AEROSPACE MATERIAL SPECIFICATION

AMS4535	REV. D

Issued 1991-07
Reaffirmed 2012-04
Revised 2015-01

Superseding AMS4535C

Copper-Beryllium Alloy, Mechanical Tubing
98Cu - 1.9Be
Solution and Precipitation Heat Treated
(TF00, formerly AT)
(Composition similar to UNS C17200)

RATIONALE

AMS4535D revises Condition (3.2) and Solution Annealing (3.3.1).

1. SCOPE

1.1 Form

This specification covers a copper-beryllium alloy in the form of mechanical tubing.

1.2 Application

This tubing has been used typically for parts requiring a combination of high strength, wear resistance, and corrosion resistance and where thermal conductivity, electrical conductivity, and low magnetic susceptibility may be 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 such 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**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS4535D

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS2223 Tolerances, Copper and Copper Alloy Seamless Tubing

AMS2750 Pyrometry

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

ASTM B 251 General Requirements for Wrought Seamless Copper and Copper-Alloy Tube

ASTM B 251M General Requirements for Wrought Seamless Copper and Copper-Alloy Tube (Metric)

ASTM B 643 Copper-Beryllium Alloy Seamless Tube

ASTM E 3 Preparation of Metallographic Specimens

ASTM E 8/E 8M Tension Testing of Metallic Materials

ASTM E 18 Rockwell Hardness of Metallic Materials

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 478, 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 + Cobalt	0.20	--
Nickel + Cobalt + Iron	--	0.6
Aluminum	--	0.20
Silicon	--	0.20
Copper (3.1.2)	remainder	
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

Hot reduced or hot and cold reduced into a tube, solution and precipitation heat treated; TF00 Temper (See 8.2). Product shall not be produced from solid bar by machining methods.

3.3 Heat Treatment

Tubing shall be heat treated as follows; pyrometry shall be in accordance with AMS2750.

3.3.1 Solution Annealing

Heat within the range 1400 to 1475 °F (760 to 802 °C), hold at heat for a minimum of 30 minutes, and rapidly quench as required.

3.3.2 Precipitation Hardening

Heat to 600 to 675 °F (316 to 357 °C), hold at heat for not less than 3 hours, and cool as required.

3.4 Properties

Tubing shall conform to the following requirements (See 8.3):

3.4.1 Tensile Properties

Shall be as specified in Table 2 for tubing 2.00 inches (50.8 mm) and under in nominal wall thickness, determined in accordance with ASTM E 8/E 8M.

TABLE 2 - Minimum Tensile Properties

Property	Value
Tensile Strength	161 ksi (1110 MPa)
Yield Strength at 0.2% Offset	130 ksi (896 MPa)
Elongation in 4D	3%

3.4.2 Hardness

Tubing 0.188 inch (4.78 mm) and over in nominal wall thickness shall have hardness of 36 to 45 HRC, or equivalent (See 8.4), determined in accordance with ASTM E 18.

3.4.3 Average Grain Size

Tubing with an outside diameter to wall thickness ratio greater than 3.0 shall have average grain size not larger than specified in Table 3, determined in accordance with ASTM E 112.

TABLE 3 - Maximum Average Grain Size

Nominal Wall Thickness Inches				Nominal Wall Thickness Millimeters				Grain Size Millimeter
Up	to	1.00,	excl	Up	to	25.4,	excl	0.050
1.00	to	1.50,	excl	25.4	to	38.1,	excl	0.075
1.50	to	2.00,	excl	38.1	to	50.8,	excl	0.100

3.4.4 Microstructure

Tubing shall contain not more than 6% beta phase constituent, determined at 100X magnification on specimens prepared in accordance with ASTM E 3.

3.5 Quality

Tubing, 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 tubing.

3.6 Tolerances

Shall conform to AMS2223 as applicable to refractory alloys unless ASTM B 643 or other applicable tolerance specification is specified by purchaser.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of tubing 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 tubing conforms to specified requirements.

4.2 Classification of Tests

All technical requirements are acceptance tests and shall be performed on each heat or lot as applicable.

4.3 Sampling and Testing

Shall be in accordance with ASTM B 251 or ASTM B 251M and the following; a lot shall be all tubing of the same size, from the same heat, processed at one time through all steps of manufacture.

4.3.1 One or more chemical analysis samples from each heat shall be analyzed in accordance with 3.1.

4.3.2 One or more tensile specimens from each lot shall be tested in accordance with 3.4.1.

4.3.3 One or more hardness specimens from each lot shall be tested in accordance with 3.4.2.

4.3.4 One or more specimens from each lot shall be tested in accordance with 3.4.3 for average grain size.

4.3.5 One or more specimens from each lot shall be tested in accordance with 3.4.4 for microstructure.

4.4 Reports

The vendor of tubing shall furnish with each shipment a report showing the results of tests on each lot to determine conformance to the technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS4535D, 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 tubing 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 tubing represented. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY

5.1 Identification

Individual tubes or bundles shall have attached a durable tag legibly marked with not less than the purchase order number, lot number, AMS4535D, and nominal size or shall be boxed and the box marked with the same information.