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AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 6305A
Superseding AMS 6305

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

UNS K14675

1. SCOPE:

- 1.1 Form: This specification covers a premium aircraft-quality, low-alloy, heat-resistant steel in the form of bars, forgings, mechanical tubing, and stock for forging or heading.
- 1.2 Application: Primarily for parts such as compressor discs, turbine discs, shafts, and fasteners for use in service up to 1000°F (540°C) and subject to very rigid inspection standards.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications and Aerospace Standards 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 2251 - Tolerances, Low-Alloy Steel Bars
MAM 2251 - Tolerances, Metric, Low-Alloy Steel Bars
AMS 2253 - Tolerances, Carbon and Alloy Steel Tubing
MAM 2253 - Tolerances, Metric, Carbon and Alloy Steel Tubing
AMS 2259 - Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS 2300 - Premium Aircraft Quality Steel Cleanliness, Magnetic Particle Inspection Procedure
MAM 2300 - Premium Aircraft-Quality Steel Cleanliness, Magnetic Particle Inspection Procedure, Metric (SI) Measurement
AMS 2350 - Standards and Test Methods
AMS 2370 - Quality Assurance Sampling of Carbon and Low Alloy Steels, Wrought Products Except Forgings and Forging Stock

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2.1.1 (Continued):

- AMS 2372 - Quality Assurance Sampling of Carbon and Low Alloy Steels, Forgings and Forging Stock
- AMS 2375 - Control of Forgings Requiring First Article Approval
- AMS 2806 - Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Heat and Corrosion Resistant Steels and Alloys
- AMS 2808 - Identification, Forgings

2.1.2 Aerospace Standards:

- AS 1182 - Standard Machining Allowance, Aircraft Quality and Premium Quality Steel Products

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

- ASTM A370 - Mechanical Testing of Steel Products
- ASTM A604 - Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
- ASTM E112 - Determining Average Grain Size
- ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

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 Standards:

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

3. TECHNICAL REQUIREMENTS:

- 3.1 Composition: Shall conform to the following percentages by weight, \emptyset determined by wet chemical methods in accordance with ASTM E350 or by spectrographic or other analytical methods approved by purchaser:

	min	max
Carbon	0.40	0.50
Manganese	0.40	0.70
Silicon	0.15	0.35
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	0.80	1.10
Molybdenum	0.45	0.65
Vanadium	0.25	0.35
Nickel	--	0.25
Copper	--	0.35
Lead	--	0.001 (10 ppm)

- 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 A370:
- 3.2.1 Bars:
- 3.2.1.1 Bars 0.500 In. (12.50 mm) and Under in Nominal Diameter or Distance Between Parallel Sides: Cold finished having tensile strength not higher than 125,000 psi (860 MPa) or equivalent hardness.
- 3.2.1.2 Bars Over 0.500 In. (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.
- 3.2.2 Forgings: Annealed having hardness not higher than 248 HB or equivalent.
- 3.2.3 Mechanical Tubing: Cold finished having hardness not higher than 25 HRC or equivalent except that tubing ordered hot finished and annealed shall have hardness not higher than 99 HRB or equivalent.
- 3.2.4 Stock for Forging or Heading: As ordered by the forging or heading manufacturer.
- 3.3 Properties: The product shall conform to the following requirements; hardness testing shall be performed in accordance with ASTM A370:
- 3.3.1 Macrostructure: Visual examination of transverse sections as in 4.3.3 from bars, billets, tube rounds or tubes, and stock for forging or heading, etched in accordance with ASTM A604 in hot hydrochloric acid (1:1) at 160° - 180°F (70° - 80°C) for sufficient time to develop a well-defined macrostructure, shall show no pipe or cracks. Except as specified in 3.3.1.1, porosity, segregation, inclusions, and other imperfections for product 36 sq in. (230 cm²) and under in nominal cross-sectional area shall be no worse than the following macrographs of ASTM A604; macrostructure standards for product over 36 sq in. (230 cm²) in nominal cross-sectional area shall be as agreed upon by purchaser and vendor:

Class	Condition	Severity
1	Freckles	A
2	White Spots	A
3	Radial Segregation	B
4	Ring Pattern	B

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.
 Ø Macrostructure standards for such tubes shall be as agreed upon by purchaser and vendor.

3.3.2 Grain Size: Predominantly 5 or finer with occasional grains as large as 3 permissible, determined in accordance with ASTM E112.

3.3.3 Decarburization:

3.3.3.1 Bars and tubing ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces. Decarburization on tubing ID shall not exceed the maximum depth specified in Table II.

