

**AEROSPACE  
MATERIAL  
SPECIFICATION**

Submitted for recognition as an American National Standard

SAE AMS 4650H

Issued 12-5-39

Revised 1-1-86

Superseding AMS 4650G

**COPPER-BERYLLIUM ALLOY BARS, RODS, AND FORGINGS**  
98Cu - 1.9Be  
Solution Heat Treated

UNS C17200

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 shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

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 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

SAE Technical Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

AMS documents are protected under United States and international copyright laws. Reproduction of these documents by any means is strictly prohibited without the written consent of the publisher.

## 2.2 (Continued):

ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

ASTM E106 - Chemical Analysis of Copper-Beryllium Alloys

ASTM E112 - Determining Average Grain Size

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.2.3.1 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 by wet chemical methods in accordance with ASTM E106 or by spectrographic or 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 Solution Heat Treatment: Bars, rods, and forgings shall be solution heat treated by heating to  $1450^{\circ}\text{F} + 25$  ( $790^{\circ}\text{C} + 15$ ), holding at heat for 1 hr per inch (25 mm) of nominal thickness, and quenching in water.3.4 Properties: The product shall conform to the following requirements:3.4.1 As Solution Heat Treated:3.4.1.1 Bars and Rods:

3.4.1.1.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8; elongation requirement applies only to product over 0.311 in. (7.75 mm) in nominal diameter or distance between parallel sides.

|                       |                                     |
|-----------------------|-------------------------------------|
| Tensile Strength      | 60,000 - 85,000 psi (415 - 585 MPa) |
| Elongation in 4D, min | 35%                                 |

3.4.1.1.2 Hardness: Bars and rods over 0.311 in. (7.75 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 3.4.1.1.1 are met. Hardness requirements for bars and rods 0.311 in. (7.75 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: The product shall have average grain size not larger than the following, determined in accordance with ASTM E112. Product may be precipitation heat treated as in 3.4.2 before examination.

| <u>Nominal Diameter<br/>or Distance Between Parallel Sides</u> |                      | <u>Average<br/>Grain Size</u> |
|--|----------------------|-------------------------------|
| <u>Inches</u>  | <u>Millimetres</u>   | <u>mm, max</u>                |
| Up to 1.500, excl  | Up to 37.50, excl    | 0.050                         |
| 1.500 to 3.000, excl   | 37.50 to 75.00, excl | 0.075                         |
| 3.000 and over   | 75.00 and over       | 0.100                         |

3.4.1.2 Forgings:

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

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

3.4.1.2.3 Grain Flow: Except in areas of die forgings containing end grain, the grain flow shall follow the general contour of the forging, showing no evidence of re-entrant flow.

3.4.1.3 Bars, Rods, and Forgings:

3.4.1.3.1 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 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, 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  $\pm$  0.25, and cooling in air:

### 3.4.2.1 Bars and Rods:

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

|                                    |  |
|------------------------------------|--|
| Tensile Strength                   | 165,000 - 190,000 psi<br>(1140 - 1310 MPa) |
| Yield Strength at 0.2% Offset, min | 145,000 psi (1000 MPa)                     |
| Elongation in 4D, min              | 3%   |

3.4.2.1.2 Hardness: Bars and rods 0.188 in. (4.75 mm) and over in nominal diameter or least distance between parallel sides should have hardness of 36 - 42 HRC or equivalent, determined in accordance with ASTM E18, 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 and rods under 0.188 in. (4.75 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 36 - 42 HRC, or equivalent, determined in accordance with ASTM E18.

3.4.3 After Re-Solution and Precipitation Heat Treatment: Bars, rods, and forgings shall have hardness of 36 - 42 HRC or equivalent, determined in accordance with ASTM E18, after being resolution-heat treated in accordance with 3.3 and precipitation treated in accordance with 3.4.2.

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

3.5 Quality: The 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  $\emptyset$  samples for vendor's tests 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 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 to determine conformance to all technical requirements of this specification except properties after re-solution and precipitation heat treatment (3.4.3) and properties of forging stock (3.4.4) are classified as acceptance tests and shall be performed on each lot.