SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4651C

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Superseding AMS 4651B

Copper-Beryllium Alloy, Bars and Rods
98Cu - 1.9Be (CDA 172)
Hard Temper (TD04)

(Composition similar to UNS C17200)

1. SCOPE:

1.1 Form:

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

1.2 Application:

These products have been used typically for parts requiring high strength with good electrical conductivity and the nonmagnetic properties are 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 each 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 issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2221	Tolerances, Copper and Copper Alloy Bars and Rods
AMS 2750	Pyrometry

2.2 ASTM Publications:

Available from ASTM, 100 Bar Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

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 B 194 Annex	Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar
ASTM E 112	Determining the Average Grain Size

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined by the chemical methods in accordance with ASTM B 194; by spectrochemical methods, or by other analytical methods acceptable to purchaser.

Table 1 - Composition

Element (3.1.1)	min	max
Beryllium	1.80	2.00
Nickel plus Cobalt	0.20	--
Nickel plus Cobalt plus Iron	--	0.6
Aluminum	--	0.20
Silicon	--	0.20
Lead	--	0.20
Copper	(see 3.1.2)	--
Sum of Named Elements (3.1.3)	99.5	--

3.1.1 These composition limits do not preclude the presence of other elements. Limits may be established and analysis required for unnamed elements by agreement between the manufacturer or supplier and purchaser.

3.1.2 Copper may be reported as “remainder”, or as the difference between the sum of results for all elements and 100%, or as the result of direct analysis.

3.1.3 When all the elements in the table are analyzed, the sum shall be 99.5% minimum, but such determination is not required for routine acceptance of each lot.

3.2 Condition:

Solution heat treated and cold worked to hard temper (TD04), in a suitable condition for precipitation heat treatment.

3.3 Properties:

The product shall conform to the following requirements: The applicable limits are those that apply to the specified (ordered) dimension.

3.3.1 As Solution Heat Treated and Cold Rolled:

3.3.1.1 Tensile Properties: Shall be shown in Table 2, determined in accordance with ASTM E 8, or ASTM E 8M:

TABLE 2A - Tensile Properties, Inch/Pound Units

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength ksi	Elongation in 4D %, minimum
Up to 0.375, incl	95.0 to 130.0	10
Over 0.375 to 1.000, incl	90.0 to 120.0	10
Over 1.000 to 2.000, incl	85.0 to 115.0	8

TABLE 2B - Tensile Properties, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Tensile Strength MPa	Elongation in 4D %, Minimum
Up to 9.52, incl	655 to 896	10
Over 9.52 to 25.40, incl	621 to 827	10
Over 25.40 to 50.80, incl	586 to 793	8

3.3.1.2 Hardness: Should be as shown in Table 3 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 3.3.1.1 are met on material from the same lot with similar nonconforming hardness.

TABLE 3 - Hardness

Nominal Diameter or Least Distance Between Parallel Sides Inches	Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Hardness HRB
Over 0.188 to 0.249, incl	Over 4.78 to 6.32, incl	88 to 96
Over 0.249 to 0.375, incl	Over 6.32 to 9.52, incl	92 to 103
Over 0.375 to 1.000, incl	Over 9.52 to 25.40, incl	91 to 102
Over 1.000 to 2.000, incl	Over 25.40 to 50.80, incl	88 to 101

3.3.1.3 Microstructure: Shall reveal not more than 6% beta phase. Any beta phase present shall be fine and well dispersed. Product may be precipitation heat treated as in 3.3.2 before examination. Specimen shall be prepared in accordance with ASTM E 3 or other suitable procedure.

3.3.1.4 Grain Size: Shall be not larger than as shown in Table 4, determined in accordance with ASTM E 112. Product may be precipitation heat treated as in 3.3.2 before determining grain size.

TABLE 4 - Maximum Average Grain Size

Nominal Diameter or Distance Between Parallel Sides Inches	Nominal Diameter or Distance Between Parallel Sides Millimeters	Average Grain Size Millimeter
Up to 1.500, excl	Up to 38.10, excl	0.050
1.500 to 2.000, incl	38.10 to 50.80, incl	0.075

3.3.2 After Precipitation Heat Treatment: The product shall have the following properties after being precipitation heat treated by heating in the range 600 to 660 °F (315 to 349 °C), holding at heat for 2 to 3 hours, and cooling in air. Pyrometry shall be in accordance with AMS 2750.

3.3.2.1 Tensile Properties: Shall be as specified in Table 5.

TABLE 5A - Tensile Properties, Inch/Pound Units

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi, minimum	Elongation in 4D %, minimum
Up to 0.375, incl	185.0 to 215.0	145.0	2
Over 0.375 to 1.000, incl	180.0 to 210.0	145.0	2
Over 1.000 to 3.000, incl	175.0 to 205.0	145.0	3

TABLE 5B - Tensile Properties, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min
Up to 9.52, incl	1276 to 1482	1000	2
Over 9.52 to 25.40, incl	1241 to 1448	1000	2
Over 25.40 to 76.20, incl	1207 to 1413	1000	3

3.3.2.2 Hardness: Should be as shown in Table 6, 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 3.3.2.1 are met on material from the same lot with similar nonconforming hardness.

TABLE 6 - Hardness

Nominal Diameter or Least Distance Between Parallel Sides Inches	Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Hardness HRC min	Hardness HRC max
Up to 0.249, incl	Up to 6.32, incl	40	—
Over 0.249 to 0.375, incl	Over 6.32 to 9.52, incl	39	45
Over 0.375 to 1.000, incl	Over 9.52 to 25.40, incl	38	44
Over 1.000 to 2.000, incl	Over 25.40 to 50.80, incl	37	45

3.4 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.

3.5 Tolerances:

The product 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 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: Composition (3.1), tensile properties (3.3.1.1 and 3.3.2.1), and tolerances (3.5) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Microstructure (3.3.1.3), hardness (3.3.1.2 and 3.3.2.2) and grain size (3.3.1.4) requirements 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 ASTM B 249 or ASTM B 249M and the following.