AEROSPACE MATERIAL SPECIFICATION

AMS6477™	REV. C

Issued 1988-04
Reaffirmed 2006-02
Revised 2015-09

Superseding AMS6477B

Steel, Bars, Forgings, and Tubing
0.80Cr (0.90 - 1.03C)
For Bearing Applications
(Composition similar to UNS G51985)

RATIONALE

AMS6477C is a Five Year Review and update of this specification and revises decarburization and reporting.

1. SCOPE

1.1 Form

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

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**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS6477C

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

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

AMS2808 Identification, Forgings

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 E45 Determining the Inclusion Content of Steels

ASTM E350 Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

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

ASTM E384 Knoop and Vickers Hardness 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 E350 or by spectrochemical or other analytical methods acceptable to purchaser.

Table 1 - Composition

Element	min	max
Carbon	0.90	1.03
Manganese	0.75	1.00
Silicon	0.15	0.35
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	0.70	0.90
Nickel	--	0.25
Molybdenum	--	0.10
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

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 ferrite matrix, having tensile strength not higher than 120 ksi (825 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

Hot finished and annealed, unless otherwise ordered, with microstructure of spheroidized cementite in 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.

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

3.2.2 Forgings

As ordered.

3.2.3 Mechanical Tubing

Cold finished and annealed, unless otherwise ordered, 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 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 A370:

3.3.1 Macrostructure

Visual examination of transverse full cross-sections from bars, billets, tube rounds, or 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 agreed upon by purchaser and producer (see 8.6).

3.3.2 Micro-Inclusion Rating of Each Heat

At least one specimen 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 2, determined in accordance with ASTM E45, Method A.

Table 2 - Micro-inclusion rating limits

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 of 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 heated to 1525 °F ± 10 °F (829 °C ± 6 °C), held at heat for 20 minutes ± 2 minutes, and quenched in commercial paraffin oil (90-110 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. Decarburization on tubing ID shall not exceed the maximum depth specified in Table 4.

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 ferrite matrix shall be as agreed upon by purchaser and producer.

3.3.4.3 Decarburization of bars for anti-friction balls and rollers that 3.3.4.1 or 3.3.4.2 is not applicable shall be not greater than shown in Table 3.

Table 3A – Maximum total depth of Decarburization limits, inch/pound units

Nominal Diameter or Distance Between Parallel Sides Inch	Total Depth of Decarburization Inch Hot Finished	Total Depth of Decarburization Inch Cold Finished
Up to 0.250, incl	0.005	0.003
Over 0.250 to 0.500, incl	0.006	0.004
Over 0.500 to 0.750, incl	0.008	0.006
Over 0.750 to 1.000, incl	0.010	0.008

Table 3B - Maximum total depth of decarburization limits, SI units

Nominal Diameter or Distance Between Parallel Sides Millimeters			Total Depth of Decarburization Millimeters Hot Finished	Total Depth of Decarburization Millimeters Cold Finished
	Up to	6.35, incl	0.13	0.08
Over	6.35 to	12.70, incl	0.15	0.10
Over	12.70 to	19.05, incl	0.20	0.15
Over	19.05 to	25.40, incl	0.25	0.20

3.3.4.4 Decarburization of bars and of the ID and OD of tubes that 3.3.4.1, 3.3.4.2, or 3.3.4.3 is not applicable shall be not greater than shown in Table 4.

Table 4A - Maximum total depth of 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 1.000, incl	0.012	0.015	0.012	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 total depth of 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 25.40, incl	0.30	0.38	0.30	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

3.3.4.5 Decarburization shall be evaluated by one of the two methods of 3.3.4.6 or 3.3.4.7.

3.3.4.6 Metallographic Method

A cross section taken perpendicular to the surface shall be prepared, etched, and visually 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 Tables 3 or 4.

3.3.4.7 Hardness Traverse Method

The total depth of decarburization shall be determined by a traverse method using microhardness testing in accordance with ASTM E384, at a magnification not exceeding 100X, conducted on a hardened but untempered specimen protected during heat treatment to prevent changes in surface carbon content. Tempering is generally not recommended, but if tempered, the tempering temperature shall be not higher than 300 °F (149 °C). Depth of decarburization is defined as the perpendicular distance from the surface to the depth under that surface where there is not further increase in hardness. Such 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 Tables 3 or 4.

3.3.4.8 When determining the depth of decarburization, it is permissible to disregard local areas provided the decarburization of such areas does not exceed the limits of Tables 3 or 4 by more than 0.005 inch (0.13 mm) and the width is 0.065 inch (1.65 mm) or less.

3.3.4.9 In case of dispute, the total depth of decarburization determined using the microhardness 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 ordered hot rolled or cold drawn, or ground, turned or polished, shall, after removal of the standard stock removal allowance in accordance with AS1182, be free from seams, laps, tears, and cracks open to the machined, ground, turned, or polished surface.

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

3.5.1 Bars

In accordance with AMS2251.

3.5.2 Mechanical Tubing

In accordance with AMS2253.

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 ratings (3.3.2), response to heat treatment (3.3.3), decarburization (3.3.4), and tolerances (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 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 or ground 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 or ground 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 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 for 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, AMS6477C, product form and size or part number, 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 3.2.1.3).

4.4.3 The producer of forging stock 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) and the results of tests for composition, macrostructure, and micro-inclusion rating of each heat. This report shall include the purchase order number, heat number, AMS6477C, size and quantity.