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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4650K

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Superseding AMS 4650J

Submitted for recognition as an American National Standard

COPPER-BERYLLIUM ALLOY, BARS, RODS, SHAPES, AND FORGINGS
98Cu - 1.9Be
Solution Heat Treated TB00 (A)

UNS C17200

1. SCOPE:

This specification covers a copper-beryllium alloy in the form of bars, rods, shapes, and forgings.

1.2 Application:

These products have been used typically for parts requiring a combination of high strength, good wear resistance, and corrosion resistance and where electrical conductivity or low magnetic susceptibility may be important, 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 following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2221 Tolerances, Copper and Copper Alloy Bars and Rods
MAM 2221 Tolerances, Metric, Copper and Copper Alloy Bars and Rods
AMS 2750 Pyrometry
AMS 2808 Identification, Forgings

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 249	General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes, and Forgings
ASTM B 249M	General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes, and Forgings (Metric)
ASTM E 3	Preparation of Metallographic Specimens
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 106	Chemical Analysis of Copper-Beryllium Alloys
ASTM E 112	Determining the Average Grain Size
ASTM E 478	Chemical Analysis of Copper Alloys

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-C-3993 Copper and Copper-Base Alloy Mill Products, Packaging of

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 106 or ASTM E 478, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	min	max
Beryllium	1.80	2.00
Cobalt + Nickel	0.20	--
Cobalt + Nickel + Iron	--	0.6
Aluminum	--	0.20
Silicon	--	0.20
Copper (3.1.1)	remainder	0.20
Copper + sum of all named elements (3.1.2)	99.5	--

3.1.1 Applicable when copper is not determined by analysis. The reported (certified) value is the difference between the sum of all other specified elements and 100%; it will therefore include unnamed elements. Limits for unnamed elements may be established by agreement between purchaser and manufacturer or supplier.

3.1.2 Applicable only when copper is determined by direct analysis.

3.2 Condition:

The product shall be supplied in the following condition:

3.2.1 Bars, Rods, and Shapes: Hot or cold worked to size, solution heat treated, and cold straightened if necessary.

3.2.1.1 The cross-sectional area of bars, rods, and shapes shall be less than one-half that of the ingots from which they are formed; i.e., bars, rods, and shapes shall have been subjected to over 50% reduction of area during formation.

3.2.2 Forgings: Solution heat treated.

3.2.3 Stock for Forging: As ordered by the forging manufacturer.

3.3 Heat Treatment:

Product shall be solution heat treated by heating within the range 1400 to 1475 °F (760 to 802 °C), holding at heat for 30 to 60 minutes, and quenching in water. Pyrometry shall be in accordance with AMS 2750.

3.4 Properties:

The product shall conform to the following requirements:

3.4.1 As Solution Heat Treated:

3.4.1.1 Bars, Rods, and Shapes:

3.4.1.1.1 Tensile Properties: Shall be as shown in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M; elongation requirement applies only to product over 0.311 inch (7.90 mm) in nominal diameter or distance between parallel sides.

TABLE 2 - Tensile Properties

Property	Value
Tensile Strength, maximum	85.0 ksi (586 MPa)
Elongation in 2 Inches (50.8 mm), minimum	35%

3.4.1.1.2 Average Grain Size: Shall be not larger than shown in Table 3, determined in accordance with ASTM E 112. Product may be precipitation heat treated as in 3.4.2 before examination.

TABLE 3 - Maximum Average Grain Size

Nominal Diameter or Least Distance Between Parallel Sides Inches	Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Grain Size Millimeter
Up to 1.000, excl	Up to 25.40, excl	0.050
1.000 to 1.500, excl	25.40 to 38.10, excl	0.075
1.500 to 2.000, excl	38.10 to 50.80, excl	0.100
2.000 to 3.000, excl	50.80 to 76.20, excl	0.125

3.4.1.2 Forgings:

3.4.1.2.1 Hardness: Shall be not higher than 85 HRB, or equivalent, determined in accordance with ASTM E 18.

3.4.1.2.2 Average Grain Size: Shall be as agreed upon by purchaser and vendor, determined in accordance with ASTM E 112.

3.4.1.2.3 Average Grain Flow: Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of re-entrant grain flow.

3.4.1.3 Bar, Rod, Shapes, and Forgings:

3.4.1.3.1 (R) Microstructure: Product shall contain not more than 6% beta phase constituent, determined at 100X magnification on specimens prepared in accordance with ASTM E 3.

