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AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 4616D
Superseding AMS 4616C

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SILICON BRONZE BARS, FORGINGS, AND TUBING
92Cu - 3.2Si - 2.8Zn - 1.5Fe
Stress Relieved

1. SCOPE:

1.1 Form: This specification covers one type of bronze in the form of bars, rods, 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 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 2223 - Tolerances, Copper and Copper Alloy Seamless Tubing
MAM 2223 - Tolerances, Metric, Copper and Copper Alloy Seamless Tubing
AMS 2350 - Standards and Test Methods
AMS 2375 - Control of Forgings Requiring First Article Approval
AMS 2808 - Identification, Forgings

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2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, 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 - 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 E54 or by spectrographic or other analytical methods approved by purchaser:

	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	--

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

3.2.1 Bars, Rods, 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 Bars, Rods, 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 (385 MPa)
Yield Strength at 0.2% Offset, min	20,000 psi (140 MPa)
Elongation in 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 Bars, Rods, 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 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 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars, rods, and tubing will be acceptable in mill lengths of 6 - 20 ft (2 - 6 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft (3 m).

3.6 Tolerances: Shall conform to the following:

3.6.1 Bars and Rods: AMS 2221 or MAM 2221 as applicable to refractory alloys.
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3.6.2 Tubing: AMS 2223 or MAM 2223 as applicable to refractory alloys.
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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 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 requirements for composition (3.1), tensile properties (3.3.1.1), hardness (3.3.1.2), and grain size (3.3.1.3) are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for embrittlement (3.3.1.4) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests: Tests of forgings to determine conformance to all applicable technical requirements of this specification when AMS 2375 is specified are classified as preproduction tests and shall be performed prior to or on the first article shipment of a forging to a purchaser, when a change in material or processing, or both, requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.

4.2.3.1 For direct U.S. Military procurement of forgings, substantiating test data and, when requested, preproduction forgings shall be submitted to the cognizant 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:

4.3.1 Bars and Rods: ASTM B249.

4.3.2 Tubing: ASTM B251.

4.3.3 Forgings and Forging Stock: As agreed upon by purchaser and vendor, a lot of forgings shall be not more than 5,000 lb (2250 kg) of forgings of the same part number produced in a continuous series of operations and presented for vendor's inspection at one time.

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 specimens from bars over 1.500 in. (37.50 mm) in nominal diameter or distance between parallel sides and from forgings over 1.500 in. (37.50 mm) in nominal cross-section shall be located approximately midway between center and surface.

4.3.6 Hardness: Each piece.

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