

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6424E

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Superseding AMS 6424D

Steel Bars, Forgings, and Tubing
0.80Cr - 1.8Ni - 0.25Mo (0.49 - 0.55C)

(Composition similar to UNS K22950)

RATIONALE

AMS 6424E 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 bars, forgings, mechanical tubing, and forging stock.

1.2 Application

These products have been used primarily for parts 3.5 inches (90 mm) and under in nominal section-thickness at time of heat treatment requiring a through-hardening steel capable of developing hardness as high as 40 HRC and also for parts with thicker cross-section which require 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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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.

AMS 2251	Tolerances, Low-Alloy Steel Bars
AMS 2253	Tolerances, Carbon and Alloy Steel Tubing
AMS 2259	Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS 2301	Steel Cleanliness, Aircraft Quality, Magnetic Particle Inspection Procedure
AMS 2370	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock
AMS 2372	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Forgings
AMS 2806	Identification Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat-Resistant Steels and Alloys
AMS 2808	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 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 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.

TABLE 1 - COMPOSITION

Element	min	max
Carbon	0.49	0.55
Manganese	0.65	0.85
Silicon	0.15	0.35
Phosphorous	--	0.025
Sulfur	--	0.025
Chromium	0.70	0.90
Nickel	1.65	2.00
Molybdenum	0.20	0.30
Copper	--	0.35

3.1.1 Check Analysis

Composition variations shall meet the applicable requirements of AMS 2259, except that variations for carbon shall apply to over max only.

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 (12.50 mm) and Under in Nominal Diameter or Least Distance Between Parallel Sides

Cold finished having tensile strength not higher than 135 ksi (930 MPa) or equivalent hardness (See 8.2).

3.2.1.2 Bars Over 0.500 Inch (12.50 mm) in Nominal Diameter or Least Distance Between Parallel Sides

Hot finished and annealed unless otherwise ordered, having hardness not higher than 255 HB, or equivalent (See 8.3). Bars ordered cold finished may have hardness as high as 277 HB, or equivalent (See 8.3).

3.2.2 Forgings

As ordered.

3.2.3 Mechanical Tubing

Cold finished, unless otherwise ordered, having hardness not higher than 28 HRC, or equivalent (See 8.3). Tubing ordered hot finished and annealed shall have hardness not higher than 23 HRC, or equivalent (See 8.3).

3.2.4 Forging Stock

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 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 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 macrographs of ASTM E 381 shown in Table 2.

TABLE 2 - MACROSTRUCTURE LIMITS

Cross-Sectional Area Square Inches	Cross-Sectional Area Square Centimeters	Cross-Sectional Area Macrographs
Up to 36, incl	Up to 230, incl	S2 - R1 - C2
Over 36 to 100, incl	Over 230 to 645, incl	S2 - R2 - C3

3.3.2 Average Grain Size

Shall be ASTM No. 5 or finer determined in accordance with ASTM E 112.

3.3.3 Hardenability

Shall be J 2/16 inch (3.175 mm) = 62 HRC min and J 12/16 inch (19.050 mm) = 55 HRC min, determined on the standard end-quench test specimen in accordance with ASTM A 255 except that the steel shall be normalized at 1700 °F ± 10 (925 °C ± 6) and the test specimen austenitized at 1525 °F ± 10 (830 °C ± 6).

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.
- 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 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 3.

TABLE 3A - MAXIMUM DECARBURIZATION, INCH/POUND UNITS

Nominal Diameter or Distance Between Parallel Sides Inches	Total Depth of Decarburization Inch
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	0.045

TABLE 3B - MAXIMUM DECARBURIZATION, SI UNITS

Nominal Diameter or Distance Between Parallel Sides Millimeters	Total Depth of Decarburization Millimeters
Up to 9.50, incl	0.25
Over 9.50 to 12.50, incl	0.30
Over 12.50 to 15.50, incl	0.35
Over 15.50 to 25.00, incl	0.42
Over 25.00 to 37.50, incl	0.50
Over 37.50 to 50.00, incl	0.62
Over 50.00 to 62.50, incl	0.75
Over 62.50 to 75.00, incl	0.88
Over 75.00 to 100.00, incl	1.12

- 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 4.

TABLE 4A - MAXIMUM DECARBURIZATION, 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	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 DECARBURIZATION, SI UNITS

Nominal Wall Thickness Millimeters	Total Depth of Decarburization Millimeter ID	Total Depth of Decarburization Millimeter OD
Up to 2.75, incl	0.20	0.38
Over 2.75 to 5.00, incl	0.25	0.50
Over 5.00 to 10.00, incl	0.30	0.62
Over 10.00 to 15.00, incl	0.38	0.75
Over 15.00 to 25.00, incl	0.42	0.88
Over 25.00	0.50	1.00

- 3.3.4.5 Decarburization shall be measured by the metallographic method, by the HR30N scale hardness testing method, or by a 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.

- 3.3.4.5.1 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 AMS 2301.
- 3.4.2 Bars and mechanical tubing ordered hot rolled or cold drawn or ground, turned, or polished shall, after removal of the standard machining allowance in accordance with AS1182, be free from seams, laps, tears, and cracks open to the ground, turned, or polished surface.
- 3.4.3 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forgings, showing no evidence of reentrant grain flow.

3.5 Tolerances

Shall be as follows:

3.5.1 Bars

Shall conform to the applicable requirements of AMS 2251.

3.5.2 Mechanical Tubing

Shall conform to the applicable requirements of AMS 2253.

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 (3.3.1), average grain size (3.3.2), hardenability (3.3.3), decarburization (3.3.4), 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.

4.2.2 Periodic Tests

Grain flow of die forgings (3.4.3) is a periodic test and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing

Shall be as follows:

4.3.1 Bars, Mechanical Tubing and Forging Stock

In accordance with AMS 2370.

4.3.2 Forgings

In accordance with AMS 2372.

4.4 Reports

The vendor of the product shall furnish with each shipment a report showing the results of tests for composition, macrostructure, hardenability, and frequency-severity cleanliness rating of each heat and for the condition and average grain size on 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, AMS 6424E, product form, size, 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.