



AEROSPACE MATERIAL SPECIFICATION	AMS6324™	REV. L
	Issued 1945-05 Reaffirmed 2000-09 Revised 2023-10	
Superseding AMS6324K		
Steel Bars, Forgings, Mechanical Tubing, and Forging Stock Aircraft-Quality 0.65Cr - 0.70Ni - 0.25Mo (0.38 - 0.43C) (8740 Modified) (Composition similar to UNS K11640)		

RATIONALE

AMS6324L is the result of a Five-Year Review and update of the specification. The revision includes update of the Title to match the Scope and product quality, update to composition reporting (see 3.1.2), clarification of macrostructure for hollow forgings (see 3.3.1 and 8.8), revision of hardenability requirements (see 3.3.3), revision of decarburization testing requirements (see 3.3.4.5), incorporation of requirements for periodic testing per AMS2301 (see 4.2.1 and 4.4.5), additional ordering information on forging stock (see 4.4.3 and 8.8), notes on bar stock quality (see 8.6), and updates to the requirements for product exceptions (see 8.7).

1. SCOPE

1.1 Form

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

1.2 Application

These products have been used typically for parts, 0.750 inch (19.05 mm) and under in section thickness at time of heat treatment, requiring a through-hardening steel capable of developing hardness as high as 50 HRC when properly hardened and tempered and also parts of greater thickness but requiring proportionately lower hardness, 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.

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<https://www.sae.org/standards/content/AMS6324L/>

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
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
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
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 A255	Determining Hardenability of Steel
ASTM A370	Mechanical Testing of Steel Products
ASTM A751	Chemical Analysis of Steel Products
ASTM E112	Determining Average Grain Size
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	Estimating the Depth of Decarburization of Steel Specimens

2.3 Definitions

Terms used in AMS are defined in AS7766.

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	0.75	1.00
Silicon	0.15	0.35
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	0.55	0.75
Nickel	0.55	0.85
Molybdenum	0.20	0.30
Copper	--	0.35

3.1.1 Aluminum, vanadium, and columbium (niobium) are optional grain refining elements and need not be determined or reported unless used to satisfy the average grain size requirements of 3.3.2.2.

3.1.2 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.

3.1.3 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 A370:

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 shall be cold finished having tensile strength not higher than 130 ksi (896 MPa).

3.2.1.2 Bars over 0.500 inch (12.70 mm) in nominal diameter or least distance between parallel sides shall be hot finished and annealed, unless otherwise ordered, having hardness not higher than 229 HBW, or equivalent (see 8.2). Bars ordered cold finished may have hardness as high as 248 HBW, or equivalent (see 8.2).

3.2.1.3 Bar shall not be cut from plate (see 4.4.2).

3.2.2 Forgings

Forgings shall be as ordered.

3.2.3 Mechanical Tubing

Mechanical tubing shall be cold finished, unless otherwise ordered, having hardness not higher than 25 HRC, or equivalent (see 8.2). Tubing ordered hot finished and annealed shall have hardness not higher than 99 HRB, or equivalent (see 8.2).

3.2.4 Forging Stock

Forging stock shall be 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 A370:

3.3.1 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-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 the producer and purchaser

3.3.1.1 Macrostructure examination is not required for bored/hollow forgings (including ring forgings) and mechanical tubing that are produced directly from ingots or large blooms unless otherwise agreed by the purchaser and producer (see 8.8).

3.3.1.2 If mechanical tubing is produced directly from ingots or large blooms, transverse sections may be taken from the tubing. Macrostructure standards for such tubes shall be as agreed upon by the purchaser and producer (see 8.8).

3.3.2 Average Grain Size of Bars, Forgings, and Mechanical Tubing

The average grain size shall be determined by either 3.3.2.1 or 3.3.2.2.

3.3.2.1 The average grain size shall be ASTM No. 5 or finer, determined in accordance with ASTM E112.

3.3.2.2 The product of a heat shall be considered to have an ASTM No. 5 or finer austenitic grain size if one or more of the following are determined by heat analysis (see 8.5):

- A total aluminum content of 0.020 to 0.050%.
- An acid soluble aluminum content of 0.015 to 0.050%.
- A vanadium content of 0.02 to 0.08%.
- A columbium (niobium) content of 0.02 to 0.05%.

3.3.3 Hardenability of Each Heat

Hardenability shall be J 7/16 inch (11 mm) = 50 HRC minimum and J 10/16 inch (16 mm) = 45 HRC minimum, determined on the standard end-quench test specimen in accordance with ASTM A255 except that the steel shall be normalized at 1700 °F ± 10 °F (927 °C ± 6 °C) and the test specimen austenitized at 1525 °F ± 10 °F (829 °C ± 6 °C). Cast specimens do not need to be normalized.

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 3.

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 by the purchaser and producer.

