



AEROSPACE MATERIAL SPECIFICATION

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AMS 6312D

Superseding AMS 6312C

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STEEL BARS, FORGINGS, AND TUBING
1.8Ni - 0.25Mo (0.38 - 0.43C) (4640)

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: Primarily for parts with sections 0.250 in. (6.25 mm) and under in nominal thickness at the time of heat treatment which require a through-hardening steel capable of developing hardness as high as 50 HRC when properly hardened and tempered and also parts of greater thickness requiring proportionately lower hardness.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) and Aerospace Standards (AS) shall apply. The applicable issue of other documents shall be specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

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 - 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, Extrusions, and Mechanical Tubing, 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

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

ASTM A255 - End-Quench Test for Hardenability of Steel

ASTM A370 - Mechanical Testing of Steel Products

ASTM E112 - Estimating the Average Grain Size of Metals

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:

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	min	max
Carbon	0.38	0.43
Manganese	0.60	0.80
Silicon	0.15	0.35
Phosphorus	--	0.025
Sulfur	--	0.025
Nickel	1.65	2.00
Molybdenum	0.20	0.30
Chromium	--	0.20
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; hardness and tensile strength shall be determined in accordance with ASTM A370:

- 3.2.1 Bars:

- 3.2.1.1 Bars 0.500 In. (12.50 mm) and Under in Nominal Diameter or Distance Between Parallel Sides: Cold finished having tensile strength not higher than 130,000 psi (896 MPa), or equivalent hardness.

- 3.2.1.2 Bars Over 0.500 In. (12.50 mm) in Nominal Diameter or Distance Between Parallel Sides: Hot finished having hardness not higher than 229 HB or equivalent except that bars ordered cold finished may have hardness as high as 241 HB or equivalent.

- 3.2.2 Forgings: As ordered.

- 3.2.3 Mechanical Tubing: Cold finished having hardness not higher than 25 HRC except that tubing ordered hot finished shall have hardness not higher than 99 HRB or equivalent.
- 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 A370:
- 3.3.1 Macrostructure: Visual examination of transverse sections from bars, billets, tube rounds or tubes, and forging stock, etched in accordance with ASTM E381 in hot hydrochloric acid (1:1) at 160° - 180°F (71° - 82°C) for sufficient time to develop a well-defined macrostructure, shall show no pipe or cracks. Except as specified in 3.3.1.1, 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 35, incl	(Up to 232, incl)	S2 - R1 - C2
Over 36 to 100, incl	(Over 232 to 645, incl)	S2 - R2 - C3
Over 100	(Over 645)	As agreed upon

- 3.3.1.1 If tubes are produced directly from ingots or large blooms, transverse sections may be taken from tubes rather than tube rounds. Macrostructure standards for such tubes shall be as agreed upon by purchaser and vendor.
- 3.3.2 Grain Size: Predominantly 5 or finer with occasional grains as large as 3 permissible, determined in accordance with ASTM E112.
- 3.3.3 Hardenability: Shall be J50=3 min and J35=9 min, determined on the standard end-quench test specimen in accordance with ASTM A255 except that the steel shall be normalized at 1550° F $\pm$ 10 (845°C $\pm$ 5) and the test specimen austenitized at 1500° F $\pm$ 10 (815°C $\pm$ 5). The hardenability test is not required on a product that will not yield a suitable specimen but the steel from which the product is made shall conform to the hardenability specified.
- 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 II.
- 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 I.

TABLE I

Nominal Diameter or Distance Between Parallel Sides Inches	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 I (SI)

Nominal Diameter or Distance Between Parallel Sides Millimetres	Depth of Decarburization Millimetres
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

3.3.4.3.1 Limits for depth of decarburization of bars over 4.000 in. (101.60 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

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 II.

TABLE II

Nominal Wall Thickness Inches	Depth of Decarburization Inch	
	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 II (SI)

Nominal Wall Thickness Millimetres	Depth of Decarburization Millimetres	
	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 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.

- 3.3.4.5.1 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 in. (0.13 mm) and the width is 0.065 in. (1.65 mm) or less.

3.4 Quality:

- 3.4.1 Steel shall be aircraft quality conforming to AMS 2301.

- 3.4.2 The product, as received by the purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from internal and external imperfections detrimental to usage of the product.

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

- 3.4.3.2 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.

- 3.5 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars and tubing will be acceptable in mill lengths of 6 - 20 ft (1.8 - 6.1 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft (3 m).

- 3.6 Tolerances: Unless otherwise specified, tolerances shall conform to all applicable requirements of the following:

- 3.6.1 Bars: AMS 2251.

- 3.6.2 Mechanical Tubing: 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 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 such confirmatory testing as he deems 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 on the first-article shipment of a forging to a purchaser, when a change in material or processing 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 and Mechanical Tubing: AMS 2370.

- 4.3.2 Forgings and Forging Stock: AMS 2372.

- 4.3.3 Samples for macrostructure (3.3.1) 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.