

AEROSPACE MATERIAL SPECIFICATION

SAE AMS4249

REV. A

Issued 1992-07
Revised 2005-03
Reaffirmed 2012-04

Superseding AMS4249

Aluminum Alloy Castings
7.0Si - 0.58Mg - 0.15Ti - 0.06Be (D357.0-T6)
Solution and Precipitation Heat Treated
(Requiring Fatigue and Fracture Toughness Testing)
(Composition similar to UNS A43570)

RATIONALE

AMS4249A has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE:

1.1 Form:

This specification covers an aluminum alloy in the form of castings.

1.2 Application:

These castings have been used typically for durability and damage tolerance structural aircraft components (See 8.2) requiring fatigue resistance and fracture toughness, but usage is not limited to such applications.

1.3 Safety - Hazardous Materials:

While the material, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

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 cancelled and no superseding document has been specified, the last published issue of that document shall apply.

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on this Technical Report, please visit
<http://www.sae.org/technical/standards/AMS4249A>**

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or 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 Alloy Castings
AMS 2804	Identification, Castings
AMS 4246	Aluminum Alloy Welding Wire, 7.0Si - 0.52Mg
ARP1947	Dendrite Arm Spacing of Structural Aircraft Quality D357 Aluminum Alloy Castings, Determination and Acceptance of
AS1990	Aluminum Alloy Tempers

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 or 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 660	Packaging/Packing of Aluminum and Magnesium Products
ASTM E 10	Brinell Hardness of Metallic Materials
ASTM E 29	Using Significant Digits in Test Data to Determine Conformance with Specifications
ASTM E 34	Chemical Analysis of Aluminum and Aluminum-Base Alloys
ASTM E 155	Reference Radiographs for Inspection of Aluminum and Magnesium Castings
ASTM E 227	Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique
ASTM E 466	Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials
ASTM E 607	Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere
ASTM E 716	Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis
ASTM E 1251	Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Argon Atmosphere, Point-to-Plane, Unipolar Self-Initiating Capacitor Discharge
ASTM E 1304	Plane-Strain (Chevron Notch) Fracture Toughness of Metallic Materials
ASTM E 1417	Liquid Penetrant Examination
ASTM E 1742	Radiographic Examination

2.3 Aluminum Association Publications:

Available from the Aluminum Association, Inc., 900 19th Street, N.W., Washington, DC 20006 or www.aluminum.org.

AA-CS-E18 Cast Surface Smoothness

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.

TABLE 1 - Composition

Element	min	max
Silicon	6.5	7.5
Iron	--	0.12
Manganese	--	0.10
Magnesium	0.55	0.6
Titanium	0.10	0.20
Beryllium	0.04	0.07
Other Elements, each	--	0.05
Other Elements, total	--	0.15
Aluminum	remainder	

3.1.1 When permitted by purchaser, strontium or sodium may be used as a silicon particle modifier. When permitted, the maximum percentage by weight shall be 0.014 for strontium or 0.012 for sodium.

3.1.2 Test results may be rounded in accordance with the "rounding off" method of ASTM E 29.

3.2 Condition:

Solution and precipitation heat treated to T6 condition (See AS1990).

3.3 Casting:

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. 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 4.4.1.2).

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. Spectrochemical sample shall be prepared in accordance with ASTM E 716.
- 3.4.2 Integrally-Cast Coupons: Shall be integrally attached to each casting and tested for tensile, fatigue, and fracture toughness property determination as specified in 3.6.1.1, 3.6.2.1, and 3.6.3, respectively. Unless otherwise specified by purchaser, the following shall apply:
- 3.4.2.1 Each casting shall have at least two integrally-cast tensile coupons. One coupon shall be left attached and used only if repeated heat treatment is necessary. The coupons shall be flat and sufficiently large to permit excision of a sub-size round tensile specimen 0.250 inch (6.35 mm) in diameter with a gage length of 1 inch (25.4 mm) conforming to ASTM B 557 or ASTM B 557M.
- 3.4.2.2 Each casting shall have at least three integrally-cast fatigue coupons. The coupons shall be sufficiently large to permit excision of a round specimen 0.50 inch (12.7 mm) in diameter, with a minimum gage length of 2.0 inches (50.8 mm), conforming to ASTM E 466. All machining marks shall be removed and the gage section shall be polished parallel to the specimen axis. The final polish shall be with Crocus cloth or similar polishing material.
- 3.4.2.3 Each casting shall have at least two integrally-cast fracture toughness coupons. One coupon shall be left attached and used only if repeated heat treatment is necessary. The coupons shall be sufficiently large to permit excision of a specimen conforming to ASTM E 1304.
- 3.4.2.4 The radiographic quality of the coupons shall meet the requirements for designated areas shown in Table 2.

