

AEROSPACE MATERIAL SPECIFICATION



AMS 6477A

Issued APR 1988
Revised SEP 2001
Reaffirmed FEB 2006

Superseding AMS 6477

Steel, Bars, Forgings, and Tubing 0.80Cr (0.90 - 1.03C) For Bearing Applications

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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

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

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2.1 (Continued):

- 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 Heat and Corrosion Resistant Steels and Alloys
- AMS 2808 Identification, Forgings

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

- 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 Steel Bars, Billets, Blooms, and Forgings
- ASTM E 384 Microindentation 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 E 350 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 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 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.

3.2.2 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 A 370:

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 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 agreed upon by purchaser and vendor.

3.3.2 Micro-Inclusion Rating: 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 E 45, 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: 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 $1525^{\circ}\text{F} \pm 10$ ($830^{\circ}\text{C} \pm 5$), 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. Decarburization on tubing ID shall not exceed the maximum depth specified in 3.3.4.4.

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 vendor.

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

TABLE 3A - Maximum Decarburization Limits, Inch/Pound Units

Nominal Diameter or Distance Between Parallel Sides Inch	Total Depth of Decarburization Inch	Total Depth of Decarburization Inch
	Hot Finished	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 Decarburization Limits, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Total Depth of Decarburization Millimeters	Total Depth of Decarburization Millimeters
	Hot Finished	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 to which 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 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 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 measured by the metallographic method, by the HR30N 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 uninfluenced by any decarburization on the adjacent surface. In case of dispute, the depth of decarburization determined using the microhardness traverse method shall govern.

- 3.3.4.5.1 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 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 mechanical 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 conform to all applicable requirements of the following:

- 3.5.1 Bars: In accordance with AMS 2251 or MAM 2251.
- 3.5.2 Mechanical Tubing: In accordance with 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 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 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 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 or 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 machined or 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, 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, AMS 6477A, size, and quantity. If forgings are supplied, 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 Stock: In accordance with AMS 2370.

4.5.2 Forgings: In accordance with AMS 2372.

5. PREPARATION FOR DELIVERY:

5.1 Sizes:

Except when exact lengths or multiples of exact lengths are ordered, straight bars and tubing will be acceptable in mill lengths of 6 to 20 feet (2 to 6 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 feet (3 m).

5.2 Identification:

Shall be as follows:

5.2.1 Bars and Mechanical Tubing: In accordance with AMS 2806.

5.2.2 Forgings: In accordance with AMS 2808.

5.2.3 Forging Stock: As agreed upon by purchaser and vendor.