SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS4511 | REV. A

Issued 1989-10
Revised 2004-07
Reaffirmed 2012-02

Superseding AMS4511

Copper-Beryllium Alloy Castings
97Cu - 2.1Be - 0.52(Co + Ni) - 0.28Si
Solution and Precipitation Heat Treated (TFOO)

(Composition similar to UNS C82500)

RATIONALE

AMS4511A has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE:

1.1 Form:

This specification covers a copper-beryllium alloy in the form of sand, investment, or centrifugal castings.

1.2 Application:

These products have been used typically for small parts of intricate design requiring good corrosion resistance and high strength, 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 canceled 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/AMS4511A

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2360	Room Temperature Tensile Properties of Castings
AMS 2750	Pyrometry
AMS 2804	Identification, Castings

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 194	Test Methods for Determination of Compliance with Copper-Beryllium Alloys
ASTM B 208	Preparing Tension Test Specimens for Copper Alloy Sand, Permanent Mold, Centrifugal and Continuous Coatings
ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E 272	Reference Radiographs for High-Strength Copper-Base and Nickel-Copper Alloy Castings
ASTM E 478	Chemical Analysis of Copper Alloys
ASTM E 1417	Liquid Penetrant Examination
ASTM E 1742	Radiographic Inspection

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 B 194/B 194M or ASTM E 478, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

TABLE 1 – Composition

Element (3.1.1)	min	max
Beryllium	1.90	2.25
Cobalt + Nickel	0.35	0.70
Silicon	0.20	0.35
Iron	--	0.25
Nickel	--	0.20
Aluminum	--	0.15
Chromium	--	0.10
Tin	--	0.10
Zinc	--	0.10
Lead	--	0.02
Copper (3.1.2)	remainder	
Sum of named elements (3.1.3)	99.5	

3.1.1 These composition limits do not preclude the presence of other elements. Limits may be established and analysis required for unnamed elements by agreement between the manufacturer or supplier and purchaser.

3.1.2 Copper may be reported as “remainder”, or as the difference between the sum of results for all elements and 100%, or as the result of direct analysis.

3.1.3 When all of the elements in the table are analyzed, the sum shall be 99.5% minimum, but such determination is not required for routine acceptance of each lot.

3.2 Condition:

Solution and precipitation heat treated to the TF00 Temper (formerly AT) (See 8.3).

3.3 Casting:

Castings shall be poured from a single furnace charge of not more than 2000 pounds (907 kg). The furnace charge may consist of virgin material, gates, sprues, risers, or other recycled material. Final composition shall be certifiable to the composition referenced in 3.1.

3.4 Heat Qualification:

Each heat shall be qualified by chemical analysis and tensile specimens conforming to 3.4.1 and 3.4.2, respectively. Heat identity shall be maintained with all specimens and parts through all operations.

3.4.1 Chemical Analysis Specimens: Shall be cast from each heat and shall be of any convenient size, shape, and form.

3.4.2 Tensile Specimens: Shall be of standard proportions in accordance with ASTM E 8 or ASTM E 8M. Subsize specimens proportional to the standard specimens may be used. Specimens shall be prepared from at least one casting from each lot from the most representative measure of the condition of the casting, if specimen location is not shown on the part drawing. Tensile specimens shall be prepared in accordance with ASTM B 208 or with an 0.250 inch (6.35 mm) diameter at the reduced gage section, whichever is more representative of the casting as directed by the purchaser. Normally, bars are cast oversize and machined to size. Castings and separately-cast tensile specimens must be treated identically.

3.5 Heat Treatment:

All castings and representative tensile specimens shall be solution and precipitation heat treated according to 3.5.1 and 3.5.2, respectively, for acceptance according to 3.6.2 as being peak precipitation heat treated. Pyrometry shall be in accordance with AMS 2750. (See 8.2 for purchaser designed precipitation heat treatments for particular design requirements.)

3.5.1 Solution Heat Treating: All castings and tensile specimens shall be heated to 1400 to1475 °F (760 to 802 °C), held at temperature for 15 to 60 minutes per inch (25 mm) of cross-sectional area but in no case for less than 15 minutes, and quenched in cold water.

