



AEROSPACE MATERIAL SPECIFICATION

AMS6496**REV. A**Issued 2009-09
Revised 2013-11

Steel Bars, Forgings, and Tubing, Nitriding
1.4Cr - 1.2Mo - 0.3V (0.29 - 0.36C)
Aircraft-Quality for Bearing Applications
(Composition similar to UNS K23280)

RATIONALE

AMS6496A results from a Five Year Review and update of this specification.

1. SCOPE

1.1 Form

This specification covers a nitriding grade of aircraft-quality, low-alloy steel in the form of bars, forgings, mechanical tubing, and forging stock. AMS6497 and AMS6498 cover UNS K23280 having other quality levels.

1.2 Application

These products have been used typically for nitrided parts such as bearings, operating under heavy loads and high speeds at moderate temperatures, and subject to rigid inspection standards, and requiring highest surface hardness, high core toughness, and less distortion than parts made from steel requiring quenching to case harden, 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), 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
AMS2301	Steel Cleanliness, Aircraft-Quality, Magnetic Particle Inspection Procedure

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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
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 A 255	Determining Hardenability of Steel
ASTM A 370	Mechanical Testing of Steel Products
ASTM E 381	Macroetch Testing Steel Bars, Billets, Blooms and Forgings
ASTM E 112	Determining Average Grain Size
ASTM E 350	Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
ASTM E 384	Knoop and Vickers Hardness of Materials

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the following 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	0.29	0.36
Manganese	0.70	1.20
Silicon	--	0.30
Phosphorus	--	0.015
Sulfur	--	0.005
Chromium	1.10	1.60
Nickel	0.50	1.00
Molybdenum	0.90	1.40
Vanadium	0.20	0.40
Aluminum	0.10	0.30

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 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 having tensile strength not higher than 138 ksi (950 MPa) or hardness not higher than 285 HB or equivalent (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, having hardness not higher than 285 HB or equivalent (See 8.2). Bars ordered cold finished may have hardness as high as 310 HB or equivalent (See 8.2).

3.2.1.3 Bars shall not be cut from plate.

3.2.2 Forgings

As ordered.

3.2.3 Mechanical Tubing

Cold finished, unless otherwise ordered, having hardness not higher than 285 HB, or equivalent (See 8.2). Tubing ordered hot finished and annealed or tempered shall have hardness not higher than 285 HB or equivalent (See 8.2).

3.2.4 Forging Stock

As ordered by the forging manufacturer.

3.3 Properties

The product shall conform to the following requirements; hardness, tensile, and impact 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 - MACROSTRUCTURE LIMITS

Cross-Section Area Square Inches	Cross-Section Area 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 vendor. The purchaser shall have written approval of the agreement from the cognizant engineering organization.

3.3.1.1 If tubes are produced directly from ingots or large blooms, transverse sections may be taken from the tubes rather than tube rounds. Macroetch standards for such tubes shall be agreed upon by purchaser and vendor.

3.3.2 Average Grain Size

Shall be ASTM No. 6 or finer determined in accordance with ASTM E 112.

3.3.3 Response to Heat Treatment

3.3.3.1 Bars, Forgings and Mechanical Tubing

Specimens from product shall have the properties shown in Table 4 after being austenitized by heating to 1720 °F $\pm$ 25 (938 °C $\pm$ 14), holding at heat for a time commensurate with section thickness, heating equipment, and procedure used, oil quenched to below 90 °F (32 °C) followed by tempering for 2 hours minimum at no lower than 1110 °F (599 °C).

TABLE 4 – LONGITUDINAL MECHANICAL PROPERTIES

PROPERTY	VALUE
Tensile Strength, min	181 ksi (1250 MPa)
Yield Strength 0.2%, min	155 ksi (1070 MPa)
Elongation in 4D, min	10%
Charpy V-notch, min	15 ft-lb (20 J)
Hardness	375 to 450 HB, or equivalent (See 8.2)

3.3.3.2 Forging Stock

When a sample of stock is forged to a test coupon and heat treated as in 3.3.3.1, specimens taken from the heat treated coupon shall conform to the requirements of 3.3.3.1. If specimens taken from the stock after heat treatment as in 3.3.3.1 conform to the requirements of 3.3.3.1, tests shall be accepted as equivalent to tests of a forged coupon.

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 6.