3.4.2 (R) After Precipitation Heat Treatment: Bars, rods, shapes, and forgings shall have the following properties after being precipitation heat treated by heating within the range 600 to 675 °F (316 to 358 °C), holding at heat for 3 hours ± 0.25, and cooling in air.

3.4.2.1 Bars, Rods, and Shapes:

3.4.2.1.1 Tensile Properties: Shall be as shown in Table 4, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 4 - Minimum Tensile Properties

Property	Value
Tensile Strength	165 ksi (1138 MPa)
Yield Strength at 0.2% Offset	140 ksi (965 MPa)
Elongation in 2 Inches (50.8 mm)	3%

3.4.2.1.2 (R) Hardness: Bars, rods, and shapes 0.188 inch (4.78 mm) and over in nominal diameter or least distance between parallel sides shall have hardness not lower than 36 HRC, or equivalent, determined in accordance with ASTM E 18. The product shall not be rejected on the basis of hardness if the tensile properties of 3.4.2.1.1 are acceptable, determined on product taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness.

3.4.2.2 Forgings:

3.4.2.2.1 Hardness: Shall be not lower than 36 HRC, or equivalent, determined in accordance with ASTM E 18.

3.4.3 After Re-Solution and Precipitation Heat Treatment: Bars, rods, shapes, and forgings shall have hardness not lower than 36 HRC, or equivalent, determined in accordance with ASTM E 18, after being re-solution heat treated in accordance with 3.3 and precipitation heat treated in accordance with 3.4.2.

3.4.4 Forging Stock: As agreed upon by purchaser and vendor.

3.5 Quality: Product, 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 product.

3.6 Tolerances:

Bars and rods shall conform to AMS 2221 or MAM 2221 as applicable to refractory alloys.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The vendor of the product 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 product conforms to specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: All technical requirements, except hardness of bars, rods, and shapes after precipitation heat treatment (3.4.2.1.2), properties after re-solution and precipitation heat treatment (3.4.3), and properties of forging stock (3.4.4), are acceptance tests and shall be performed on each lot.

4.2.2 (R) Periodic Tests: Hardness of bars, rods, and shapes after precipitation heat treatment (3.4.2.1.2), properties of bars, rods, shapes, and forgings after re-solution and precipitation heat treatment (3.4.3), and properties of forging stock (3.4.4) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing:

Shall be in accordance with the following:

4.3.1 Bars, Rods, and Shapes: ASTM B 249 or ASTM B 249M and the following:

4.3.1.1 Specimens for tensile testing of bars, rods, and shapes over 1.500 inch (38.10 mm) in nominal diameter or least distance between parallel sides shall have their axes located at approximately mid-radius.

4.3.2 Forgings: Two samples from each lot; a lot shall be all forgings of one part number processed consecutively and presented for vendor's inspection at one time.

4.3.3 Forging Stock: As agreed upon by purchaser and vendor.

4.4 Reports:

The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition of each lot and the results of tests on each lot to determine conformance to the other acceptance test requirements and, when performed, to the periodic test requirements. This report shall include the purchase order number, lot number, AMS 4650K**,** size, and quantity. If forgings are supplied, the part number and the size and melt source of stock used to make the forgings shall also be included.

4.5 Resampling and Retesting: Failure of any specimen to meet specified requirements shall cause product represented by such specimens to be subject to rejection. A retest sample of at least two specimens shall be randomly selected to replace each failed specimen from the original sample. All retest samples shall conform to specified requirements. If any retest specimen fails to meet specified requirements, the product represented shall be rejected.

5. PREPARATION FOR DELIVERY:

5.1 Identification:

Shall be as follows:

5.1.1 Bars, Rods, and Shapes: Individual pieces or bundles shall have attached a suitable tag legibly marked with the purchase order number, AMS 4650K, and the nominal size or shall be boxed and the box marked with the same information.

5.1.2 Forgings: In accordance with AMS 2808.

5.1.3 Forging Stock: As agreed upon by purchaser and vendor.