# AEROSPACE
# MATERIAL SPECIFICATIONS

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc. 485 Lexington Ave., New York 17, N.Y.

**AMS 4650E**

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

1. ACKNOWLEDGMENT: A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

2. FORM: Bars, rods, forgings, and forging stock.

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

4. COMPOSITION:

| | min | max |
|---|---|---|
| Beryllium | 1.80 | 2.05 |
| Nickel + Cobalt | 0.20 | -- |
| Nickel + Cobalt + Iron | -- | 0.6 |
| Copper + Total Named Elements | 99.5 | -- |

5. CONDITION:

5.1 Bars and Rods: Hot or cold worked to size and solution heat treated, in a suitable condition for precipitation heat treatment. Bars and rods may be cold straightened if necessary.

5.1.1 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.

5.2 Forgings: Solution heat treated, in a suitable condition for precipitation heat treatment, unless otherwise specified.

5.3 Forging Stock: As ordered by the forging manufacturer.

6. TECHNICAL REQUIREMENTS:

6.1 Tensile Properties:

6.1.1 Bars and Rods:

| | |
|---|---|
| Tensile Strength, psi | 60,000 - 85,000 |
| Elongation, % in 2 in. or 4D | 35 min |

6.1.1.1 Elongation requirement applies only to material over 0.311 in. in diameter or distance between parallel sides.

6.2 Hardness:

6.2.1 Bars and Rods: Should have hardness of Rockwell B 45 - 85 or equivalent but shall not be rejected on the basis of hardness if the tensile property requirements are met. Hardness requirements apply only to material over 0.311 in. in diameter or distance between parallel sides.

Ø 6.2.2 Forgings: Shall have hardness not higher than Brinell (500 kg) 142 or equivalent.

6.2.3 The requirements of 6.2.1 and 6.2.2 apply from surface to center of the material.

6.3 Microstructure: Shall reveal a minimum of beta phase constituent. Any beta phase present shall be Ø fine and well dispersed and shall not be in the form of stringers. Material may be precipitation heat treated as in 6.5 before examination.

6.4 Grain Size: Average grain size, determined in accordance with the issue of ASTM E112 listed in the Ø latest issue of AMS 2350, shall be not larger than shown below. Material may be precipitation heat treated as in 6.5 before examination.

6.4.1 Bars and Rods:

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| Nominal Diameter or Distance Between Parallel Sides Inches | Average Grain Size mm, max |
|---|---|
| Up to 1.5, excl | 0.050 |
| 1.5 to 3.0, excl | 0.075 |
| 3.0 and over | As agreed upon by purchaser and vendor |

Ø 6.4.2 Forgings: As agreed upon by purchaser and vendor.

6.5 Properties After Precipitation Heat Treatment: Material shall conform to the following requirements after being precipitation heat treated by heating to 600 F ± 5 (315.6 C ± 2.8), holding at heat for 3 hr, and cooling in air.

6.5.1 Tensile Properties:

6.5.1.1 Bars and Rods:

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| | |
|---|---|
| Tensile Strength, psi | 165,000 - 190,000 |
| Yield Strength at 0.2% Offset or at 0.0197 in. in 2 in. Extension Under Load (E = 18,500,000), psi | 145,000 min |
| Elongation, % in 2 in. or 4D | 3 min |

6.5.2 Hardness:

6.5.2.1 Bars and Rods: Should have hardness of Rockwell C 36 - 42 or equivalent but shall not be rejected Ø on the basis of hardness if the tensile property requirements are met. Hardness, requirements apply only to material 0.188 in. and over in diameter or distance between parallel sides.

Ø 6.5.2.2 Forgings: Rockwell C 36 - 42 or equivalent.

6.6 Properties After Re-Solution and Precipitation Heat Treatment: Material after being re-solution heat treated by heating to 1450 F ± 25 (787.8 C ± 14), holding at heat for 1 hr per inch of thickness, and Ø quenching in water, and then being precipitation treated as in 6.5 shall have hardness of Rockwell C 36 - 42 or equivalent.

7. QUALITY: Material shall be uniform in quality and condition, clean, sound, smooth, and free from foreign materials and from internal and external imperfections detrimental to fabrication or to performance of parts.

8. TOLERANCES: Unless otherwise specified, tolerances shall conform to all applicable requirements of the latest issue of AMS 2221 for Refractory Alloys.