

**AEROSPACE
MATERIAL
SPECIFICATION**

AMS 6472B
Superseding AMS 6472A

Issued 2-15-65
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STEEL BARS AND FORGINGS, NITRIDING
1.6Cr - 0.35Mo - 1.1Al (0.38 - 0.43C)
Hardened and Tempered, 112,000 psi (770 MPa) Tensile Strength
UNS K24065

1. SCOPE:

- 1.1 Form: This specification covers a nitriding grade of aircraft-quality, low-alloy steel in the form of heat treated bars and forgings, and of forging stock.
- 1.2 Application: Primarily for nitrided parts requiring high surface hardness, resistance to heat, and less distortion than parts made from steel requiring quenching to case harden. This steel may be case hardened in dissociated ammonia gas to give a minimum case hardness of 900 HV.
2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications and Aerospace Standards shall apply. The applicable issue of other documents shall be as specified in AMS 2350.
- 2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

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2.1.1 Aerospace Material Specifications:

AMS 2251 - Tolerances, Low-Alloy Steel Bars
MAM 2251 - Tolerances, Metric, Low-Alloy Steel Bars
AMS 2259 - Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS 2301 - Aircraft Quality Steel Cleanliness, Magnetic Particle Inspection Procedure
AMS 2350 - Standards and Test Methods
AMS 2370 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Wrought Products Except Forgings and Forging Stock
AMS 2372 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Forgings and Forging Stock
AMS 2375 - Control of Forgings Requiring First Article Approval
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

2.1.2 Aerospace Standards:

AS 1182 - Standard Machining Allowance, Aircraft Quality and Premium Quality Steel Products

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products
ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
ASTM E381 - Macroetch Testing, Inspection, and Rating Steel Products, Comprising Bars, Billets, Blooms, and Forgings

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 Military Standards:

MIL-STD-163 - Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

- 3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E350, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

	min	max
Carbon	0.38 - 0.43	
Manganese	0.50 - 0.80	
Silicon	0.20 - 0.40	
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	1.40 - 1.80	
Molybdenum	0.30 - 0.40	
Aluminum	0.95 - 1.30	
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:

- 3.2.1 Bars and Forgings: Hardened and tempered.

- 3.2.2 Forging Stock: As ordered by the forging manufacturer.

- 3.3 Heat Treatment: Bars and forgings shall be hardened by quenching from $1700^{\circ}\text{F} + 25$ ($925^{\circ}\text{C} + 15$) and tempered to meet the tensile property requirements of 3.4.2.

- 3.4 Properties: The product shall conform to the following requirements; hardness and tensile testing shall be performed in accordance with ASTM A370:

- 3.4.1 Macrostructure: Visual examination of transverse sections as in 4.3.3 from bars and forging stock, etched in accordance with ASTM E381 in hot hydrochloric acid (1:1) at $160^{\circ} - 180^{\circ}\text{F}$ ($70^{\circ} - 80^{\circ}\text{C}$) for sufficient time to develop a well-defined macrostructure, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the following macrographs of ASTM E381:

Section Size		Macrographs
Square Inches	(Square Centimetres)	
Up to 36, incl	(Up to 230, incl)	S2 - R1 - C2
Over 36 to 100, incl	(Over 230 to 645, incl)	S2 - R2 - C3
Over 100	(Over 645)	As agreed upon

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3.4.2 Tensile Properties:

Tensile Strength, min	112,000 psi (770 MPa)
Yield Strength at 0.2% Offset, min	90,000 psi (620 MPa)
Elongation in 4D, min	16%
Reduction of Area, min	50%

3.4.3 Hardness:

Nominal Diameter or Section Thickness		Hardness Brinell
Inches	(Millimetres)	
Up to 3.125, incl	(Up to 78, incl)	241 - 285
Over 3.125 to 6.000, incl	(Over 78 to 150, incl)	229 - 285

3.4.3.1 Hardness shall be determined midway between surface and center of bars.

3.4.4 Decarburization:

- 3.4.4.1 Bars ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces.
- 3.4.4.2 Allowable decarburization of bars and billets ordered for redrawing or forging or to specified microstructural requirements shall be as agreed upon by purchaser and vendor.
- 3.4.4.3 Decarburization of bars to which 3.4.4.1 or 3.4.4.2 is not applicable shall be not greater than shown in Table I.

TABLE I

Nominal Diameter or Distance Between Parallel Sides Inches	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

TABLE I (SI)

Nominal Diameter or Distance Between Parallel Sides Millimetres	Depth of Decarburization Millimetres
Up to 12.50, incl	0.75
Over 12.50 to 25.00, incl	0.88
Over 25.00 to 37.50, incl	1.00
Over 37.50 to 50.00, incl	1.25
Over 50.00 to 62.50, incl	1.50
Over 62.50 to 75.00, incl	1.75

3.4.4.3.1 Limits for depth of decarburization of bars over 3.000 in. (75.00 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.4.4 Decarburization shall be measured by the microscopic method or by Rockwell Superficial 30-N scale or equivalent hardness testing method on hardened but untempered specimens 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 or lack of decarburization thereon.

3.4.4.4.1 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 in. (0.12 mm) and the width is 0.065 in. (1.65 mm) or less.

3.5 Quality:

3.5.1 Steel shall be aircraft quality conforming to AMS 2301.

3.5.2 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.

3.5.2.1 Bars ordered ground, turned, or polished shall be free from seams, laps, tears, and cracks open to the ground, turned, or polished surfaces.

3.5.2.2 Product ordered to surface conditions other than ground, turned, or polished shall, after removal of the standard machining allowance, be free from seams, laps, tears, cracks, and other defects exposed to the machined surfaces. Standard machining allowance shall be in accordance with AS 1182.

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3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, bars will be acceptable mill lengths of 6 - 20 ft (2 - 6 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft (3 m).

3.7 Tolerances: Unless otherwise specified, tolerances for bars shall conform to all applicable requirements of AMS 2251.

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 performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Preproduction Tests: Tests of forgings to determine conformance to all applicable technical requirements of this specification when AMS 2375 is specified are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a forging to a purchaser, when a change in material or processing, or both, requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.

4.2.2.1 For direct U.S. Military procurement of forgings, substantiating test data and, when requested, preproduction forgings shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be in accordance with the following:

4.3.1 Bars: AMS 2370.

4.3.2 Forgings and Forging Stock: AMS 2372.

4.3.3 Samples for macrostructure (3.4.1) testing shall be full cross-sectional specimens obtained from the finished billet or suitable rerolled product representing the top and bottom of at least the first, middle, and last usable ingots of each heat.

4.4 Approval: When specified, approval and control of forgings shall be in accordance with AMS 2375.