TABLE 2 - Radiographic Requirements – Maximum Allowable Discontinuity Severity Level

Discontinuity	ASTM E 155 Reference Radiograph	Designated Areas	Other Areas
Gas holes	1.1	1	2
Gas porosity (round)	1.21	1	3
Gas porosity (elongated)	1.22	1	3
Shrinkage cavity	2.1	1	2
Shrinkage porosity or sponge	2.2	1	2
Foreign material (less dense)	3.11	1	2
Foreign material (more dense)	3.12	1	2
Segregation	---	none	none
Cracks	---	none	none
Cold shuts	---	none	none
Laps	---	none	none

- 3.4.2.4.1 When two or more types of discontinuities are present to an extent equal to or not better than the acceptance standards for respective discontinuities, the parts shall be rejected.
- 3.4.2.4.2 When two or more types of discontinuities are present and the predominating discontinuity is not better than the acceptance standard, the part shall be reviewed for disposition by the cognizant engineering personnel.
- 3.4.2.4.3 Gas holes or sand spots and inclusions allowed by Table 2 shall be cause for rejection when closer than twice their maximum dimension to an edge or extremity of a casting.
- 3.4.3 Specimens Cut from Castings: Shall be subsize and proportional to the standard round or sheet-type specimens defined in ASTM B 557 or ASTM B 557M. For sheet-type specimens, elongation shall be measured based on a gage length of $4.5 \times (\text{cross-sectional area})^{1/2}$.

3.5 Heat Treatment:

Shall be in accordance with AMS 2771.

3.6 Properties:

Castings and integrally-cast coupons 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:
- 3.6.1.1 Tensile properties of integrally-cast coupons shall be as shown in Table 3.

TABLE 3 - Tensile Properties

Property	Value
Tensile Strength, minimum	51.0 ksi (352 MPa)
Yield Strength at 0.2% Offset	42.0 to 47.0 ksi (290 to 324 MPa)

- 3.6.1.2 Specimens Cut from Castings: Tensile properties of specimens cut from a casting or castings shall be as shown in Table 4 or Table 5.

TABLE 4 - Minimum Tensile Properties, Designated Areas

Property	Value
Tensile Strength	50.0 ksi (345 MPa)
Yield Strength at 0.2% Offset	40.0 ksi (276 MPa)
Elongation in 4D (See 3.6.1.2.1)	3%

TABLE 5 - Minimum Tensile Properties, Areas Other Than Designated Areas

Property	Value
Tensile Strength	45.0 ksi (310 MPa)
Yield Strength at 0.2% Offset	36.0 ksi (248 MPa)
Elongation in 4D (See 3.6.1.2.1)	2%

3.6.2 Fatigue Properties: Shall be as follows, determined in accordance with ASTM E 466:

3.6.2.1 Integrally-Cast Coupons: Three specimens shall be tested under constant amplitude fatigue loading at a frequency between 10 and 20 Hz. The maximum stress shall be 40.0 ksi (276 MPa) at a stress ratio of 0.1 and stress concentration factor of 1.0.

3.6.2.1.1 The log average life of the three specimens shall be 85,000 cycles, with a minimum individual life of 46,000 cycles.

