- 3.3.2 A lot shall be all castings poured from a single melt in not more than eight consecutive hours and solution and precipitation heat treated in the same heat treatment batch.
- 3.4 Cast Test Specimens: Chemical analysis specimens, and tensile specimens
Ø when required, shall be cast as follows:
- 3.4.1 Chemical Analysis Specimens: Shall be cast from each melt and shall be of any suitable size and shape.
- 3.4.2 Tensile Specimens: When purchaser specifies use of separately-cast specimens, they shall be cast with each lot of castings, shall be of standard proportions conforming to ASTM B 557 or ASTM B 557M with 0.500 inch (12.70 mm) diameter at the reduced parallel gage section, and shall be cast to size in molds representative of the practice used for castings. Metal for the specimens shall be part of the melt which is used for the castings. If the metal for castings is given any treatment, such as fluxing or cooling and reheating, the metal for the specimens shall be a portion of the metal so treated and, during such treatment, shall be heated to the same maximum temperature and held for approximately the same time as the molten metal for the castings. The temperature of the metal during pouring of the specimens shall be not lower than that during pouring of the castings.
- 3.5 Heat Treatment: Castings, and separately-cast tensile specimens when
Ø required, shall be solution and precipitation heat treated as in 3.5.1 and 3.5.2; furnace surveys and calibration of temperature controllers and recorders shall be in accordance with MIL-H-6088. When separately-cast specimens are required, at least one set of tensile specimens shall, during each stage of heat treatment, be put into a batch-type furnace with each load of castings or into a continuous furnace at intervals of not longer than three hours.
- 3.5.1 Solution Heat Treatment: Heat to a temperature within the range
Ø 960° - 990°F (516° - 532°C), hold at the selected temperature within $\pm 10^\circ\text{F}$ ($\pm 6^\circ\text{C}$) for not less than 6 hours, and quench in hot, 150° - 212°F (66° - 100°C), water or aqueous polymer solution (15 - 30% polymer).
- 3.5.2 Precipitation Heat Treatment: Castings shall be processed using one of
Ø the following precipitation heat treatment cycles:
- 3.5.2.1 Sand, Investment, or Composite Mold Castings: Heat to a temperature
Ø within the range 310° - 330°F (154° - 166°C), hold at the selected temperature within $\pm 10^\circ\text{F}$ ($\pm 6^\circ\text{C}$) for 3 - 6 hours, and cool in air.

3.5.2.2 Composite or Permanent Mold Castings: Heat to a temperature within the range 310° - 330°F (154° - 166°C), hold at the selected temperature within $\pm 10^\circ\text{F}$ ($\pm 6^\circ\text{C}$) for 6 - 12 hours, and cool in air.

3.6 Properties: Castings, and separately-cast tensile specimens when required, shall conform to the following requirements:

3.6.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM B 557 or ASTM B 557M; conformance to the requirements of 3.6.1.1 shall be used as the basis for acceptance of castings except when purchaser specifies that the requirements of 3.6.1.2 or 3.6.1.3 apply:

3.6.1.1 Specimens Cut From Any Area of a Casting: Specimens as in 4.3.3 shall have the following properties:

Tensile Strength, minimum	35 ksi (241 MPa)
Yield Strength at 0.2% Offset, minimum	28 ksi (193 MPa)
Elongation in 4D, minimum	2%

3.6.1.2 Specimens Cut From Integrally-Cast Coupons: Specimens as in 4.3.3.1 shall have the following properties:

Tensile Strength, minimum	35 ksi (241 MPa)
Yield Strength at 0.2% Offset, minimum	28 ksi (193 MPa)
Elongation in 4D, minimum	2%

3.6.1.3 Separately-Cast Specimens: Specimens as in 4.3.4 shall have the following properties:

Tensile Strength, minimum	37 ksi (255 MPa)
Yield Strength at 0.2% Offset, minimum	30 ksi (207 MPa)
Elongation in 4D, minimum	1%

3.6.2 Hardness of Castings: Castings should have hardness of 75 - 110 HB/10/500 or 80 - 115 HB/10/1000, determined in accordance with ASTM E 10, but castings shall not be rejected on the basis of hardness if the tensile property requirements of 3.6.1.1 are met.

