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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4650J

Issued 5 DEC 1939
Revised 1 JUL 1991

Submitted for recognition as an American National Standard

Superseding AMS 4650H

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

UNS C17200

1. SCOPE:

1.1 Form: This specification covers one type of copper-beryllium alloy in the form of bars, rods, shapes, and forgings.

1.2 Application: Primarily for parts requiring a combination of high strength, good wear resistance, and corrosion resistance and where electrical conductivity or low magnetic susceptibility is important.

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.

2.1.1 Aerospace Material Specifications:

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

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Printed in U.S.A.

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM B 249 - General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, and Shapes
ASTM B 249M - General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, and Shapes (Metric)
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 Average Grain Size
ASTM E 478 - Chemical Analysis of Copper Alloys

2.3 U.S. Government Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

2.3.1 Military Specifications:

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

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined Ø 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:

	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
Copper + sum of all named elements (3.1.2)	99.5	--

3.1.1 Applicable when copper is not determined by analysis. The reported Ø (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. Ø

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 Solution Heat Treatment: Bars, rods, shapes, and forgings shall be solution heat treated by heating to 1450°F ± 25 (788°C ± 14), holding at heat for 30 minutes, and quenching in water. Pyrometry shall conform to 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 follows, determined in accordance with ASTM E 8 or ASTM E 8M; elongation requirement applies only to product over 0.311 inch (7.87 mm) in nominal diameter or distance between parallel sides:

Tensile Strength, maximum	85.0 ksi (586 MPa)
Elongation, minimum	35%

3.4.1.1.2 Hardness: Bars, rods, and shapes over 0.311 inch (7.87 mm) in nominal diameter or distance between parallel sides should have hardness not higher than 85 HRB, or equivalent, determined in accordance with ASTM E 18, but the product shall not be rejected on the basis of hardness if the tensile property requirements of 3.4.1.1.1 are met. Hardness requirements for bars, rods, and shapes 0.311 inch (7.87 mm) and under in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.1.1.3 Grain Size: Shall be not larger than the following, determined in accordance with ASTM E 112. Product may be precipitation heat treated as in 3.4.2 before examination.

Nominal Diameter or Least Distance Between Parallel Sides		Average Grain Size
Inches	Millimeters	mm, max
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

3.4.1.1.3.1 Grain size of bars, rods, and shapes 3.000 inches (76.20 mm) and over in nominal diameter or least distance between parallel sides shall be as agreed upon between purchaser and vendor.

3.4.1.2 Forgings:

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

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

3.4.1.2.3 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 Microstructure: Shall not reveal more than 6% beta phase constituent, Ø determined at 100X magnification. Any beta phase present shall be fine and well dispersed and shall not be in the form of stringers. Standards for acceptance shall be as agreed upon by purchaser and vendor. Product may be precipitation heat treated as in 3.4.2 before examination.

3.4.2 After Precipitation Heat Treatment: Bars, rods, shapes, and forgings Ø shall have the following properties after being precipitation heat treated by heating to 600° - 625°F (316° - 329°C), holding at heat for 3 hours ± 1/4 and cooling in air. Pyrometry shall comform to AMS 2750.

3.4.2.1 Bars, Rods, and Shapes:

3.4.2.1.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E 8 or ASTM E 8M:

Tensile Strength, minimum	165 ksi (1138 MPa)
Yield Strength at 0.2% Offset, minimum	140 ksi (965 MPa)
Elongation, minimum	3%

3.4.2.1.2 Hardness: Bars, rods, and shapes 0.188 inch (4.78 mm) and over in nominal diameter or least distance between parallel sides should have hardness not lower than 36 HRC, or equivalent, determined in accordance with ASTM E 18, but the product shall not be rejected on the basis of hardness if the tensile properties of 3.4.2.1.1 are met. Hardness requirements for bars, rods, and shapes under 0.188 inch (4.78 mm) in nominal diameter or least distance between parallel sides shall be as agreed upon by purchaser and vendor.

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 Ø samples for vendor's tests and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for all technical requirements except 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 Periodic Tests: Tests for properties of bars, rods, shapes, and forgings after re-solution and precipitation heat treatment (3.4.3) and for 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:
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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.