SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS4616 | REV. F

Issued 1956-07
Revised 2004-04
Reaffirmed 2012-02

Superseding AMS4616E

Silicon Bronze Bars, Rods, Forgings, and Tubing
92Cu - 3.2Si - 2.8Zn - 1.5Fe
Stress Relieved

(Composition similar to UNS C65620)

RATIONALE

AMS4616F has been reaffirmed to comply with the SAE five-year review policy.

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:

These products have been used typically for anti-friction bearing cages, but usage is not limited to such applications.

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 supplied 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.

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 2223	Tolerances, Copper and Copper Alloy Seamless Tubing
AMS 2808	Identification, Forgings

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

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 or www.astm.org.

ASTM B 154	Mercurous Nitrate Test for Copper and Copper Alloys
ASTM B 249	General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings
ASTM B 251	General Requirements for Wrought Seamless Copper and Copper-Alloy Tube
ASTM B 858	Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys
ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 10	Brinell Hardness of Metallic Materials
ASTM E 18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E 54	Chemical Analysis of Special Brasses and Bronzes
ASTM E 112	Determining Average Grain Size
ASTM E 478	Chemical Analysis of Copper Alloys

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 54 or ASTM E 478, as applicable, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

TABLE 1 - Composition

Element (3.1.1)	min	max
Copper	90.0	--
Silicon	2.4	4.0
Zinc	1.5	4.0
Iron	1.0	2.0
Manganese	--	1.0
Phosphorus	--	0.10
Sum of Named Elements (3.1.2)	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 When all named elements in Table 1 are analyzed, the sum shall be 99.5% minimum, but such determination is not required for routine acceptance of each lot.

3.2 Condition:

The product shall be supplied in the following condition:

3.2.1 Bars, Rods, and Tubing: Hot rolled, 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 shown in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M:

TABLE 2 Minimum Tensile Properties

Property	Value
Tensile Strength	56.0 ksi (386 MPa)
Yield Strength at 0.2% Offset	20.0 ksi (138 MPa)
Elongation in 4D	30%

3.3.1.2 Hardness: Shall be not lower than 90 HB/10/1000, or equivalent, determined in accordance with ASTM E 10 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 E 18, 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 E 112:

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

3.3.1.3.2 Forgings: Maximum grain size on the outer half of the radii for anti-function bearing cages shall be 0.50 mm except that not more than 25% of the area may show grains up to 1.00 mm.

3.3.1.4 Embrittlement: Specimens as in 4.3.8.1 and 4.3.8.2 shall withstand, without cracking, immersion in mercurous nitrate solution in accordance with ASTM B 154, Procedure A, or the ammonia vapor test in accordance with ASTM B 858.

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 to 20 feet (2 to 6 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 feet (3 m).

3.6 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 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), hardness (3.3.1.2), and grain size (3.3.1.3) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Embrittlement (3.3.1.4) is a periodic test and shall be perform 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 the following:

4.3.1 Rods and Bars: ASTM B 249.

4.3.2 Tubing: ASTM B 251.

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 pounds (2268 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 inches (38.10 mm) in nominal diameter or distance between parallel sides and from forgings over 1.500 inches (38.10 mm) in nominal cross-section shall be located approximately midway between center and surface.

4.3.6 Hardness: Each piece.

4.3.7 Grain Size: One sample from each lot.

4.3.8 Embrittlement: As agreed upon by purchaser and vendor.

4.3.8.1 Test specimens from bars, rods, and tubing shall be full cross-section of the product and shall have length of either approximately 6 inches (152 mm) or twice the nominal diameter or least distance between parallel sides, whichever is greater.

4.3.8.2 Specimens from forgings may be any convenient size or shape or an entire forging may be used.

4.4 Reports:

4.4.1 The vendor of bars, rods, forgings, and tubing shall furnish with each shipment 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. This report shall include the purchase order number, lot number, AMS 4616F, size, and quantity. If forgings are supplied, the number and the size and melt source of stock used to make the forgings shall also be included.

4.4.2 The vendor of forging stock shall furnish with each shipment a report stating that the chemical composition of the stock conforms to the specified requirements. This report shall include the purchase order number, lot number, AMS 4616F, size, and quantity.

4.5 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 two 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. Results of all tests shall be reported.