3.7 Quality:

3.7.1 Castings, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the castings.

3.7.1.1 Castings shall have smooth surfaces and shall be well cleaned.

3.7.2 Castings shall be subjected to radiographic examination in accordance with AMS 2635 or other inspection techniques acceptable to purchaser until proper foundry technique, which will produce castings free from harmful internal imperfections, is established for each part number and of production castings as necessary to ensure maintenance of satisfactory quality.

- 3.7.3 When specified, castings shall be subjected to fluorescent penetrant inspection in accordance with AMS 2645, to contrast dye penetrant inspection in accordance with AMS 2646, or to both.
- 3.7.4 Radiographic, fluorescent penetrant, contrast dye penetrant, and other quality standards shall be as agreed upon by purchaser and vendor. ASTM E 155 may be used to define radiographic acceptance standards.
- 3.7.5 Castings shall not be reworked by peening, plugging, welding, or other methods without written permission from purchaser.
- 3.7.5.1 When permitted in writing by purchaser, defects in castings may be removed and the castings reworked by welding in accordance with AMS 2694.
- 3.7.6 Castings shall not be impregnated, chemically treated, or coated to prevent leakage unless specified or allowed by written permission of purchaser, designating the method to be used.
4. QUALITY ASSURANCE PROVISIONS:
- 4.1 Responsibility for Inspection: The vendor of castings shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the castings conform to the requirements of this specification.
- 4.2 Classification of Tests:
- 4.2.1 Acceptance Tests: Except as specified in 4.2.1.1, tests for composition (3.1), tensile properties of specimens cut from castings (3.6.1.1) or from integrally-cast coupons (3.6.1.2) or, when specified, tensile properties of separately-cast specimens (3.6.1.3), and quality (3.7) are acceptance tests and shall be performed to represent each melt or lot as applicable.
- 4.2.1.1 Tensile properties of separately-cast specimens shall be determined only when specified by purchaser or when specimens cut from castings or from integrally-cast coupons cannot be obtained. Tensile properties of separately-cast specimens need not be determined when tensile properties of specimens cut from castings or from integrally-cast coupons are determined.
- 4.2.2 Periodic Tests: Tests for hardness (3.6.2) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.
- 4.2.3 Preproduction Tests: Tests for all technical requirements are preproduction tests and shall be performed prior to or on the first-article shipment of a casting to a purchaser, when a change in ingredients and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, contracting officer, or request for procurement.

4.3 Sampling and Testing: Shall be in accordance with the following:

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4.3.1 At least one chemical analysis specimen in accordance with 3.4.1 from each melt or a casting from each lot.

4.3.2 Two preproduction castings in accordance with 4.4.1 of each part number.

4.3.3 Not less than four tensile specimens machined from a casting or castings from each lot except when purchaser specifies use of integrally-cast coupons as in 4.3.3.1 or use of separately-cast specimens as in 4.3.4. Specimens shall conform to ASTM B 557 or ASTM B 557M and shall be either 0.500 inch (12.70 mm) diameter at the reduced parallel gage section, subsize specimens proportional to the standard, or standard sheet-type specimens. If specimen locations are not shown on the drawing, not less than four specimens, two from the thickest section and two from the thinnest section, shall be cut from a casting or castings from each lot.

4.3.3.1 When permitted by purchaser, test bars integrally-cast with the castings may be tested in lieu of testing specimens cut from castings provided that the casting is too small for either excising test coupons or testing of the casting is not feasible and that the thickness of the integrally-cast test bars is equal to or greater than the thickness of the portion of the casting to which the bars are attached. Size, number, and location of integrally-cast coupons shall be as specified on the casting drawing or as agreed upon by purchaser and vendor.

4.3.4 When specified by purchaser, three separately-cast tensile specimens in accordance with 3.4.2 representing each lot of castings; one specimen shall be tensile tested and the other two retained for retests if necessary.

4.4 Approval:

4.4.1 Sample castings from new or reworked patterns or molds and the casting procedure shall be approved by purchaser before castings for production use are supplied, unless such approval be waived by purchaser.

4.4.2 Vendor shall establish, for production of sample castings of each part number, parameters for the process control factors which will produce acceptable castings; these shall constitute the approved casting procedure and shall be used for producing production castings. If necessary to make any change in parameters for the process control factors, vendor shall submit for reapproval a statement of the proposed changes in processing and, when requested, sample castings, test specimens, or both. Production castings incorporating the revised operations shall not be shipped prior to receipt of reapproval.