SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE MAM 6304A

Issued JAN 1988
Revised JUL 1994

Superseding MAM 6304

Submitted for recognition as an American National Standard

LOW-ALLOY STEEL, HEAT-RESISTANT, BARS, FORGINGS, AND TUBING
0.95Cr - 0.55Mo - 0.30V (0.40 - 0.50C)

UNS K14675

1. SCOPE:

1.1 Form:

This specification covers an aircraft-quality, low-alloy, heat-resistant steel in the form of bars, forgings, mechanical tubing, and forging stock procured in SI (metric) units.

1.1.1 AMS 6304 is the inch/pound version of this MAM.

1.2 Application:

These products have been used typically for parts, such as shafts and fasteners, for service up to 540 °C, but usage is not limited to such applications.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

MAM 2251 Tolerances, Metric, Low-Alloy Steel Bars
MAM 2253 Tolerances, Metric, Carbon and Alloy Steel Tubing
AMS 2259 Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS 2301 Aircraft Quality Steel Cleanliness, Magnetic Particle Inspection Procedure
AMS 2370 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock
AMS 2372 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Forgings
AMS 2806 Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat Resistant Steels and Alloys
AMS 2808 Identification, Forgings

AS1182 Standard Machining Allowance, Aircraft-Quality and Premium Aircraft-Quality Steel Bars and Mechanical Tubing

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM A 370 Mechanical Testing of Steel Products
ASTM E 112 Determining the Average Grain Size
ASTM E 350 Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
ASTM E 381 Macroetch Testing, Inspection, and Rating Steel Products, Comprising Bars, Billets, Blooms, and Forgings

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition:
(R)

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 350, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	min	max
Carbon	0.40	0.50
Manganese	0.40	0.70
Silicon	0.15	0.35
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	0.80	1.10
Molybdenum	0.45	0.65
Vanadium	0.25	0.35
Nickel	--	0.25
Copper	--	0.35

3.1.1 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2259.

3.2 Condition:

The product shall be supplied in the following condition; hardness and tensile strength shall be determined in accordance with ASTM A 370:

3.2.1 Bars:

3.2.1.1 Bars 12.50 mm and Under in Nominal Diameter or Distance Between Parallel Sides: Cold finished having tensile strength not higher than 860 MPa.

3.2.1.2 Bars Over 12.50 mm in Nominal Diameter or Distance Between Parallel Sides: Hot finished and annealed having hardness not higher than 229 HB, or equivalent, except that bars ordered cold finished may have hardness as high as 248 HB, or equivalent (See 8.2).

3.2.2 Forgings: Annealed having hardness not higher than 248 HB, or equivalent (See 8.2).

3.2.3 Mechanical Tubing: Cold finished having hardness not higher than 25 HRC, or equivalent, except that tubing ordered hot finished shall have hardness not higher than 99 HRB, or equivalent (See 8.2).

3.2.4 Forging Stock: As ordered by the forging manufacturer.

3.3 Properties:

The product shall conform to the following requirements; hardness testing shall be performed in accordance with ASTM A 370:

3.3.1 Macrostructure: Visual examination of transverse sections from bars, billets, tube rounds or tubes, and forging stock, etched in hot hydrochloric acid in accordance with ASTM E 381, shall show no pipe or cracks. Except as specified in 3.3.1.1, porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM E 381 shown in Table 2.

TABLE 2 - Macrostructure Limits

Cross-Sectional Area Square Centimeters	Macrographs
Up to 230, incl	S2 - R1 - C2
Over 230 to 645, incl	S2 - R2 - C3

3.3.1.1 If tubes are produced directly from ingots or large blooms, transverse sections may be taken from tubes rather than tube rounds. Macrostructure standards for such tubes shall be as agreed upon by purchaser and vendor.

3.3.2 (R) Average Grain Size: Shall be ASTM No. 5 or finer, determined in accordance with ASTM E 112 (See 8.3).

3.3.3 Response to Heat Treatment: Specimens as in 4.3.3 shall have hardness at the center of the specimen not lower than 331 HB, or equivalent (See 8.2), for cross-sections 50 mm and under and not lower than 302 HB, or equivalent, for larger cross-sections after being heated to 955 °C ± 15, held at heat for 60 to 90 minutes, cooled in still air, reheated to 595 °C ± 8, held at heat for 6 hours ± 0.25, and cooled in air.

3.3.4 Decarburization:

3.3.4.1 Bars and tubing ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces.

3.3.4.2 Allowable decarburization of bars, billets, tube rounds, and tubing ordered for redrawing or forging or to specified microstructural requirements shall be as agreed upon by purchaser and vendor.