3.3.4.3 Where 3.3.4.1 or 3.3.4.2 are not applicable, decarburization of bars shall be not greater than shown in Table 3.

Table 3A - Maximum total depth of decarburization, inch/pound units

Nominal Diameter or Distance Between Parallel Sides Inches	Total Depth of Decarburization Inches
Up to 0.375, incl	0.010
Over 0.375 to 0.500, incl	0.012
Over 0.500 to 0.625, incl	0.014
Over 0.625 to 1.000, incl	0.017
Over 1.000 to 1.500, incl	0.020
Over 1.500 to 2.000, incl	0.025
Over 2.000 to 2.500, incl	0.030
Over 2.500 to 3.000, incl	0.035
Over 3.000 to 4.000, incl	0.040

Table 3B - Maximum total depth of decarburization, SI units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Total Depth of Decarburization Millimeters
Up to 9.52, incl	0.25
Over 9.52 to 12.70, incl	0.30
Over 12.70 to 15.88, incl	0.36
Over 15.88 to 25.40, incl	0.43
Over 25.40 to 38.10, incl	0.51
Over 38.10 to 50.80, incl	0.64
Over 50.80 to 63.50, incl	0.76
Over 63.50 to 76.20, incl	0.89
Over 76.20 to 101.60, incl	1.14

3.3.4.4 Where 3.3.4.1 or 3.3.4.2 are not applicable, decarburization of tubing shall be not greater than shown in Table 4.

Table 4A - Maximum total depth of decarburization, inch/pound units

Nominal Wall Thickness Inches	Total Depth of Decarburization Inches	Total Depth of Decarburization Inches
	ID	OD
Up to 0.109, incl	0.008	0.015
Over 0.109 to 0.203, incl	0.010	0.020
Over 0.203 to 0.400, incl	0.012	0.025
Over 0.400 to 0.600, incl	0.015	0.030
Over 0.600 to 1.000, incl	0.017	0.035
Over 1.000	0.020	0.040

Table 4B - Maximum total depth of decarburization, SI units

Nominal Wall Thickness Millimeters	Total Depth of Decarburization Millimeters	Total Depth of Decarburization Millimeters
	ID	OD
Up to 2.77, incl	0.20	0.38
Over 2.77 to 5.16, incl	0.25	0.51
Over 5.16 to 10.16, incl	0.30	0.64
Over 10.16 to 15.24, incl	0.38	0.76
Over 15.24 to 25.40, incl	0.43	0.89
Over 25.40	0.51	1.02

3.3.4.5 Decarburization shall be evaluated by one of the two methods of 3.3.4.5.1 or 3.3.4.5.2.

3.3.4.5.1 A cross section of the surface shall be prepared in accordance with ASTM E1077 and examined metallographically at a magnification not to exceed 200X. Optical indications of decarburization shall not show a layer of complete (ferrite) or partial decarburization exceeding the limits of Tables 3 and 4.

3.3.4.5.2 Hardness Traverse (Microindentation) Method

3.3.4.5.3 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 Tables 3 and 4.

3.3.4.5.4 When determining the depth of decarburization, it is permissible to disregard local areas provided the decarburization of such areas does not exceed the limits of Table 3 or Table 4 by more than 0.005 inch (0.13 mm) and the width is 0.065 inch (1.65 mm) or less.

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

3.4 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.

3.4.1 Steel shall be aircraft quality conforming to AMS2301.

3.4.2 Bars and mechanical tubing shall be free from seams, laps, tears, and cracks after removal of the standard stock removal allowance in accordance with AS1182.

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

Tolerances for bars shall be in accordance with AMS2251.

3.5.2 Mechanical Tubing

Tolerances for mechanical tubing shall be in accordance with AMS2253.

3.6 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 3.3.1), average grain size (see 3.3.2), hardenability (see 3.3.3), decarburization (see 3.3.4), frequency-severity cleanliness (see 3.4.1), and tolerances (see 3.5) are acceptance tests and shall be performed on each heat or lot as applicable. If grain refining elements (see 3.3.2.2) are not present, the ASTM E112 grain size test (see 3.3.2.1) shall be conducted on each lot. 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

If grain refining elements (see 3.3.2.2) are present, the ASTM E112 grain size test (see 3.3.2.1) shall be conducted on a periodic basis and shall be performed at a frequency selected by the producer (not to exceed 1 year) unless frequency of testing is specified by the purchaser. Grain flow of die forgings (see 3.4.3) 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, mechanical tubing, and forging stock shall be sampled and tested in accordance with AMS2370.

4.3.2 Forgings

Forgings shall be sampled and tested in accordance with AMS2372.

4.4 Reports

4.4.1 The producer of bars, forgings, and mechanical tubing 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), the results of tests for composition, macrostructure, hardenability, and frequency-severity cleanliness rating of each heat (see 4.4.5), and, if measured, for average grain size 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, AMS6324L, 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 3.2.1.3).

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), the results of tests for composition macrostructure, hardenability, 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 8.8). This report shall include the purchase order number, heat number, AMS6324L, 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 AMS6324L(EXC) because of the following exceptions:" and the specific exceptions shall be listed (see 5.2.1).

4.4.5 Reduced Testing

If the producer has qualified for periodic testing for frequency-severity cleanliness rating in accordance with AMS2301, then the frequency-severity cleanliness rating is not required to be reported for each shipment. In this circumstance the report shall read, "Process qualification in accordance with AMS2301 has been completed."

4.5 Resampling and Retesting

4.5.1 Bars, mechanical tubing, and forging stock shall be resampled and retested in accordance with AMS2370.

4.5.2 Forgings shall be resampled and retested in accordance with AMS2372.