SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

AMS 6476C

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Superseding AMS 6476B

Steel, Bars, Forgings, and Tubing
0.50Cr - 0.12Mo (0.89 - 1.01C)

(Composition similar to UNS K19526)

RATIONALE

AMS 6476C is a Five Year Review and update of this specification.

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 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.

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), or www.sae.org.

AMS 2251	Tolerances, Low-Alloy Steel Bars
AMS 2253	Tolerances, 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
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 International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, or www.astm.org.

ASTM A 370 Mechanical Testing of Steel Products
ASTM E 45 Determining the Inclusion Content of Steel
ASTM E 350 Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
ASTM E 381 Macroetch Testing Steel Bars, Billets, Blooms, and Forgings
ASTM E 384 Microindentation Hardness Testing of Materials

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 Least 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 Least Distance Between Parallel Sides

Unless otherwise ordered, hot finished and annealed, with microstructure of spheroidized cementite in a ferrite matrix, having hardness not higher than 207 HB, or equivalent (See 8.3). 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

Unless otherwise ordered, 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.

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 full cross-sections from bars, billets, tube rounds, and forging stock, etched in hot hydrochloric acid in accordance with ASTM E 381, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM E 381 shown in Table 2.

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

3.3.2 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

3.3.3 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 °F ± 10 (829 °C ± 6), allowed to heat to 1525 °F ± 10 (829 °C ± 6), held at heat for 20 minutes ± 2, and quenched in commercial paraffin oil (100 SUS at 100 °F (38 °C)) at room temperature.

3.3.4 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, 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.

3.3.4.3 Decarburization of bars and of the ID and OD of tubes to which 3.3.4.1 or 3.3.4.2 is not 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	Total Depth of Decarburization Bars, Hot Finished Inch	Total Depth of Decarburization Bars Annealed Inch	Total Depth of Decarburization Bars, Cold Finished Inch	Total Depth of Decarburization Tubes Annealed Inch	Total 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	Total Depth of Decarburization Bars, Hot Finished Millimeters	Total Depth of Decarburization Bars Annealed Millimeters	Total Depth of Decarburization Bars, Cold Finished Millimeters	Total Depth of Decarburization Tubes Annealed Millimeters	Total 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	0.38	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

3.3.4.4 Decarburization shall be measured by the metallographic method, by HR 30N scale hardness testing method, or by a traverse method using microhardness testing in accordance with ASTM E 384. The hardness method(s) shall be conducted on a hardened but untempered specimen 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 influenced by any decarburization on the adjacent surface. In case of dispute, the depth of decarburization determined using the microhardness traverse method shall govern.

3.3.4.4.1 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 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 surface.

3.4.2 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 reentrant grain flow.

3.5 Tolerances

Shall be as follows:

3.5.1 Bars

In accordance with AMS 2251.

3.5.2 Mechanical Tubing

In accordance with AMS 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 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), condition (3.2), macrostructure (3.3.1), micro-inclusion rating (3.3.2), response to heat treatment (3.3.3), decarburization (3.3.4), and tolerance (3.5) are acceptance tests and shall be performed on each heat or lot, as applicable.

4.2.2 Periodic Tests

Grain flow of die forgings (3.4.2) is a periodic test and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing

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 (3.3.3) shall be as follows:

4.3.3.1 Specimens from bars shall be full cross-sections of the bar machined on both faces normal to the axis so that length is 0.50 inch ± 0.010 (12.7 mm ± 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 ± 0.010 (15.88 mm ± 0.25), and shall be machined on both faces so that length is 0.50 inch ± 0.010 (12.7 mm ± 0.25).