AEROSPACE MATERIAL SPECIFICATION

AMS6476™	REV. F
Issued 1988-04 Revised 2021-11 Superseding AMS6476E	

Steel, Bars, Forgings, Mechanical Tubing and Forging Stock
0.50Cr - 0.12Mo (0.89 - 1.01C)
(Composition similar to UNS K19526)

RATIONALE

AMS6476F is the result of a Five-Year Review and update of the specification. The revision updates the Title to match the scope, prohibits unauthorized exceptions (3.6, 4.4.4, 5.2.1.1, 8.8), updates composition testing (3.1), updates macrostructure (3.3.1.1, 3.3.1.2, 8.9), updates decarburization limits and test methods (3.3.4.1, 3.3.4.4.1, 3.3.4.4.2), adds note on stock removal (8.6), and allows prior revisions (8.7).

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 +1 724-776-4970 (outside USA), www.sae.org.

AMS2251 Tolerances, Low-Alloy Steel Bars

AMS2253 Tolerances, Carbon and Alloy Steel Tubing

AMS2259 Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels

AMS2370 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock

AMS2372 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Forgings

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**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS6476F/

AMS2806 Identification Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat-Resistant Steels and Alloys

AMS2808 Identification Forgings

ARP1917 Clarification of Terms Used in Aerospace Metals Specifications

AS1182 Standard Stock Removal 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, www.astm.org.

ASTM A370 Mechanical Testing of Steel Products

ASTM A751 Chemical Analysis of Steel Products

ASTM E45 Determining the Inclusion Content of Steel

ASTM E140 Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

ASTM E381 Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

ASTM E1077 Estimating the Depth of Decarburization of Steel Specimens

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined in accordance with ASTM A751 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 AMS2259.

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

Bar shall not be cut from plate (also see 4.4.2).

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 8.2). Bars ordered cold finished may have hardness as high as 248 HB, or equivalent (see 8.2).

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 8.2).

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 A370:

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 E381, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM E381 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 133, incl	Over 232 to 858, incl	S2 - R2 - C3
Over 133	Over 858	Note 1

Note 1: Limits for larger sizes shall be agreed upon by purchaser and producer. The purchaser shall have written approval of the agreement from the cognizant engineering organization.

3.3.1.1 Macrostructure examination is not required for bored/hollow forgings (including ring forgings) and mechanical tubing that is produced directly from ingots or large blooms unless otherwise agreed upon by purchaser and producer (see 8.9).

3.3.1.2 If mechanical tubing is produced directly from ingots or large blooms, transverse sections may be taken from the tubing. Macroetch standards for such tubes shall be as agreed upon by purchaser and producer (see 8.9).

3.3.2 Micro-Inclusion Rating of Each Heat

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 E45, 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 for Bars, Forgings, and Tubing

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 °F (829 °C ± 6 °C), allowed to heat to 1525 °F ± 10 °F (829 °C ± 6 °C), held at heat for 20 minutes ± 2 minutes, and quenched in commercial paraffin oil (90 to 110 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 producer.

3.3.4.3 Decarburization of bars and of the ID and OD of tubes that 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 Inches	Total Depth of Decarburization Bars Annealed Inches	Total Depth of Decarburization Bars, Cold Finished Inches	Total Depth of Decarburization Tubes Annealed Inches	Total Depth of Decarburization Tubes, Cold Finished Inches
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 Millimeters
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 evaluated by one of the two methods of 3.3.4.4.1 or 3.3.4.4.2.

3.3.4.4.1 Metallographic (Microscopic) Method

A cross section taken perpendicular to the surface shall be prepared in accordance with ASTM E1077, etched, and examined metallographically at a magnification not to exceed 100X. The product shall not show a layer of complete (ferrite) or partial decarburization exceeding the limits of Table 4.

3.3.4.4.2 Hardness Traverse (Microindentation) Method

The total depth of decarburization shall be determined by a traverse method using microindentation hardness testing in accordance with ASTM E1077. Samples shall be hardened but untempered specimen protected during heat treatment to prevent changes in surface carbon content. Measurements shall be far enough away from any adjacent surface to be uninfluenced by any decarburization on the adjacent surface. Acceptance shall be as listed in Table 4.

3.3.4.5 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.

3.3.4.6 In case of dispute, the total depth of decarburization determined using the microindentation hardness traverse method shall govern.

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 mechanical tubing shall be free from seams, laps, tears, and cracks after removal of the standard stock removal allowance in accordance with AS1182.

3.4.2 Grain flow of die forgings, except in areas that 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 AMS2251.

3.5.2 Mechanical Tubing

In accordance with AMS2253.

3.6 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.4.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for producer'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 producer unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing

4.3.1 Bars, Mechanical Tubing, and Forging or Tubing Stock

In accordance with AMS2370.

4.3.2 Forgings

In accordance with AMS2372.

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 inch (12.7 mm ± 0.25 mm).

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 inch (15.88 mm ± 0.25 mm), and shall be machined on both faces so that length is 0.50 inch ± 0.010 inch (12.7 mm ± 0.25 mm).

4.4 Reports

4.4.1 The producer of the bars, forgings, and tubing shall furnish with each shipment a report showing the producer identity, country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations), results of tests for composition, macrostructure and micro-inclusion rating of each heat, and for response to heat treatment of each lot and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS6476F, product form and size (and/or part number, if applicable), and quantity. If forgings are supplied, the size and melt source of stock used to make the forgings shall also be included.

4.4.2 Report the nominal metallurgically worked cross sectional size and the cut size, if different (also see 3.2.1).