3.3.4.2 Allowable decarburization of bars, billets, and tube rounds ordered for redrawing or forging or to specified microstructural requirements shall be as agreed upon purchaser and vendor.

3.3.4.3 Decarburization of bars to which 3.3.4.1 or 3.3.4.2 is not applicable shall be not greater than shown in Table 5.

TABLE 5A - MAXIMUM TOTAL DEPTH OF DECARBURIZATION, BARS, INCH/POUND UNITS

Nominal Diameter or Distance Between Parallel Sides Inches				Total Depth of Decarburization Inch
Up	to	0.500,	incl	0.030
Over 0.500	to	1.000,	incl	0.035
Over 1.000	to	1.500,	incl	0.040
Over 1.500	to	2.000,	incl	0.050
Over 2.000	to	2.500,	incl	0.060
Over 2.500	to	3.000,	incl	0.070
Over 3.000				0.080

TABLE 5B - MAXIMUM TOTAL DEPTH OF DECARBURIZATION, BARS, SI UNITS

Nominal Diameter or Distance Between Parallel Sides Millimeters				Total Depth of Decarburization Millimeters
Up	to	12.70,	incl	0.76
Over 12.70	to	25.40,	incl	0.89
Over 25.40	to	38.10,	incl	1.02
Over 38.10	to	50.80,	incl	1.27
Over 50.80	to	63.50,	incl	1.52
Over 63.50	to	76.20,	incl	1.78
Over 76.20				2.04

3.3.4.4 Decarburization of tubing to which 3.3.4.1 or 3.3.4.2 is not applicable shall be not greater than shown in Table 6.

TABLE 6A - MAXIMUM TOTAL DEPTH OF DECARBURIZATION, TUBING, INCH/POUND UNITS

Nominal Wall Thickness Inches				Total Depth of Decarburization Inch ID	Total Depth of Decarburization Inch OD
Up	to	0.109	incl	0.008	0.015
Over	0.109	to	0.203	incl	0.010
Over	0.203	to	0.400	incl	0.012
Over	0.400	to	0.600	incl	0.015
Over	0.600	to	1.000	incl	0.017
Over	1.000			0.020	0.040

TABLE 6B - MAXIMUM TOTAL DEPTH OF DECARBURIZATION, TUBING, SI UNITS

Nominal Wall Thickness Millimeters				Total Depth of Decarburization Millimeter ID	Total Depth of Decarburization Millimeters OD
Up	to	2.77	incl	0.20	0.38
Over	2.77	to	5.16	incl	0.25
Over	5.16	to	10.16	incl	0.30
Over	10.16	to	15.24	incl	0.38
Over	15.24	to	25.40	incl	0.43
Over	25.40			0.51	1.02

3.3.4.5 Decarburization shall be measured by the metallographic method or by a traverse method using microhardness testing in accordance with ASTM E 384. The microhardness method 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 the microhardness method, is defined as the perpendicular distance from the surface to the depth under that surface where 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 (0.12 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 Steel shall be aircraft-quality conforming to AMS2301.

3.4.2 Product ordered hot finished or cold finished 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.

3.4.3 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 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

4.2.1.1 Composition (3.1), condition (3.2), macrostructure (3.3.1), average grain size (3.3.2), response to heat treatment (3.3.3.1), frequency-severity cleanliness rating (3.4.1) and tolerances (3.5) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.1.2 When specified, decarburization (3.3.4).

4.2.2 Periodic Tests

Grain flow of die forgings (3.4.3) and response to heat treatment of forging stock (3.3.3.2) are periodic tests and shall be performed at a frequency selected by the vendor 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.

4.4 Reports

4.4.1 The producer of bars, forgings and tubing shall furnish with each shipment a report showing producer identity and country where the metal was melted (i.e., final melt in the case of metal processed by multiple melting operations) and the results of tests for composition, macrostructure and frequency-severity cleanliness rating of each heat, and for condition, average grain size, and 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, AMS6496A, 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 (See 3.2.1.3).

4.4.3 The producer of forging stock shall furnish with each shipment a report showing the producer identity and country where the metal was melted (e. g., final melt in the case of metal processed by multiple melting operations) and the composition, macrostructure and frequency-severity cleanliness rating of each heat. This report shall include the purchase order number, heat number, AMS6496A, size and quantity.

4.5 Resampling and Retesting

4.5.1 Bars, Mechanical Tubing, and Forging Stock

In accordance with AMS2370.