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

3.3.3.3 Decarburization of bars to which 3.3.3.1 or 3.3.3.2 is not applicable shall be not greater than shown in Table I:

TABLE I

Nominal Diameter or Distance Between Parallel Sides Inches	Depth of Decarburization Inch
Up to 0.375, incl	0.015
Over 0.375 to 0.500, incl	0.017
Over 0.500 to 0.625, incl	0.019
Over 0.625 to 1.000, incl	0.022
Over 1.000 to 1.500, incl	0.025
Over 1.500 to 2.000, incl	0.030
Over 2.000 to 2.500, incl	0.035
Over 2.500 to 3.000, incl	0.040
Over 3.000 to 4.000, incl	0.045

3.3.3.3 (Continued):

TABLE I (SI)

Nominal Diameter or Distance Between Parallel Sides Millimetres	Depth of Decarburization Millimetres
Up to 9.50, incl	0.38
Over 9.50 to 12.50, incl	0.42
Over 12.50 to 15.50, incl	0.48
Over 15.50 to 25.00, incl	0.55
Over 25.00 to 37.50, incl	0.62
Over 37.50 to 50.00, incl	0.75
Over 50.00 to 62.50, incl	0.88
Over 62.50 to 75.00, incl	1.00
Over 75.00 to 100.00, incl	1.12

3.3.3.3.1 Limits for depth of decarburization of bars over 4.000 in. (100.00 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.3.3.4 Decarburization of tubing to which 3.3.3.1 or 3.3.3.2 is not applicable shall be no greater than shown in Table II:

TABLE II

Nominal Wall Thickness Inches	Depth of Decarburization Inch	
	ID	OD
Up to 0.109, incl	0.008	0.020
Over 0.109 to 0.203, incl	0.010	0.025
Over 0.203 to 0.400, incl	0.012	0.030
Over 0.400 to 0.600, incl	0.015	0.035
Over 0.600 to 1.000, incl	0.017	0.040
Over 1.000	0.020	0.045

TABLE II (SI)

Nominal Wall Thickness Millimetres	Depth of Decarburization Millimetres	
	ID	OD
Up to 2.75, incl	0.20	0.50
Over 2.75 to 5.00, incl	0.25	0.62
Over 5.00 to 10.00, incl	0.30	0.75
Over 10.00 to 15.00, incl	0.38	0.88
Over 15.00 to 25.00, incl	0.42	1.00
Over 25.00	0.50	1.12

3.3.3.5 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.

3.3.3.5.1 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 0.005 in. (0.12 mm) and the width is 0.065 in. (1.65 mm) or less.

3.3.4 Response to Heat Treatment: Test specimens as in 4.3.4, heated to $1750^{\circ}\text{F} + 25$ ($955^{\circ}\text{C} + 15$), held at heat for 60 - 90 min., and cooled in still air, reheated to $1100^{\circ}\text{F} + 15$ ($595^{\circ}\text{C} + 8$), held at heat for 6 hr + 0.25, and cooled in air shall have hardness at the center of the test specimen not lower than 331 HB or equivalent for sections 2 in. (50 mm) and under and not lower than 302 HB or equivalent for 4 in. (100 mm) section thicknesses.

3.4 Quality:

3.4.1 Steel shall be premium aircraft-quality conforming to AMS 2300 or MAM 2300. It shall be multiple melted using vacuum consumable electrode process in the remelt cycle.

3.4.2 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.

3.4.2.1 Bars and tubing ordered ground, turned, or polished shall be free from seams, laps, tears, and cracks open to the ground, turned, or polished surfaces.

3.4.2.2 Product ordered to surface conditions other than ground, turned, or polished shall, after removal of the standard machining allowance, be free from seams, laps, tears, cracks, and other defects exposed to the machined surfaces. Standard machining allowance shall be in accordance with AS 1182.

3.5 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars 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 all applicable requirements of the following:

3.6.1 Bars: AMS 2251 or MAM 2251.

3.6.2 Mechanical Tubing: AMS 2253 or MAM 2253.

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 all technical requirements of this specification are classified as acceptance tests and shall be performed on each heat or lot as applicable.
- 4.2.2 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, processing, or both requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.
- 4.2.3 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; a heat shall be the consumable electrode remelted ingots produced from steel originally melted as a single furnace charge.
- 4.3.1 Bars and Mechanical Tubing: AMS 2370.
- 4.3.2 Forgings and Forging Stock: AMS 2372.
- 4.3.3 Samples for macrostructure (3.3.3) rating shall be full cross-sectional specimens obtained from the finished billet or suitable rerolled product representing the top and bottom of at least the first, middle, and last usable ingots of each heat.
- 4.3.4 Specimens for response to heat treatment (3.3.4) shall be not shorter than twice the nominal diameter or distance between parallel sides or 6 in. (150 mm), whichever is less, and shall have the full cross section of the product from which they were cut except that sections over 2 in. to 4 in. (over 50 mm to 100 mm), incl, in diameter or distance between parallel sides shall be reduced to 2.00 in. + 0.01 (50.0 mm + 0.3) and sections over 4 in. (100 mm) shall be reduced to 4.00 in. + 0.01 (100.0 mm + 0.3).
- 4.4 Approval: When specified, approval and control of forgings shall be in accordance with AMS 2375.