3.3.4.3 Decarburization of bars to which 3.3.4.1 or 3.3.4.2 is not applicable shall be not greater than shown in Table 3.

TABLE 3 - Maximum Depth of Decarburization

Nominal Diameter or Distance Between Parallel Sides Millimeters	Depth of Decarburization Millimeters
Up to 9.50, incl	0.38
Over 9.50 to 12.50, incl	0.43
Over 12.50 to 15.50, incl	0.48
Over 15.50 to 25.00, incl	0.56
Over 25.00 to 37.50, incl	0.64
Over 37.50 to 50.00, incl	0.76
Over 50.00 to 62.50, incl	0.89
Over 62.50 to 75.00, incl	1.02
Over 75.00 to 100.00, incl	1.14

3.3.4.3.1 Limits for depth of decarburization of bars over 100.00 mm in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.3.4.4 Decarburization of tubing to which 3.3.4.1 or 3.3.4.2 is not applicable shall be not greater than shown in Table 4.

TABLE 4 - Maximum Depth of Decarburization

Nominal Wall Thickness Millimeters	Depth of Decarburization Millimeter ID	Depth of Decarburization Millimeter OD
Up to 2.75, incl	0.20	0.50
Over 2.75 to 5.00, incl	0.25	0.64
Over 5.00 to 10.00, incl	0.30	0.76
Over 10.00 to 15.00, incl	0.38	0.89
Over 15.00 to 25.00, incl	0.43	1.02
Over 25.00	0.51	1.14

3.3.4.5 Decarburization shall be measured by the microscopic method or by Rockwell Superficial 30-N scale or equivalent hardness testing method on hardened but untempered specimens protected during heat treatment to prevent changes in surface carbon content. Depth of decarburization, when measured by a hardness method, is defined as the perpendicular distance from the surface to the depth under that surface below which there is no further increase in hardness. Such measurements shall be far enough away from any adjacent surface to be uninfluenced by any decarburization or lack of decarburization thereon.

3.3.4.5.1 When determining the depth of decarburization, it is permissible to disregard local areas provided the decarburization of such areas does not exceed the above limits by more than 0.13 mm and the width is 1.65 mm or less.

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.

3.4.1 Steel shall be aircraft quality conforming to AMS 2301.

3.4.2 (R) Bars and mechanical tubing ordered hot rolled or cold drawn or ground, turned, or polished shall, after removal of the standard machining allowance in accordance with AS1182, be free from seams, laps, tears, and cracks open to the ground, turned, or polished surfaces.

3.4.3 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of re-entrant grain flow.

3.5 Tolerances:

Shall be as follows:

3.5.1 Bars: Shall conform to all applicable requirements of MAM 2251.

3.5.2 Mechanical Tubing: Shall conform to all applicable requirements of MAM 2253.

4. QUALITY ASSURANCE PROVISIONS:

4.1 (R) 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. 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:

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

4.3 (R) Sampling and Testing:

Shall be as follows:

4.3.1 Bars, Mechanical Tubing, and Forging Stock: In accordance with AMS 2370.

4.3.2 Forgings: In accordance with AMS 2372.

4.3.3 Specimens for response to heat treatment (3.3.3) shall be not shorter than twice the nominal diameter or distance between parallel sides or 150 mm, whichever is less, and shall have the full cross-section of the product from which they were cut except that sections over 50 to 100 mm, inclusive, in nominal diameter or distance between parallel sides shall be reduced to 50 mm ± 0.2 and sections over 100 mm shall be reduced to 100 mm ± 0.2.

4.4 Reports:

The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition, macrostructure, grain size, and frequency-severity cleanliness rating of each heat and for response to heat treatment of each lot. This report shall include the purchase order number, heat and lot number, MAM 6304A, 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 Resampling and Retesting:

Shall be as follows:

4.5.1 Bars, Mechanical Tubing, and Forging Stock: In accordance with AMS 2370.

4.5.2 Forgings: In accordance with AMS 2372.

5. PREPARATION FOR DELIVERY:

5.1 Sizes:

Except when exact lengths or multiples of exact lengths are ordered, straight bars and tubing will be acceptable in mill lengths of 2 to 6 meters but not more than 10% of any shipment shall be supplied in lengths shorter than 3 m.

5.2 Identification:

Shall be as follows:

5.2.1 Bars and Mechanical Tubing: In accordance with AMS 2806.

5.2.2 Forgings: In accordance with AMS 2808.

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

5.3 Packaging:

5.3.1 Bars and tubing ordered cold drawn, cold rolled, ground, turned, or polished shall be coated with a corrosion-preventive compound prior to shipment.