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AEROSPACE MATERIAL SPECIFICATION



AMS 6476A

Issued APR 1988
Revised MAR 1995

Superseding AMS 6476

Submitted for recognition as an American National Standard

STEEL, BARS, FORGINGS, AND TUBING
0.50Cr - 0.12Mo (0.89 - 1.01C)

UNS K19526

1. SCOPE:

1.1 Form:

This specification covers a low-alloy steel in the form of bars, forgings, mechanical tubing, and forging or tubing stock.

1.2 Application:

These products have been used typically for bearing components requiring a through-hardening steel usually with hardness of approximately 60 HRC and section thickness under 0.50 inch (12.7 mm), 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.

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 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

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2.1 (Continued):

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 45 Determining the Inclusion Content of Steels

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:

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	0.89	1.01
Manganese	0.50	0.80
Silicon	0.15	0.35
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	0.40	0.60
Molybdenum	0.08	0.15
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 0.500 Inch (12.70 mm) and Under in Nominal Diameter or Distance Between Parallel Sides: Cold finished, with microstructure of spheroidized cementite in a ferrite matrix, having tensile strength not higher than 120 ksi (827 MPa), or equivalent hardness (See 8.2).

3.2.1.2 Bars Over 0.500 Inch (12.70 mm) in Nominal Diameter or Distance Between Parallel Sides: Hot finished and annealed, with microstructure of spheroidized cementite in a ferrite matrix, having hardness not higher than 207 HB, or equivalent, except that bars ordered cold finished may have hardness as high as 248 HB, or equivalent (See 8.3).

3.2.2 Forgings: As ordered

3.2.3 Mechanical Tubing: Cold finished with microstructure of spheroidized cementite in ferrite matrix. Tubing ordered hot finished and annealed shall have hardness not higher than 95 HRB, or equivalent (See 8.3).

3.2.4 Forging or Tubing Stock: As ordered by the forging or tubing manufacturer.
(R)

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 Inclusion Rating: Shall be as follows:

3.3.1.1 Macrostructure: Visual examination of transverse full cross-sections, etched in hot hydrochloric acid in accordance with ASTM E 381, shall show no pipe or cracks. Unless otherwise specified, porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM E 381 shown in Table 2.
(R)

TABLE 2 - Maximum Macrostructure Ratings

Section Size Square Inches	Section Size Square Centimeters	Macrographs
Up to 36, incl	Up to 232, incl	S2 - R1 - C2
Over 36 to 100, incl	Over 232 to 645, incl	S2 - R2 - C3

- 3.3.1.2 Micro-Inclusion Rating: One or more specimens from each ingot tested, as well as two-thirds of the total number of specimens and the average of all specimens, shall not exceed the limits shown in Table 3, determined in accordance with ASTM E 45, Method A.

TABLE 3 - Micro-Inclusion Rating

Type	A	B	C	D
Thin	2.5	2.0	0.5	1.0
Heavy	1.5	1.0	0.5	1.0

- 3.3.2 Response to Heat Treatment: Specimens as in 4.3.3, protected by suitable means or treated in a neutral atmosphere to minimize scaling and prevent either carburization or decarburization, shall have substantially uniform hardness not lower than 63 HRC at any point below any permissible decarburization after being placed in a furnace which is at $1525^{\circ}\text{F} \pm 10$ ($829^{\circ}\text{C} \pm 6$), allowed to heat to $1525^{\circ}\text{F} \pm 10$ ($829^{\circ}\text{C} \pm 6$), held at heat for 20 minutes ± 2 , and quenched in commercial paraffin oil (100 SUS at 100°F (38°C)) at room temperature.

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.
- 3.3.3.2 Allowable decarburization of bars, billets, and tube rounds ordered for redrawing or forging or to specified microstructural requirements other than spheroidized cementite in a ferrite matrix shall be as agreed upon by purchaser and vendor.
- 3.3.3.3 Decarburization of bars and of the ID and OD of tubes to which 3.3.3.1 or 3.3.3.2 is not (R) applicable shall be not greater than shown in Table 4.

TABLE 4A - Maximum Decarburization Limits, Inch/Pound Units

Nominal Diameter or Distance Between Parallel Sides Inches	Depth of Decarburization Bars, Hot Finished Inch	Depth of Decarburization Bars Annealed Inch	Depth of Decarburization Bars, Cold Finished Inch	Depth of Decarburization Tubes Annealed Inch	Depth of Decarburization Tubes, Cold Finished Inch
Up to 0.250, incl	0.005	0.015	0.003	0.012	0.010
Over 0.250 to 0.500, incl	0.006	0.015	0.004	0.012	0.010
Over 0.500 to 0.750, incl	0.008	0.015	0.006	0.012	0.010
Over 0.750 to 1.000, incl	0.010	0.015	0.008	0.012	0.010
Over 1.000 to 2.000, incl	0.017	0.022	0.015	0.020	0.014
Over 2.000 to 3.000, incl	0.025	0.030	0.025	0.030	0.019
Over 3.000 to 4.000, incl	0.035	0.045	0.035	0.035	0.024
Over 4.000 to 5.000, incl	0.055	0.065	0.055	0.040	0.028

TABLE 4B - Maximum Decarburization Limits, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Depth of Decarburization Bars, Hot Finished Millimeter	Depth of Decarburization Bars Annealed Millimeter	Depth of Decarburization Bars, Cold Finished Millimeter	Depth of Decarburization Tubes Annealed Millimeter	Depth of Decarburization Tubes, Cold Finished Millimeter
Up to 6.35, incl	0.13	0.38	0.08	0.30	0.25
Over 6.35 to 12.70, incl	0.15	0.38	0.10	0.30	0.25
Over 12.70 to 19.05, incl	0.20	0.38	0.15	0.30	0.25
Over 19.05 to 25.40, incl	0.25	0.36	0.20	0.30	0.25
Over 25.40 to 50.80, incl	0.43	0.56	0.38	0.51	0.36
Over 50.80 to 76.20, incl	0.64	0.76	0.64	0.76	0.48
Over 76.20 to 101.60, incl	0.89	1.14	0.89	0.89	0.61
Over 101.60 to 127.00, incl	1.40	1.65	1.40	1.02	0.71

3.3.3.4 Decarburization shall be measured by the microscopic method or by HR30N 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.

3.3.3.4.1 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 inch (0.13 mm) and the width is 0.065 inch (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 Bars and tubing ordered hot rolled or cold finished, or ground, turned, or polished, shall, after (R) 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.

3.4.2 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the (R) 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 AMS 2251 or MAM 2251.

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

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

4.3 Sampling and Testing:

(R)

Shall be as follows:

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

4.3.2 Forgings: In accordance with AMS 2372.

4.3.3 Samples for response to heat treatment (3.3.2) shall be as follows:

4.3.3.1 Specimens from bars shall be full cross-sections of the bar ground on both faces normal to the axis so that length is 0.50 inch $\pm$ 0.010 (12.7 mm $\pm$ 0.25).

4.3.3.2 Specimens from mechanical tubing shall be full cross-sections of the tubing, shall have wall thickness not over 0.625 inch (15.88 mm), with wall thicknesses over 0.625 inch (15.88 mm) being turned to 0.625 inch $\pm$ 0.010 (15.88 mm $\pm$ 0.25), and shall be ground on both faces so that length is 0.50 inch $\pm$ 0.010 (12.7 mm $\pm$ 0.25).

4.4 Reports:

The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition and inclusion rating of each heat, and response to heat treatment of each lot. This report shall include the purchase order number, lot number, AMS 6476A, 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 or Tubing Stock: In accordance with AMS 2370.