Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 4650G
Superseding AMS 4650F
Issued 12-5-39
Revised 1-15-79

UNS C17200

COPPER-BERYLLIUM ALLOY BARS, RODS, AND FORGINGS
98Cu - 1.9Be (CDA 172)
Solution Heat Treated

1. SCOPE:

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

1.2 Application: Primarily for parts requiring high strength with good electrical conductivity or lack of magnetic susceptibility.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2221 - Tolerances, Copper and Copper Alloy Rods and Bars
AMS 2350 - Standards and Test Methods
AMS 2808 - Identification, Forgings

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

ASTM B249 - General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, and Shapes
ASTM E8 - Tension Testing of Metallic Materials
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E106 - Chemical Analysis of Copper-Beryllium Alloys
ASTM E112 - Estimating the Average Grain Size of Metals

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

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 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 by wet chemical methods in accordance with ASTM E106, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

	min	max
Beryllium	1.8	2.0
Cobalt	0.20	--
Nickel + Cobalt + Iron	--	0.60
Other Elements, total	--	0.50
Copper	remainder	

3.2 Condition: The product shall be supplied in the following condition:

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

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

3.2.2 Forgings: Solution heat treated.

3.2.3 Forging Stock: As ordered by the forging manufacturer.

3.3 Properties: The product shall conform to the following requirements:

3.3.1 As Solution Heat Treated:

3.3.1.1 Bars and Rods:

3.3.1.1.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8; elongation requirement applies only to product over 0.311 in. (7.90 mm) in nominal diameter or distance between parallel sides.

Tensile Strength	60,000 - 85,000 psi (414 - 586 MPa)
Elongation in 4D, min	35%

3.3.1.1.2 Hardness: Bars and rods over 0.311 in. (7.90 mm) in nominal diameter or distance between parallel sides should have hardness of 45 - 85 HRB or equivalent, determined in accordance with ASTM E18, but the product shall not be rejected on the basis of hardness if the tensile property requirements of 3.3.1.1.1 are met. Hardness requirements for bars and rods 0.311 in. (7.90 mm) and under in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.3.1.1.3 Grain Size: The product shall have average grain size not larger than the following, determined
ø in accordance with ASTM E112. Product may be precipitation heat treated as in 3.3.2 before examination.

Nominal Diameter or Distance Between Parallel Sides		Average Grain Size mm, max
Inches	(Millimetres)	
Up to 1.500, excl	(Up to 38.10, excl)	0.050
1.500 to 3.000, excl	(38.10 to 76.20, excl)	0.075
3.000 and over	(76.20 and over)	0.100

3.3.1.2 Forgings:

3.3.1.2.1 Hardness: Shall be not higher than 142 HB/10/500 or equivalent, determined in accordance
ø with ASTM E10.

3.3.1.2.2 Grain Size: Shall be as agreed upon by purchaser and vendor, determined in accordance with
ø ASTM E112.

3.3.1.3 Bars, Rods, and Forgings:

3.3.1.3.1 Microstructure: Shall reveal a minimum of beta phase constituent. Any beta phase present shall be fine and well dispersed and shall not be in the form of stringers. Standards for
ø acceptance shall be as agreed upon by purchaser and vendor. Material may be precipitation heat treated as in 3.3.2 before examination.

3.3.2 After Precipitation Heat Treatment: Bars, rods, and forgings shall have the following properties after being precipitation heat treated by heating to 600° - 625° F (315° - 330°C) holding at heat for 3 hr ± 0.25, and cooling in air:

3.3.2.1 Bars and Rods:

3.3.2.1.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8:

ø Tensile Strength	165,000 - 190,000 psi (1138 - 1310 MPa)
Yield Strength at 0.2% Offset, min	145,000 psi (1000 MPa)
Elongation in 4D, min	3%

3.3.2.1.2 Hardness: Bars and rods 0.188 in. (4.78 mm) and over in nominal diameter or least distance between parallel sides should have hardness of 36 - 42 HRC or equivalent, determined in
ø accordance with ASTM E18, but the product shall not be rejected on the basis of hardness if the tensile properties of 3.3.2.1.1 are met. Hardness requirements for bars and rods under 0.188 in. (4.78 mm) in nominal diameter or least distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.3.2.2 Forgings:

ø 3.3.2.2.1 Hardness: Shall be 36 - 42 HRC or equivalent, determined in accordance with ASTM E18.

3.3.3 After Re-Solution and Precipitation Heat Treatment: Bars, rods, and forgings shall have hardness of HRC 36 - 42 or equivalent, determined in accordance with ASTM E18, after being resolution-
ø heat treated by heating to 1450° F ± 25 (790° C ± 15), holding at heat for 1 hr per inch (25 mm) of nominal thickness, and quenching in water and precipitation treated by heating to 600° - 625° F (315° - 330°C), holding at heat for 3 hr ± 0.25, and cooling in air.

Ø 3.3.4 Forging Stock: As agreed upon by purchaser and vendor.

3.4 Quality: The product, as received by purchaser, shall be uniform in quality and condition, sound, Ø free from foreign materials and from internal and external imperfections detrimental to usage of the product.

3.5 Tolerances: Unless otherwise specified, tolerances for bars and rods shall conform to AMS 2221 as applicable to refractory alloys.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to all technical requirements of this Ø specification except properties after re-solution heat treatment (3.3.3) and properties of forging stock (3.3.4) are classified as acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for properties of bars, rods, Ø and forgings after re-solution and precipitation heat treatment (3.3.3) and for properties of forging stock (3.3.4) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling: Shall be in accordance with the following:

4.3.1 Bars and Rods: ASTM B249 and the following:

4.3.1.1 Specimens for tensile testing of bars and rods over 1.500 in. (38.10 mm) in nominal diameter Ø or distance between parallel sides shall have their axes located at approximately midradius.

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

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