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

AEROSPACE MATERIAL SPECIFICATION

AMS 4616C
Superseding AMS 4616B
Issued 7-1-56
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SILICON BRONZE BARS, FORGINGS, AND TUBING
92Cu - 3.2Si - 2.8Zn - 1.5Fe

1. SCOPE:

1.1 Form: This specification covers one type of bronze in the form of bars, forgings, tubing, and forging stock.

1.2 Application: Primarily for anti-friction bearing cages.

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 2223 - Tolerances, Copper and Copper Alloy Seamless Tubing
AMS 2350 - Standards and Test Methods
AMS 2375 - Approval and Control of Critical Forgings
AMS 2808 - Identification, Forgings

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

ASTM B154 - Mercurous Nitrate Test for Copper and Copper Alloys
ASTM B249 - General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, and Shapes
ASTM B251 - General Requirements for Wrought Seamless Copper and Copper-Alloy Tube
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 E54 - Chemical Analysis of Special Brasses and Bronzes
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

Printed in U.S.A.

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E54, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other approved analytical methods:

	min	max
Copper	90.00	--
Silicon	2.40	4.00
Zinc	1.50	4.00
Iron	1.00	2.00
Manganese	--	1.00
Phosphorus	--	0.10
Total Named Elements	99.50	--

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

3.2.1 Rods, Bars, and Tubing: Hot rolled or drawn, or extruded, cold finished if necessary, and stress-relieved.

3.2.2 Forgings: Stress-relieved.

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 Rods, Bars, Forgings, and Tubing:

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

Tensile Strength, min	56,000 psi (386 MPa)
Yield Strength at 0.2% Offset, min	20,000 psi (138 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	30 %

3.3.1.2 Hardness: Shall be not lower than 90 HB/10/1000 or equivalent, determined in accordance with ASTM E10 on the surface, except on rounds where a flat, as necessary for accuracy, may be made; hardness also shall be not lower than 55 HRB, determined in accordance with ASTM E18, approximately midway between center and surface of the cross-section.

3.3.1.3 Grain Size: Shall be as follows, determined in accordance with ASTM E112:

3.3.1.3.1 Rods, Bars, and Tubing: Average grain size shall be not larger than 0.20 millimetre.

3.3.1.3.2 Forgings: Maximum grain size shall be 0.50 mm except that not more than 25% of the area may show grains up to 1.00 mm; these requirements apply only to the outer half of the radii of forgings for anti-friction bearing cages.

3.3.1.4 Embrittlement: Specimens as in 4.3.5.1 and 4.3.5.2 shall withstand, without cracking, immersion in mercurous nitrate solution in accordance with ASTM B154, Procedure A.

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

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

3.5 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight rods, bars, and Ø tubing will be acceptable in mill lengths of 6 - 20 ft (1.8 - 6.1 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft (3 m).

3.6 Tolerances: Unless otherwise specified, tolerances shall conform to the following:

3.6.1 Bars and Rods: AMS 2221 as applicable to refractory alloys.

3.6.2 Tubing: AMS 2223 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 Ø 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 composition (3.1), tensile property (3.3.1.1), Ø hardness (3.3.1.2), and grain size (3.3.1.3) requirements are classified as acceptance tests.

4.2.2 Periodic Tests: Tests to determine conformance to embrittlement (3.3.1.4) requirements are Ø classified as periodic tests.

4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this Ø specification are classified as preproduction tests.

4.2.3.1 For direct U.S. Military procurement of forgings, substantiating test data and, when requested, Ø preproduction forgings shall be submitted to the congnizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be in accordance with the following:

Ø 4.3.1 Rods and Bars: ASTM B249.

Ø 4.3.2 Tubing: ASTM B251.

4.3.3 Forgings and Forging Stock: As agreed upon by purchaser and vendor, a lot shall be not more than Ø 5,000 lb (2270 kg) of forgings of the same part number produced in a continuous series of operations and presented for vendor's inspection at one time.

Ø 4.3.4 Composition: One sample from each lot.

4.3.5 Tensile Properties: One sample from each lot.

4.3.5.1 The axis of tensile test specimens from bars over 1.500 in. (38.10mm) in diameter or distance between parallel sides and from forgings over 1.500 in. (38.10mm) in nominal cross-section thickness shall be located approximately midway between center and surface.

Ø 4.3.6 Hardness: Each piece.

Ø 4.3.7 Grain Size: One sample from each lot.

Ø 4.3.8 Embrittlement: As agreed upon by purchaser and vendor.

4.3.8.1 Test specimens from rods, bars, and tubing shall be full cross-section of the product and shall have length of either approximately 6 in. or 150 mm or twice the diameter or least distance between parallel sides, whichever is greater.

4.3.8.2 Test specimens from forgings may be any convenient size or shape, or an entire forging may be used.

Ø 4.4 Approval: When specified, approval and control of forgings shall be in accordance with AMS 2375.

4.5 Reports:

4.5.1 The vendor of the product shall furnish with each shipment three copies of a report showing the results of tests for chemical composition of each lot and the results of tests on each lot to determine conformance to the other acceptance test requirements of this specification. This report shall include the purchase order number, lot number, material specification number and its revision letter, size, and quantity. If forgings are supplied, the part number and the size and melt source of stock used to make the forgings shall also be included.

4.5.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number and its revision letter, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.6 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.

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5. PREPARATION FOR DELIVERY:

5.1 Identification: The product shall be identified as follows:

5.1.1 Rods, Bars, and Tubing: Individual pieces or bundles shall have attached a durable tag marked with the purchase order number, AMS 4616C, and nominal size, or shall be boxed and the box marked with the same information.

5.1.2 Forgings: In accordance with AMS 2808.

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

5.2 Packaging:

5.2.1 The product shall be prepared for shipment in accordance with commercial practice to ensure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

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