

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 4223B

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Superseding AMS 4223A

ALUMINUM ALLOY CASTINGS

4.5Cu - 0.70Ag - 0.30Mn - 0.25Mg - 0.25Ti (A201.0-T4)
Solution Heat Treated and Naturally Aged

UNS A12010

1. SCOPE:

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

1.2 Application: Primarily for components requiring high strength combined with good ductility and impact strength. Certain design and processing procedures (See 8.3) may cause these castings to become susceptible to stress-corrosion cracking.

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 documents shall be as specified in AMS 2350.

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

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
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 2750 - Pyrometry
AMS 2771 - Heat Treatment of Aluminum Alloy Castings
AMS 2804 - Identification, Castings

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

- 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
- ASTM G 44 - Alternate Immersion Stress Corrosion Testing in 3.5% Sodium Chloride Solution
- 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

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
Copper	4.0	5.0
Silver	0.40	1.0
Manganese	0.20	0.40
Magnesium	0.15	0.35
Titanium	0.15	0.35
Iron	--	0.10
Silicon	--	0.05
Other Impurities, each	--	0.03
Other Impurities, total	--	0.10
Aluminum	remainder	

3.2 Condition: Solution heat treated and naturally aged.

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 treated in the same heat treatment batch.
- 3.4 Cast Test Specimens: Chemical analysis specimens, and tensile specimens 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: 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: No specific heat treating instructions are specified but castings, and representative tensile specimens, when required, shall be solution heat treated and naturally aged in accordance with AMS 2771 to produce the properties specified in 3.6.1, 3.6.2, and 3.6.3. Recommended heat treatment is presented in 3.5.1 and 3.5.2. Pyrometry shall be in accordance with AMS 2750.
- 3.5.1 Thin-wall, rapidly-solidified castings shall be solution heat treated by heating to 940° - 960°F (504° - 516°C), holding at heat for 2 hours $\pm$ 0.25, raising temperature to 980° - 990°F (527° - 532°C), holding at heat for 8 hours $\pm$ 0.25, and quenching and naturally aged at room temperature for not less than 72 hours.
- 3.5.2 Heavy-wall, slowly-solidified castings (e.g., sand castings having 3/4 - 2 inches (19 - 51 mm) wall), shall be solution heat treated by heating to 900° - 920°F (482° - 493°C), holding at heat for 2 hours $\pm$ 0.25, raising temperature to 980° - 990°F (527° - 532°C), holding at heat for 12 hours $\pm$ 0.25, and quenching and naturally aged at room temperature for not less than 72 hours.
- 3.5.3 At least one set of tensile specimens shall, during solution heat treatment, be placed into a batch-type furnace with each load of castings or into a continuous furnace at intervals of not longer than three hours.

3.6 Properties: Castings with nominal wall thickness 1.0 inch (25 mm) and under and not over 50 pounds (23 kg) in overall weight and separately-cast tensile specimens produced in accordance with 3.4.2 shall conform to the following requirements; properties for castings over 1.0 inch (25 mm) in nominal wall thickness or over 50 pounds (23 kg) in overall weight shall be as agreed upon by purchaser and vendor:

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 basis for acceptance of castings except when purchaser specifies that the requirements of 3.6.1.2 apply:

3.6.1.1 Specimens Cut From Castings: Shall be as follows, determined on not less than four, and preferably ten, specimens cut from thick and thin sections of the casting:

3.6.1.1.1 Designated Casting Areas:

Tensile Strength, minimum	50,000 psi (345 MPa)
Yield Strength at 0.2% Offset, minimum	30,000 psi (207 MPa)
Elongation in 4D, minimum	12%

3.6.1.1.2 Casting Areas Other Than Designated Areas:

Tensile Strength, minimum	35,000 psi (241 MPa)
Yield Strength at 0.2% Offset, minimum	25,000 psi (172 MPa)
Elongation in 4D, minimum	5%

3.6.1.1.3 When properties other than those of 3.6.1.1.1 or 3.6.1.1.2 are required, tensile specimens as in 4.3.3 taken from locations indicated on the drawing, from a casting or castings chosen at random to represent the lot, shall have the properties indicated on the drawing for such specimens. Property requirements for such specimens may be designated in accordance with AMS 2360.

3.6.1.2 Separately-Cast Specimens:

Tensile Strength, minimum	50,000 psi (345 MPa)
Yield Strength at 0.2% Offset, minimum	30,000 psi (207 MPa)
Elongation in 4D, minimum	12%

3.6.2 Hardness of Castings: Castings, except at sprue and riser locations, should have hardness of 80 - 110 HB/10/500 or 85 - 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.

3.6.3 Stress-Corrosion Resistance: Specimens, as in 4.3.5, cut from castings shall show no evidence of stress-corrosion cracking, when tested in accordance with ASTM G 44 at a stress of 75% of the specified minimum yield strength.

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 produced under radiographic control. This control shall consist of radiographic examination of castings in accordance with AMS 2635 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 E155 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. Results of such tests shall be reported to the purchaser as required by 4.5. 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: Tests to determine conformance to requirements for composition (3.1), tensile properties of specimens cut from castings (3.6.1.1) or, when specified, tensile properties of separately-cast specimens (3.6.1.2), and quality (3.7) are classified as acceptance tests and shall be performed to represent each melt or lot as applicable.

- 4.2.2 Periodic Tests: Tests to determine conformance to requirements for hardness (3.6.2) and stress-corrosion resistance (3.6.3) are classified as 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 to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a casting to a purchaser, when a change in material 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; the number of specimens number to be sampled shall be the minimum number of specimens tested:
- 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 separately-cast specimens. 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.
- 4.3.4 Three separately-cast tensile specimens in accordance with 3.4.2 representing each lot when purchaser specifies use of separately-cast specimens, of which one shall be tested and the other two kept for retests if necessary.
- 4.3.5 Specimens for stress-corrosion tests shall be tensile specimens taken from the same areas of castings as for tensile tests of specimens cut from castings. Whenever practicable, specimens shall be not less than 0.250 inch (6.35 mm) diameter at the reduced parallel gage section. If tensile specimens are not cut from castings but are separately cast, the stress-corrosion specimen can be taken from the separately-cast tensile specimens.

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.

4.4.2.1 Process control factors include, but are not limited to, the following:

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Type of furnace

Furnace atmosphere

Mold material

Gating, risering, and chilling practices

Fluxing or deoxidation removal procedures

Metal pouring temperature; variation of $\pm 50^{\circ}\text{F}$ ($\pm 28^{\circ}\text{C}$) from the established limit is permissible

Solidification and cooling procedures

Solution heat treatment cycle

Cleaning operations

Methods of inspection

4.4.2.1.1 Any of the above process control factors for which parameters are considered proprietary by the vendor may be assigned a code designation. Each variation in such parameters shall be assigned a modified code designation.

4.5 Reports: The vendor of castings shall furnish with each shipment a report showing the results of tests for chemical composition of at least one casting or of a separately-cast specimen from each melt and the results of tests for tensile properties of specimens cut from castings from each lot or, when specified, of separately-cast specimens representing each lot. This report shall include the purchase order number, lot number, AMS 4223B, part number, and quantity.

4.6 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the castings may be based on the results of testing two additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the castings represented and no additional testing shall be permitted. Results of all tests shall be reported.