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AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 4241

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ALUMINUM ALLOY CASTINGS, SAND COMPOSITE
7.0Si - 0.58Mg - 0.15Ti - 0.06Be (D357.0-T6)
Solution and Precipitation Heat Treated
Aircraft Structural Quality

UNS A03570

1. SCOPE:

1.1 Form: This specification covers an aluminum alloy in the form of sand composite molded castings.

1.2 Application: Primarily for structural aircraft components.

1.3 Alloy D357.0 has restricted composition within the limits of alloy A357.0.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications and Aerospace Recommended Practices 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 2694 - Repair Welding of Aerospace Castings
AMS 2804 - Identification, Castings
AMS 4188/5 - Aluminum Alloy Welding Wire, 7.0Si - 0.52Mg

2.1.2 Aerospace Recommended Practices:

ARP 1947 - Determination and Acceptance of Dendrite Arm Spacing in Aluminum Castings

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM B557 - Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products
ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E34 - Chemical Analysis of Aluminum and Aluminum Alloys
ASTM E155 - Reference Radiographs for Inspection of Aluminum and Magnesium Castings

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Specifications:

MIL-H-6088 - Heat Treatment of Aluminum Alloys
MIL-I-6866 - Inspection, Penetrant Method of
MIL-I-25135 - Inspection Materials, Penetrant

2.3.2 Military Standards:

MIL-STD-410 - Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic)
MIL-STD-649 - Aluminum and Magnesium Products, Preparation for Shipment and Storage
MIL-STD-453 - Inspection, Radiographic

2.4 AIA Publications: Available from National Standard Association, Inc., 1321 14th Street, N.W., Washington, DC 20005.

NAS 823 - Cast Surface Comparison Standard

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E34 or by spectrographic or other analytical methods approved by purchaser:

	min	max
Silicon	6.5	7.5
Magnesium	0.55	0.6
Titanium	0.10	0.20
Beryllium	0.04	0.07
Iron	--	0.12
Manganese	--	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 from metal conforming to 3.1.

3.3.1 A melt shall be a single homogenous batch of molten metal on which all processing has been completed and the temperature has been adjusted ready for pouring castings.

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 treat batch.

3.4 Test Specimens:

3.4.1 Chemical Analysis Specimens: Shall be cast from each melt.

3.4.2 Integrally-Attached Coupons: At least two coupons shall be integrally-attached to each casting. The two coupons shall represent a variation of size of Dendrite Arm Spacing (DAS). The chilled coupon exhibiting a small DAS shall be identified as coupon "A"; the coupon of large DAS shall be identified as coupon "B". These coupons shall be used for tensile property determination specified in 3.6.1.1 and microstructure evaluation specified in 3.6.3. Additional coupons may be added for retest and foundry purposes at the option of the foundry.

3.4.2.1 Location and size of the integrally-attached coupons are optional with the following exceptions:

3.4.2.1.1 The coupons shall be flat and at least large enough to permit excision of a sub-size round tensile specimen of 0.250 in. (6.25 mm) diameter conforming to ASTM B557 with a gage length of 1 in. (25 mm).

3.4.2.1.2 The coupons shall be located in such a manner as to avoid any interference with inspection tooling.

3.4.2.2 The two coupons shall be produced with varying solidification rates to develop a minimum DAS size difference of 0.0010 in. (0.025 mm) within a tensile strength range of 47,000 - 57,000 psi (325 - 395 MPa).

3.4.2.3 The radiographic quality of the coupons shall meet the requirements for designated areas of Table I.

3.4.2.4 Removal and testing of integrally-attached coupons for casting acceptance shall be performed by a testing facility which has been approved by purchaser and the foundry and is independent of the foundry.

3.5 Heat Treatment: Castings and integrally-attached coupons shall be solution and precipitation heat treated in accordance with MIL-H-6088 except as specified in 3.5.1 and 3.5.2.

3.5.1 The solution heat treat temperature shall be 1000° - 1020°F (540 - 550°C).

3.5.2 The quenching and precipitation heat treating procedure shall be established to develop the required casting properties.

