SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS4471

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Cast Aluminum Alloy Composite 4.6 Cu – 3.4Ti – 1.4B – 0.75Ag – 0.27Mg (A205.0/TiB_2/3p-T7P) Investment Cast, Solution and Precipitation Heat Treated

RATIONALE

AMS4471 is a new specification for aluminum alloy composite produced by investment casting for high strength elevated temperature applications.

1. SCOPE

1.1 Form

This specification covers a dilute aluminum/TiB_2 metal matrix composite in the form of investment castings.

1.2 Application

These castings have been used typically for components requiring high strength and/or elevated temperature performance, but usage is not limited to such applications.

1.3 Safety - Hazardous Materials

While the materials, 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.

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/AMS4471

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.

AMS2175 Casting, Classification and Inspection of

AMS2360 Room Temperature Tensile Properties of Castings

AMS2694 In-Process Welding of Castings

AMS2771 Heat Treatment of Aluminum Alloy Castings

AMS2804 Identification, Castings

AS1990 Aluminum Alloy Tempers

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 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 716 Sampling and Sample Preparation of Aluminum and Aluminum Alloys for Determination of Chemical Composition by Spectrochemical Analysis

ASTM E 1251 Analysis of Aluminum and Aluminum Alloys by Spark Atomic Emission Spectrometry

ASTM E 1417 Liquid Penetrant Testing

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 1251, or by other analytical methods acceptable to purchaser (See 3.4.1).

TABLE 1 – COMPOSITION

Element	min	max
Iron	--	0.08
Copper	4.2	5.0
Magnesium	0.20	0.33
Titanium (1)	3.0	3.85
Boron (1)	1.25	1.55
Silicon	--	0.10
Silver	0.6	0.9
Other Elements, each		0.08
Other Elements, total	--	0.17
Aluminum	remainder	

(1)—Titanium and Boron are present as TiB_2 reinforcement in the cast alloy matrix.

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

3.2 Condition

Solution and precipitation heat treated to the T7 temper (See AS1990).

3.3 Castings

Castings shall be produced from metal conforming to 3.1, determined by analysis of specimens cast as in 3.4.1.

3.4 Cast Test Specimens

Chemical analysis specimens and tensile specimens shall be cast as follows:

3.4.1 Chemical Analysis Specimens

Two specimens shall be cast from each melt. The first shall be taken after the last melt addition and the second shall be after the last casting has been poured. Both specimens shall be tested to qualify the melt as in 3.1. Spectrochemical samples shall be prepared in accordance with ASTM E 716.

3.4.2 Tensile Specimens

Shall be produced as follows:

3.4.2.1 Specimens Cut from a Casting and Specimens from Integrally Cast Coupons

Shall be removed after heat treatment, 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, standard sheet type specimens, or subsize specimens proportional to the standard as required by 3.6.1.

3.4.2.2 Separately Cast Specimens

Shall conform to ASTM B 557 or ASTM B 557M and shall be cast from each melt after the last melt additions. Specimens shall be cast 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.

3.5 Heat Treatment

Heat treatment shall conform to the requirements of AMS2771. Heat treatment parameters are proprietary.

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 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 Castings

Specimens as in 4.3.3 shall have the properties shown in Table 2.

TABLE 2 - MINIMUM TENSILE PROPERTIES

Property	Value
Tensile Strength	64.0 ksi (441 MPa)
Yield Strength at 0.2% Offset	56.0 ksi (386 MPa)
Elongation in 4D	3.0%

3.6.1.1.1 When properties other than those of Table 2 are required, tensile specimens as in 4.3.3 machined 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 AMS2360.

3.6.1.2 Integrally Cast Specimens

Specimens as in 4.3.3.1 shall have the properties shown in Table 2.

3.6.1.3 Separately Cast Specimens

Specimens as in 4.3.3.2 shall have the properties shown in Table 2.

3.7 Microstructure and Particle Homogeneity

The microstructure and reinforcing particle homogeneity in purchaser designated areas of the casting shall not exceed the limits established during process approval (See 4.3.4, 4.4.2.1). Castings which exhibit an unacceptable microstructure/homogeneity 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.

3.8 Quality

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.

3.8.1 When acceptance standards are not specified, Grade C of AMS2175 shall apply.

3.8.2 Methods of inspection and frequency of inspection shall be as agreed upon by purchaser and vendor. A “Casting Class” of AMS2175 may be selected to specify the method and frequency of inspection.

3.8.3 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.

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

3.8.4 When specified by purchaser, castings shall be fluorescent penetrant inspected using a method specified by purchaser, or, if not specified, a method in accordance with ASTM E 1417.

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

3.8.5.1 When authorized by purchaser, welding in accordance with AMS2694 or other welding program approved by purchaser may be used. The welding procedures used for these castings are proprietary.

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. 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

Except as specified in 4.2.1.1, composition (3.1), tensile properties of specimens cut from castings (3.6.1.1) or, when specified, from integrally cast coupons (3.6.1.2) or separately cast specimens (3.6.1.3), and quality (3.8) are acceptance tests and shall be performed to represent each melt or heat treat lot as applicable.

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

4.2.2 Periodic Tests

Microstructure and TiB_2 homogeneity analysis (3.7) and radiographic inspection (3.8.3) following the establishment of process control (4.4.2) 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

All technical requirements are preproduction tests and shall be performed 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 Two chemical analysis specimens in accordance with 3.4.1 from each melt for conformance to 3.1.

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

4.3.3 Not less than two tensile specimens machined from a casting or castings from each heat treat lot except when purchaser specifies use of separately cast specimens as in 4.3.3 or integrally cast coupons as in 4.3.3.1. If the number and locations of specimens are not shown on the drawing, not less than two specimens, one from the thickest section and one from the thinnest section, shall be cut from a casting or castings from each heat treat 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. Size, number, and location of integrally cast coupons shall be as specified on the casting drawing or as agreed upon by purchaser and vendor.

4.3.3.2 When permitted by purchaser, separately cast test bars may be tested in lieu of testing specimens cut from castings.

4.3.4 Microstructure and TiB_2 particle homogeneity of a casting shall be analyzed in the thickest and thinnest sections of the casting, in any purchaser designated areas of the casting, and in the representative tensile specimens to establish limits for acceptance. Analysis methods and limits are proprietary, and subject to supplier control but will include optical micrograph analysis (See 4.4.2.1).

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

Type of furnace
Furnace atmosphere
Alloy additions, fluxing, deoxidation, and gas removal procedures
Casting process control factors specific to this alloy to ensure consistent melt homogeneity
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 cycles
Straightening procedure, when applicable
Cleaning operations
Methods of inspection
Radiographic inspection sampling plan, if used
Welding procedure
Limits for acceptance and laboratory test method for microstructure and reinforcement particle homogeneity.

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