

AEROSPACE MATERIAL SPECIFICATION

SAE AMS6472

REV. E

Issued 1965-02
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Superseding AMS6472D

Steel, Bars and Forgings, Nitriding
1.6Cr – 0.35Mo – 1.1Al (0.38 – 0.43C) (135 Mod)
Hardened and Tempered, 112 ksi (772 MPa) Tensile Strength

(Composition similar to UNS K24065)

RATIONALE

AMS6472E results from a Five Year Review and update of this specification

1. SCOPE

1.1 Form

This specification covers an aircraft-quality, low-alloy steel in the form of heat treated bars and forgings, and of forging stock.

1.2 Application

This material has been used typically for nitrided parts requiring high surface hardness, resistance to heat, and less distortion than parts fabricated from steel requiring quenching to case harden, but usage is not limited to such applications. This steel may be case hardened in dissociated ammonia gas to provide a minimum case hardness of 900 HV.

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
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
AMS2750	Pyrometry
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, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM A 370	Mechanical Testing of Steel Products
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, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

Element	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 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

Bar shall be hardened and tempered. Bar shall not be cut from plate, larger bar or another product form.

3.2.2 Forgings

Hardened and tempered

3.2.3 Forging Stock

As ordered by the forging manufacturer.

3.3 Heat Treatment

Bars and forgings shall be hardened by quenching from 1700 °F ± 25 (927 °C ± 14) and tempered to meet the tensile property requirements of 3.4.2. Pyrometry shall be in accordance with AMS2750.

3.4 Properties

The product shall conform to the following requirements; hardness and tensile testing shall be performed in accordance with ASTM A 370:

3.4.1 Macrostructure

Visual examination of transverse full cross sections from bars 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-Sectional Area		Macrographs
Square Inches	Cross-Sectional Area Square Centimeters	
Up to 36, incl	Up to 232, incl	S2 - R1 - C2
Over 36 to 100, incl	Over 232 to 645, incl	S2 - R2 - C3

3.4.2 Tensile Properties of Bars and Forgings

Shall be as shown in Table 3.

TABLE 3 - MINIMUM TENSILE PROPERTIES

Property	Value
Tensile Strength	112 ksi (772 MPa)
Yield Strength at 0.2% Offset	90 ksi (620 MPa)
Elongation in 4D	16%
Reduction of Area	50%

3.4.3 Hardness of Bars and Forgings

Shall be as shown in Table 4.

TABLE 4 - HARDNESS

Nominal Diameter or Least Section Thickness Inches	Nominal Diameter or Least Section Thickness Millimeters	Hardness Brinell
Up to 3.125, incl	Up to 79.38, incl	241 to 285
Over 3.125 to 6.000, incl	Over 79.38 to 152.40, incl	229 to 285

3.4.3.1 Brinell hardness, or equivalent (See 8.2), 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 5.

TABLE 5A - MAXIMUM DECARBURIZATION LIMITS, 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

TABLE 5B - MAXIMUM DECARBURIZATION LIMITS, 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

- 3.4.4.4 Decarburization shall be measured by the metallographic method, by the HR30N scale hardness testing method, or by the microhardness 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.
- 3.4.4.4.1 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 inch (0.13 mm) and the width is 0.065 inch (1.65 mm) or less.

3.5 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.

- 3.5.1 Steel shall be aircraft-quality conforming to AMS2301.
- 3.5.2 Bars 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 ground, turned, or polished surface.

3.5.3 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.

3.6 Tolerances

Bars shall conform to all applicable requirements of AMS2251.

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 (3.4.1), tensile properties (3.4.2), hardness (3.4.3), decarburization (3.4.4), frequency-severity cleanliness ratings (3.5.1) and tolerances (3.6), are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests

Grain flow of die forgings (3.5.3) is a periodic test and shall be performed at a frequency selected by the vendor unless a frequency of testing is specified by purchaser.

4.3 Sampling and Testing

4.3.1 Bars and Forging Stock

In accordance with AMS2370.

4.3.2 Forgings

In accordance AMS2372.

4.4 Reports

4.4.1 The vendor of bars and forgings shall furnish with each shipment a report showing the results of tests for composition, macrostructure, and frequency-severity cleanliness rating of each heat and for tensile properties and hardness 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, AMS6472E, 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 The vendor of forging stock shall furnish with each shipment a report showing the results of tests for composition, macrostructure, and frequency-severity cleanliness rating of each heat. This report shall include the purchase order number, heat number, AMS6472E, size and quantity