3.6 Properties: Castings and integrally-attached chilled coupon "A" shall conform to the following requirements:

3.6.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM B557 and shall be used as basis for acceptance of castings:

3.6.1.1 Integrally-Attached Chilled Coupon "A": For heat treat control, the following tensile properties shall be exhibited:

Tensile Strength, min	51,000 psi (350 MPa)
Yield Strength at 0.2% Offset	42,000 - 47,000 psi (290 - 325 MPa)

3.6.1.2 Specimens Cut from Castings: Tensile properties of specimens cut from a casting or castings shall be as follows:

3.6.1.2.1 Designated Casting Areas:

Tensile Strength, min	50,000 psi (345 MPa)
Yield Strength at 0.2% Offset, min	40,000 psi (275 MPa)
Elongation in 4D, min (See 3.6.1.2.4)	3%

3.6.1.2.2 Casting Areas Other Than Designated Areas:

Tensile Strength, min	45,000 psi (310 MPa)
Yield Strength at 0.2% Offset, min	36,000 psi (260 MPa)
Elongation in 4D, min (See 3.6.1.2.4)	2%

3.6.1.2.3 When properties other than those of 3.6.1.2.1 or 3.6.1.2.2 are required, tensile 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. Property requirements may be designated in accordance with AMS 2360.

3.6.1.2.4 Excised specimens shall be subsize and proportional to the standard round or sheet type specimens defined in ASTM B557. For sheet type specimens, elongation shall be measured based on $4.5\sqrt{\text{cross-sectional area}}$.

3.6.2 Hardness of Castings: Should be not lower than 90 HRE, determined in accordance with ASTM E18, but castings shall not be rejected on the basis of hardness if the tensile property requirements of 3.6.1.2 are met.

3.6.3 Microstructure: The microstructure of the casting surface in the designated areas of the casting shall not exceed the maximum size coarseness, determined in accordance with ARP 1947. Castings which exhibit an unacceptable microstructure shall be held for disposition by purchaser's cognizant engineering personnel. Castings shall not be rejected, however, if the requirements of 3.6.1.2 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 a surface finish in accordance with the engineering drawing and NAS 823 and shall be well cleaned.

3.7.2 Castings shall be produced under foundry control. This control shall consist of preproduction examination of castings until proper foundry technique and controls are established which will produce castings that will meet the drawing quality and dimensional requirements.

3.7.3 Radiographic inspection shall be performed on each casting in accordance with MIL-STD-453. In addition, Type 1 radiographic film shall be used, and a maximum unsharpness value of 0.003 in. (0.08 mm) and flaw sensitivity of 1% shall be maintained. ASTM E155 shall be used to define radiographic acceptance standards in accordance with Table I.

3.7.4 Each casting shall be subjected to fluorescent penetrant inspection in accordance with MIL-I-6866.

3.7.4.1 The fluorescent penetrant shall have a sensitivity level equivalent to group V of MIL-I-25135.

3.7.4.2 Personnel conducting the testing shall be qualified and certified in accordance with MIL-STD-410.

3.7.4.3 Linear indications, cold shuts, cracks, and seams are not acceptable.

3.7.4.4 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 each indication is less than twice the maximum dimension of either adjacent indication.

3.7.4.5 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 repaired by peening, plugging, welding, or other methods, except as specified in 3.7.5.1.

3.7.5.1 Defects in non-critical areas of the casting may be removed and the castings repaired by welding in accordance with AMS 2694, using AMS 4188/5 alloy filler metal. The vendor's weld procedures shall have prior approval by purchaser.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of castings shall be responsible for coordinating all acceptance testing of production castings at the purchaser's approved facilities. Tensile testing of specimens excised

4.1 (Continued):

periodically from castings and DAS determinations, when required, shall be performed at a testing facility approved by purchaser and foundry and independent of the foundry. 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 integrally-attached coupons (3.6.1.1), tensile properties of specimens cut from castings (3.6.1.2), and quality (3.7) are classified as acceptance tests and shall be performed on each casting, melt, or lot as applicable.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for hardness (3.6.2) and microstructure (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, processing, or both 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, the contracting officer, or the request for procurement.