3.5.2 Precipitation Heat Treating: All castings and tensile specimens shall be heated to 625 to 675 °F (330 to 357 °C), held at heat for three hours ± 0.25, and air cooled.

3.6 Properties:

Castings and representative tensile specimens shall conform to the following requirements:

3.6.1 Hardness As Solution Heat Treated: Shall not be higher than 80 HRB, or equivalent, determined in accordance with ASTM E 18.

3.6.2 As Precipitation Heat Treated:

3.6.2.1 Hardness: Should be not lower than 35 HRC, or equivalent, determined in accordance with ASTM E 18 but castings shall not be rejected on the basis of hardness if the tensile property requirements of 3.6.2.2 are met.

3.6.2.2 Tensile Properties: Separately-cast tensile specimens, specimens cut from a casting or integrally-cast specimens shall have properties as follows, determined in accordance with ASTM E 8 or ASTM E 8M:

TABLE 2 – Minimum Tensile Properties

Properties	Value
Tensile Strength	150 ksi (1034 MPa)
Yield Strength at 0.2% Offset	120 ksi (827 MPa)
Elongation in 4D	2%

3.6.2.2.1 When properties other than those of 3.6.2.2 are required, tensile specimens as in 3.4.2, 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. See 8.2 for thermal treatment.

3.6.2.3 Microstructure: When specified, metallographic samples shall be prepared. Microstructure and grain size acceptance criteria shall be acceptable to purchaser.

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 sufficiently cleaned to permit inspection in accordance with ASTM E 1417. Standards for acceptance shall be as agreed upon by purchaser and vendor. Metallic shot or grit shall not be used for final cleaning.

3.7.2 When castings are broken for fracture test, the fracture shall have uniform color and be substantially free from oxides and other imperfections.

3.7.3 Castings shall be produced under radiographic control. This shall consist of radiographic examination of castings in accordance with ASTM E 1742 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 satisfactory quality. ASTM E 272 may be used to define radiographic acceptance standards.

3.7.4 When specified, castings shall be subjected to fluorescent penetrant inspection in accordance with ASTM E 1417.

3.7.5 Castings shall not be repaired by plugging, welding, or other methods without written permission from 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. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the castings conform to the specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Except as specified in 4.2.1.1, composition (3.1), hardness (3.6.2.1), and tensile properties (3.6.2.2) are acceptance tests and shall be performed on each lot of castings.

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

4.2.2 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 ingredients and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.3 Sampling and Testinq:

Shall be performed on each heat and lot; a lot shall be all parts and specimens with the same part number, cast from the same heat, and heat treated at the same time. If more than one part number is prepared from the same heat, each lot must be individually tested, and accepted. A heat is the metal poured from a single furnace charge of not more than 2000 pounds (907 kg).

4.3.1 One or more chemical analysis specimen(s) from each heat shall be analyzed in accordance with 3.4.1.

4.3.2 At least two castings from each lot shall be tested for hardness in accordance with 3.6.2.1.

4.3.3 Sufficient castings of each part number shall be supplied in accordance with 4.4.1 to ensure that conformance to all requirements of the drawing and this specification can be tested.

4.3.4 One or more tensile specimen(s) in the precipitation heat treated condition shall be tested in accordance with 3.4.2.

4.4 Approval:

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

4.4.2 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 operations and, when requested, test specimens, sample castings, or both. Production castings incorporating the revised operations shall not be shipped prior to receipt of reapproval.

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

Type of furnace and its capacity
Type and size of furnace charge
Time molten metal is in furnace
Furnace atmosphere
Fluxing or deoxidation procedure
Number of ladles used in pour
Mold refractory formulation
Mold back-up material
Gating practices
Mold preheat and metal pouring temperatures; variations of ±25 °F (±14 °C) from established limits are permissible
Solidification and cooling procedures
Solution and preecipitation heat treatment cycles
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 each heat and the results of tests on each lot to determine conformance to the other technical requirements of this specification. When properties of specimens cut from castings are specified, the report shall include the results of tests to determine conformance to such requirements. This report shall include the purchase order number, heat number, lot number, AMS 4511A, 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.