SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS4406

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Reaffirmed 2012-09

Aluminum Alloy, Centrifugal Castings
5.6Zn - 2.5Mg - 1.6Cu - 0.23Cr (709.0-T61)
Hot Isostatically Pressed, Solution and Precipitation Heat Treated
(Composition similar to UNS A07090)

RATIONALE

AMS4406 has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE

1.1 Form

This specification covers an aluminum alloy (See 8.5) in the form of centrifugal castings.

1.2 Application

These products have been used typically for applications requiring high strength in light-to-medium sections and where dimensional stability is required during machining, but usage is not limited to such applications. Certain design and processing procedures may cause these castings to become susceptible to stress-corrosion cracking.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been canceled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS 2175	Classification and Inspection of Castings
AMS 2360	Room Temperature Tensile Properties of Castings
AMS 2694	Repair Welding of Aerospace Castings
AMS 2771	Heat Treatment of Aluminum Castings
AMS 2804	Identification, Castings
AS1990	Aluminum Alloy Tempers

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS4406

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

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 594	Ultrasonic Inspection of Aluminum-Alloy Wrought Products for Aerospace Applications
ASTM B 660	Packaging/Packing of Aluminum and Magnesium Products
ASTM E 10	Brinell Hardness of Metallic Materials
ASTM E 29	Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
ASTM E 34	Chemical Analysis of Aluminum-Base Alloys
ASTM E 607	Optical Emission Spectrometric Analysis of Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere
ASTM E 716	Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis
ASTM E 1251	Analysis of Aluminum and Aluminum Alloys by Atomic Emission Spectrometry
ASTM E 1417	Liquid Penetrant Inspection
ASTM E 1742	Radiographic Examination

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 34, by spectrochemical methods in accordance with ASTM E 227, ASTM E 607, or ASTM E 1251, or by other analytical methods acceptable to purchaser (See 3.4.1).

TABLE 1 - COMPOSITION

Element	min	max
Silicon	--	0.40
Iron	--	0.50
Copper	1.2	2.0
Manganese	--	0.30
Magnesium	2.1	2.9
Chromium	0.18	0.28
Zinc	5.1	6.1
Titanium	--	0.20
Other Elements, Each	--	0.05
Other Elements, Total	--	0.15
Aluminum	remainder	

3.1.1 Test results may be rounded by the "rounding off" method of ASTM E 29.

3.2 Condition

3.2.1 Centrifugal castings shall be densified by hot isostatic pressing, then solution and precipitation heat treated to the T61 condition.

3.3 Centrifugal Castings

3.3.1 Centrifugal castings shall be produced from metal conforming to 3.1, determined by analysis of a specimen (3.4.1) cast after the last melt addition.

3.4 Test Specimens

3.4.1 Chemical Analysis Specimens

Shall be cast from each melt after the last melt addition and shall be tested to qualify the melt as in 3.1. The method for control of any subsequent additions prior to pouring (i.e., grain refining, correction for magnesium fade, etc.) shall be documented as a control factor (See 4.4.2). Spectrochemical sample shall be prepared in accordance with ASTM E 716.

3.4.2 Tensile Specimens

Separately-cast specimens conforming to ASTM B 557 or ASTM B 557M shall be cast by the same method from each melt after the last melt addition in molds representing the mold used for castings. Chills are not permitted on test specimen cavity except on the end face of the specimen when approved in accordance with 4.4.2. Tensile specimens shall be processed through HIP and heat treatment with each heat treat lot and tested for conformance to 3.6.1.1. When specified, test specimens from integral cast bars or specimens conforming to ASTM B 557 or ASTM B 557M taken from the casting may be used instead of separately cast specimens.

3.4.2.1 When purchaser specifies specimens cut from a casting or from integrally-cast coupons, such specimens shall be removed after all thermal operations, including HIP, and tested for conformance to 3.6.1.1.

3.5 Heat Treatment

Shall be in accordance with AMS 2771 and as follows:

3.5.1 Solution heat treating temperature shall be 875 °F ± 10 (468 °C ± 6).

3.5.2 Precipitation heat treating temperature shall be 250 °F ± 10 (121 °C ± 6).

3.6 Properties

Castings and representative tensile specimens produced in accordance with 3.4.2 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 basis for acceptance of the lot except when purchaser specifies that the requirements of 3.6.1.2 apply:

3.6.1.1 Separately-cast specimens, specimens cut from integrally-cast coupons, or specimens cut from any area of a centrifugal casting shall have the properties shown in Table 2.

TABLE 2 - MINIMUM TENSILE PROPERTIES, INCH-POUND UNITS

Property	Value
Tensile Strength	74.0 ksi (510 MPa)
Yield Strength at 0.2% Offset	64.0 ksi (441 MPa)
Elongation in 4D	4%

3.6.1.2 When properties other than those of Table 2 are required, tensile specimens taken from locations indicated on the drawing, or from a casting or castings chosen at random to represent the heat treat lot, shall have the properties indicated on the drawing for such specimens. (See 8.5) Property requirements may be designated in accordance with AMS 2360.

3.7 Quality

3.7.1 Centrifugal 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 centrifugal castings.

3.7.2 When acceptance standards are not specified, Grade B of AMS 2175 shall apply. ASTM B 594 may be used to define ultrasonic acceptance standards.

3.7.3 Methods of inspection and frequency of inspection shall be as agreed upon by purchaser and vendor. A "Casting Class" of AMS 2175 shall be selected to specify the method and frequency of inspection.

3.7.4 When specified, centrifugal castings shall be subjected to ultrasonic inspection in accordance with ASTM B 594 to the specified acceptance standards.

