AEROSPACE MATERIAL SPECIFICATION

AMS6472™	REV. H

Issued 1965-02
Reaffirmed 2006-02
Revised 2024-01

Superseding AMS6472G

Steel, Bars and Forgings and Forging Stock, Nitriding, 1.6Cr - 0.35Mo - 1.1Al (0.38 - 0.43C) (135 Mod), Aircraft Quality, Hardened and Tempered, 112 ksi (772 MPa) Tensile Strength (Composition similar to UNS K24065)

RATIONALE

AMS6472H is the result of a Five-Year Review and update of the specification. The revision updates the title to include product form and quality consistent with the Scope and Quality, adds composition reporting information (see 3.1.1), clarifies the macrostructure requirements (see 3.4.1 and 8.7), revises decarburization testing methods (see 3.4.4.4), incorporates the requirements of AMS2301 (see 4.2.1, 4.4.1, 4.4.3, and 4.4.5), adds ordering operations for forging stock (see 4.4.3), adds information on ordering bar (see 8.5), and updates the prohibition on product exceptions (note removed from Table 2; see 8.6).

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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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For more information on this standard, visit
https://www.sae.org/standards/content/AMS6472H

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

AMS2259 Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels

AMS2301 Steel Cleanliness, Aircraft Quality, Magnetic Particle Inspection Procedure

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

AS7766 Terms Used in Aerospace Metals Specifications

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 A751 Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

ASTM E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

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

ASTM E1077 Standard Test Methods for Estimating the Depth of Decarburization of Steel Specimens

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined in accordance with ASTM A751 or by other analytical methods acceptable to the purchaser.

Table 1 - Composition

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 The producer may test for any element not listed in Table 1 and include this analysis in the report of 4.4. Reporting of any element not listed in the composition table is not a basis for rejection unless limits of acceptability are specified by the purchaser.

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS2259.

3.2 Condition

The product shall be supplied in the following condition:

3.2.1 Bars

Bars shall be hardened and tempered. Bar shall not be cut from plate (see 4.4.2).

3.2.2 Forgings

Forgings shall be hardened and tempered.

3.2.3 Forging Stock

Forging stock shall be as ordered by the forging manufacturer.

3.3 Heat Treatment

Bars and forgings shall be hardened by quenching from 1700 °F ± 25 °F (927 °C ± 14 °C) 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 A370:

3.4.1 Macrostructure

Visual examination of transverse full cross sections from bars billets, tube rounds (solid not hollow) and 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 shown in Table 2.

Table 2 - Macrostructure limits

Cross-Sectional Area Square Inches	Cross-Sectional 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 the purchaser and producer.

3.4.1.1 Macrostructure examination is not required for bored/hollow forgings (including ring forgings) that are produced directly from ingots or blooms, unless otherwise agreed by the purchaser and producer (see 8.7).

3.4.2 Tensile Properties of Bars and Forgings

Minimum tensile properties 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 or 2 inches (50 mm)	16%
Reduction of Area	50%

3.4.2.1 Unless otherwise specified, the strain rate shall be set at 0.005 in/in/min (0.005 mm/mm/min) and maintained within a tolerance of ±0.002 in/in/min (±0.002 mm/mm/min) through 0.2% offset yield strain. After the yield strain, the speed of the testing machine shall be set between 0.05 in/in and 0.5 in/in (0.05 mm/mm and 0.5 mm/mm) of the length of the reduced section or distance between the grips for specimens not having a reduced section) per minute. Alternatively, an extensometer and strain rate indicator may be used to set the strain rate between 0.05 in/in/min and 0.5 in/in/min (0.05 mm/mm/min and 0.5 mm/mm/min).

3.4.3 Hardness of Bars and Forgings

Hardness 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 the purchaser and producer.

3.4.4.3 Where 3.4.4.1 or 3.4.4.2 are not applicable, decarburization of bars shall be not greater than shown in Table 5.

Table 5A - Maximum total depth of decarburization limits, inch/pound units

Nominal Diameter or Distance Between Parallel Sides Inches	Total Depth of Decarburization Inches
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 total depth of 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 evaluated by one of the two methods of 3.4.4.4.1 or 3.4.4.4.2.

3.4.4.4.1 Metallographic (Microscopic) Method

A cross section of the surface shall be prepared and examined metallographically at a magnification not to exceed 200X in accordance with ASTM E1077. The sample shall not show a layer of complete (ferrite) or partial decarburization exceeding the limits of Table 5.

3.4.4.4.2 Hardness Traverse (Microindentation) Method

The total depth of decarburization shall be determined by a traverse method using microindentation hardness testing in accordance with ASTM E1077. Samples shall be hardened and protected during heat treatment to prevent changes in surface carbon content. Samples may be tempered at the option of the producer. 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 Table 5.

3.4.4.4.3 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.

3.4.4.4.4 In case of dispute, the total depth of decarburization determined using the microindentation hardness traverse method shall govern.

3.5 Quality

The product, as received by the 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 shall be free from seams, laps, tears, and cracks after removal of the standard stock removal allowance in accordance with AS1182.

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

Bar tolerances shall conform to all applicable requirements of AMS2251.

3.7 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.4.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for the producer's tests and shall be responsible for the performance of all required tests. The 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 (see 3.1), condition (see 3.2), macrostructure (see 3.4.1), tensile properties (see 3.4.2), hardness (see 3.4.3), decarburization (see 3.4.4), frequency-severity cleanliness ratings (see 3.5.1) and tolerances (see 3.6), are acceptance tests and shall be performed on each heat or lot as applicable. If process qualification in accordance with AMS2301 has been met, the frequency-severity cleanliness rating shall be conducted on a periodic basis as defined in AMS2301.

4.2.2 Periodic Tests

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

4.3 Sampling and Testing

4.3.1 Bars and forging stock shall be sampled and tested in accordance with AMS2370.

4.3.2 Forgings shall be sampled and tested in accordance with AMS2372.

4.4 Reports

4.4.1 The producer of bars and forgings shall furnish with each shipment a report showing the producer's 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 frequency-severity cleanliness rating of each heat (see 4.4.5), 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, AMS6472H, product form and size (and/or part number, if applicable), 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).

4.4.3 The producer of forging stock shall furnish with each shipment a report showing the producer's 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 frequency-severity cleanliness rating of each heat (see 4.4.5) and the results of additional property requirements imposed by the purchase order (see 8.7). This report shall include the purchase order number, heat number, AMS6472H, size and quantity.

4.4.4 When material produced to this specification has exceptions authorized by the purchaser taken to the technical requirements listed in Section 3, the report shall contain a statement "This material is certified as AMS6472H(EXC) because of the following exceptions:" and the specific exceptions shall be listed (see 5.2.1).