3.6.2.2 Specimens Cut From Castings: Three specimens shall be tested. If the casting is sufficiently large to permit the provision of the specimens of the size specified shown in 3.4.2.2, the average and minimum fatigue life requirements in 3.6.2.1.1 shall apply. If it is not possible to excise 0.50 inch (12.7 mm) diameter specimens from the casting, smaller specimens are permitted. These shall have a 0.250 inch (6.35 mm) or 0.375 inch (9.52 mm) diameter gauge section. The gauge section shall be between 1.50 inches (38.1 mm) and 2.00 inches (50.8 mm) long.

3.6.2.2.1 The maximum stress shall be 40.0 ksi (276 MPa) at a stress ratio of 0.1 and a stress concentration factor of 1.0. The log average life for the 0.250 inch (6.35 mm) and 0.375 inch (9.52 mm) specimens shall be 68,000 and 78,000 cycles, respectively. The minimum fatigue life for each individual specimen shall be 36,000 and 42,000 cycles for the 0.250 inch (6.35 mm) and 0.375 inch (9.52 mm) diameter gauge sections, respectively.

3.6.2.2.2 All fatigue specimens shall be excised from designated areas of the casting.

3.6.3 Fracture Toughness Properties: Shall be not lower than 21.0 ksi√in (23.1 MPa√m), determined in accordance with ASTM E 1304 on integrally-cast coupons or specimens cut from castings.

3.6.4 Microstructure: The casting surface in designated areas of the casting shall have a dendrite arm spacing not exceeding 0.0020 inch (0.051 mm), determined in accordance with ARP1947. Castings which exhibit an unacceptable microstructure may be held for disposition by cognizant engineering personnel.

3.6.5 When properties other than those of 3.6.1.2, 3.6.2.2, 3.6.3, or 3.6.4 are required, specimens 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. Tensile property requirements may be designated in accordance with AMS 2360.

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 a surface finish in accordance with the engineering drawing. The Aluminum Association AA-CS-E18 may be used to specify surface finish acceptance criteria.

- 3.7.2 Castings shall be produced under foundry 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.
- 3.7.3 Radiographic inspection shall be performed on each casting in accordance with ASTM E 1742. Type 1 radiographic film shall be used, and a maximum unsharpness value of 0.003 inch (0.08 mm) and equivalent penetrameter sensitivity of 1% shall be maintained. ASTM E 155 shall be used to define radiographic acceptance standards in accordance with Table 2.
- 3.7.4 Each casting shall be subjected to fluorescent penetrant inspection in accordance with ASTM E 1417, Sensitivity Level 2.
- 3.7.4.1 Linear indications, cold shuts, cracks, and seams are not acceptable.
- 3.7.4.2 Surface porosity is not acceptable if the individual pores are closer than twice their maximum dimension to an edge or extremity of the casting or the pores form a linear indication, i.e., three or more are in a line and the distance between any two indications is less than twice the maximum dimension of either adjacent indication.
- 3.7.4.3 Any individual indication which is three times longer than it is wide shall be considered a linear indication and is not acceptable.
- 3.7.5 Castings shall not be peened, plugged, impregnated, or welded unless authorized by purchaser.
- 3.7.5.1 When authorized by purchaser, discontinuities in non-designated areas of the casting may be removed and the castings welded in accordance with AMS 2694, or other welding program approved by purchaser, using AMS 4246 alloy filler metal. The vendor's welding procedures shall have prior approval by purchaser.

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 the performance of all required tests. All testing shall be performed at facilities acceptable to purchaser. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the castings conform to specified requirements.

4.2 Classification of Tests:

- 4.2.1 Acceptance Tests: Composition (3.1), properties of specimens cut from castings and integrally-attached coupons (3.6.1, 3.6.2, 3.6.3, 3.6.4), and quality (3.7) are acceptance tests and shall be performed on each casting, melt, or heat treat lot as applicable under 4.3.

4.2.2 Periodic Tests: Microstructure (3.6.4) when specified as in 4.3.2.1 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 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 For Acceptance Tests:

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

4.3.1.2 Destructive testing of castings for evaluation of excised test specimens for conformance to 3.6.1.2, 3.6.2.2, and 3.6.3 shall occur at the following frequency:

4.3.1.2.1 First 30 Castings Received: One casting from each ten production castings shall be selected for destructive testing.