4.3 Sampling: 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.

4.3.1.2 The destructive testing of castings for the evaluation of excised test specimens shall occur at the following frequency:

4.3.1.2.1 First 30 Castings Received: One casting from each 10 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. If a failure occurs, the test frequency reverts to one from each 10 production castings from the next 30 castings received.

4.3.1.3 An integrally-attached coupon required by 3.6.1.1 from each casting.

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

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

4.4 Approval:

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

4.4.1.1 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.

4.4.2 Vendor shall document the 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 material, processing, or both and, when requested, integrally-attached coupons, sample castings, or both. Production castings incorporating the revised operations shall not be shipped prior to receipt of written reapproval.

4.4.2.1 Control factors for producing castings include, but are not limited to, the following:

4.4.2.1.1 Melting practice regarding control of:

Chemistry
Gas content
Grain size
Melt temperature

4.4.2.1.2 Molding procedure regarding:

Materials and assembly
Gating and risering systems
Solidification rate in designated areas

4.4.2.1.3 Heat treatment practice regarding:

Temperature and time parameters
Load density
Quenching procedure

4.4.2.1.4 Shop traveler describing the sequence of processing, inspection, and testing.

4.4.2.1.5 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:

4.5.1 The vendor of castings shall furnish with each shipment a report showing the results of tests for chemical composition of each melt, tensile properties of attached specimens representing each casting and specimens cut from castings if applicable, penetrant and radiographic inspections of each casting by serial number, and, when performed, microstructure and hardness test results from each lot. This report shall include the purchase order number, AMS 4241, part number, and quantity.

4.5.2 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 4241, contractor or other direct supplier of castings, part number, and quantity. When castings for making parts are produced or purchased by the parts vendor, that vendor shall inspect each lot of castings to determine conformance to the requirements of this specification and shall include in the report either a statement that the castings conform or copies of laboratory reports showing the results of tests to determine conformance.

4.6 Resampling and Retesting:

4.6.1 Attached Coupons:

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

4.6.1.2 Testing is required of an integrally-attached chilled coupon after reheat treatment. The replacement specimen shall be taken from an additional coupon which has remained integrally attached to the casting through the reheat treat process.

4.6.2 Tensile Specimens Excised from Castings:

4.6.2.1 Replacement of tensile specimens shall be allowed in accordance with ASTM B557 for poor machining, incorrect test procedure, malfunction of test equipment, or fracture location.

4.6.2.2 Retesting of a tensile specimen excised from the castings is permitted only when the fracture face indicates an isolated gas hole or piece of foreign material. 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 tensile specimen in a second casting shall be cause to consider the lot of castings suspect and the purchaser contacted for material review action. 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 tensile specimens shall be located to represent as nearly as possible the quality of the metal of the original test. Isolated gas holes or foreign material that are discernable by production radiography may be avoided.

5. PREPARATION FOR DELIVERY:

5.1 Identification: Shall be in accordance with AMS 2804. Each casting shall be identified by an individual serial number to relate processing of the part with the inspection results for traceability.

5.1.1 Each casting shall be identified by legible raised figures with part number, foundry identification, and serial number in the area indicated on the engineering drawing. The serial number shall be used only once to provide traceability to the processing of a particular part.

5.1.2 Each casting accepted by radiographic inspection shall be ink stamped in accordance with MIL-STD-453.

5.1.3 Each casting accepted by penetrant inspection shall be ink stamped in accordance with MIL-I-6866.

5.1.4 Integrally-attached coupons shall be identified by a vibroetched serial number corresponding with the castings serial number and letter "A" or "B" to indicate the relative size of DAS.

5.1.5 Castings and the accompanying reports shall identify the heat treatment and melt analysis of each casting through the serial number.

5.1.6 When impregnation is specified or permitted by purchaser, castings shall be marked "IMP".

5.2 Packaging:

5.2.1 Castings shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the castings to ensure carrier acceptance and safe delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.