3.7.5 When specified, centrifugal castings shall be etched to produce a surface suitable for visual inspection. Surfaces shall be evaluated for discontinuities to the specified acceptance standards and, if removed so they do not reappear upon visual inspection after re-etching and the required section thickness is maintained, the centrifugal castings are acceptable.

3.7.6 Castings shall be produced under radiographic control. This control shall consist of 100% radiographic inspection of castings until process control factors (4.4.2) have been established to ensure production of acceptable castings. Unless otherwise specified by purchaser, continued radiographic inspection of production castings shall be performed at a frequency determined by the vendor to ensure continued maintenance of internal quality.

3.7.6.1 Radiographic inspection shall be conducted in accordance with ASTM E 1742, unless otherwise specified by purchaser.

3.7.7 Ultrasonic inspection conducted in accordance with ASTM B 594 may be substituted for radiographic inspection, when agreed to by purchaser and vendor. Ultrasonic acceptance standards shall be as specified by purchaser.

3.7.8 When specified by purchaser, castings shall be fluorescent penetrant inspected in accordance with ASTM E 1417.

3.7.9 Castings shall not be peened, plugged, impregnated, or welded unless authorized by purchaser.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of centrifugal castings shall supply all samples for vendor's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirming tests deemed necessary to ensure that the product conforms to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Except as specified in 4.2.1.1, composition (3.1), tensile properties of specimens of separately-cast specimens (3.6.1.1), quality (3.7.1), and, when specified, ultrasonic inspection (3.7.7) and fluorescent penetrant inspection (3.7.8) are acceptance tests and shall be performed to represent each melt or heat treat lot as applicable.

4.2.1.1 Tensile properties of integrally-cast coupons or specimens machined from castings shall be determined when specified by purchaser or when separately-cast specimens cannot be obtained. Tensile properties of integrally-cast coupons or separately-cast specimens need not be determined when tensile properties of specimens cut from centrifugal castings are determined.

4.2.2 Periodic Tests

Radiographic inspection (3.7.6) following the establishment of process control (4.4.2) is a periodic test and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests

All technical requirements are preproduction tests and shall be performed prior to or on the first-article shipment of a centrifugal 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.

4.3 Sampling and Testing

Shall be in accordance with the following:

4.3.1 One chemical analysis specimen in accordance with 3.4.1 from each melt for conformance to 3.1.

4.3.2 One or more separately-cast tensile specimens in accordance with 3.4.2 from each HIP and heat treat lot, except when purchaser specifies specimens cut from a casting or integrally-cast coupons as in 4.3.4.

4.3.3 One or more preproduction castings in accordance with 4.4.1 of each part number.

4.3.4 One or more castings from each heat treat lot when properties are required from specimens cut from a casting. For determining conformance to the requirements of 3.5.1.1, if specimen locations are not shown on the drawing, two specimens from the thickest section and two specimens from the thinnest section, shall be cut from a casting or castings from each heat treat lot.

4.3.4.1 When permitted by purchaser, tensile specimens conforming to ASTM B 557 or ASTM B 557M excised from integrally-cast coupons may be used in lieu of separately-cast specimens (4.3.2) or specimens cut from a casting or castings (4.3.4). Size, number, and location of integrally-cast coupons shall be as specified by purchaser.

4.4 Approval

4.4.1 The manufacturing procedure and sample centrifugal castings from new or reworked master patterns or molds shall be approved by purchaser before centrifugal castings for production use are supplied, unless such approval is waived by purchaser.

4.4.2 Vendor shall establish, for production of samples of each part number, parameters for the process control factors, which will produce acceptable product; these shall constitute the approved procedure and shall be used for producing production centrifugal castings. Vendor shall also establish control factors for producing separately-cast tensile specimens, but these control factors need not be identical to those used for production of product. 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 centrifugal castings, test specimens, or both. Production products incorporating the revised operations shall not be shipped prior to receipt of reapproval.

4.4.2.1 Control factors for producing tensile specimens and castings include, but are not limited to, the following. Supplier's procedures shall identify tolerances, ranges, and/or control limits, as applicable. Control factors for separately-cast tensile specimens must generally represent, but need not be identical to, those factors used for castings.

Type of furnace
Furnace atmosphere
Alloy additions, fluxing, deoxidation, and gas removal procedures
Gating and risering practices
Mold composition and molding practice
Core composition and fabrication method, when applicable
Metal pouring temperature; variation of 50 °F (28 °C) from the established limit is permissible
Solidification and cooling procedures
Hot Isostatic Pressing (HIP) cycle
Stabilization/precipitation heat treat cycle
Straightening procedure, when applicable

Cleaning operations
Methods of inspection
Radiographic inspection sampling plan, if used.

4.4.2.1.1 Any of the 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 centrifugal castings shall furnish with each shipment a report showing the results of tests for composition from each melt and the results of tests for tensile properties of separately-cast specimens representing each heat treat lot, or, when specified, of specimens cut from centrifugal castings or from integral coupons representing each heat treat lot, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, melt and heat treat lot numbers, AMS 4406, product size or part number, and quantity.

4.6 Resampling and Retesting

With the approval of the purchaser, if any specimen used in the above test fails to meet the specified requirements, disposition of the part(s) from the specific lot may be based on the results of testing two additional specimens, representing the same lot, for each original non-conforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the products represented. Results of all tests performed shall be reported.

5. PREPARATION FOR DELIVERY

5.1 Identification

Shall be in accordance with AMS 2804.

5.2 Packaging

The product shall be prepared for shipment in accordance with ASTM B 660 and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the product to ensure carrier acceptance and safe delivery.

6. ACKNOWLEDGMENT

A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS

Product not conforming to this specification or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES

8.1 A change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of a specification. An (R) symbol to the left of the document title indicates a complete revision of the specification, including technical revision. Change bars and (R) are not used in original publications, nor in specifications that contain editorial changes only.

8.2 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.