4.3.1.2.2 Castings Received Thereafter: If no failure occurs in 4.3.1.2.1, one casting from each 25 production castings consecutively received thereafter shall be tested. If a failure occurs, the test frequency reverts to one from each ten production castings from the next 30 castings received.

4.3.1.3 Determine tensile properties of one integrally-attached coupon as required by 3.6.1.1 from each casting.

4.3.1.4 Determine fatigue properties of three integrally-attached coupons as required by 3.6.2.1 from each casting.

4.3.1.5 Determine fracture toughness properties of one integrally-attached coupon as required by 3.6.3 from each casting.

4.3.1.6 Determine dendrite arm spacing as required by 3.6.4 and 4.3.2.1.

4.3.2 For Periodic Tests: As agreed upon by purchaser and vendor and the following:

4.3.2.1 When required, specific test locations on the casting and frequency of evaluating castings for surface microstructure shall be defined by purchaser at time of preproduction approval.

4.3.2.2 For Preproduction Tests:

4.3.2.3 Two preproduction castings of each part number shall be furnished to purchaser. One casting shall have been dimensionally inspected by the vendor and the results shall be forwarded with the casting for approval. The second casting shall be supplied to purchaser for metallurgical evaluation. All vendor test results obtained to substantiate the metallurgical quality of the casting shall be included.

4.4 Approval:

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

4.4.1.1 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 process control factors, vendor shall submit for reapproval a statement of the proposed changes in processing and, when requested, test specimens, sample castings, or both. Production castings incorporating the revised operations shall not be shipped prior to receipt of reapproval.

4.4.1.2 Control factors for producing castings include, but are not limited to, the following. Supplier's procedures shall identify tolerances, ranges, and/or control limits, as applicable:

Type of melting furnace and furnace atmosphere
Alloy additions, fluxing, deoxidation, gas removal, and grain refining procedures
Gating and risering practice
Mold composition and molding practice
Core composition and fabrication method, when applicable
Metal pouring temperature
Solidification and cooling procedures
Solution heat treat and precipitation hardening parameters
Straightening procedures
Cleaning operations
Methods of inspection
Shop traveler describing sequence of processing, inspection, and testing.

4.4.1.2.1 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.

4.4.1.2.2 Details of the process control shall be available for purchaser's review/audit at the foundry facility.

4.5 Reports:

The vendor of castings shall furnish with each shipment a report showing the results of tests for composition of each melt, tensile, fatigue, and fracture toughness properties of attached specimens, dendrite arm spacing representing each casting, and specimens cut from each casting by serial number, and stating that the castings conform to the other technical requirements. This report shall include the purchase order number, melt and heat treat lot numbers, AMS 4249A, casting part number, and quantity.

4.6 Resampling and Retesting:

4.6.1 Attached Coupons:

4.6.1.1 Replacement of an integrally-cast coupon is permitted when an isolated flaw is evident on the fracture face of a broken specimen.

4.6.1.2 Testing of integrally-cast tensile coupons is required after reheat treatment. The replacement specimens shall be taken from an additional coupon which has remained integrally attached to the casting through the re-heat treat process.

4.6.2 Test Specimens Excised from Castings:

4.6.2.1 Replacement of test specimens shall be allowed for poor machining, incorrect test procedure, malfunction of test equipment, or fracture location.

4.6.2.2 Retesting shall be permitted by testing two adjacent specimens. Should it not be possible to obtain adjacent specimens, or if a replacement specimen also fails, two additional castings shall be tested. Failure of a specimen in a second casting shall be cause for rejection of the lot. All castings shipped and in process since the last acceptable tensile test of a casting shall be reviewed for disposition.

4.6.2.3 All retest specimens shall be located to represent as nearly as possible the quality of the metal of the original test.

5. PREPARATION FOR DELIVERY:

5.1 Identification:

Shall be in accordance with AMS 2804.

5.1.1 Each casting shall be identified with a non-repeating serial number to relate processing of the part with the inspection results for traceability. Serial number and foundry identification shall be permanently marked in a location acceptable to purchaser.

5.1.2 Each casting accepted by radiographic inspection shall be ink stamped in accordance with ASTM E 1742.