



AEROSPACE MATERIAL SPECIFICATION

Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AMS 6418D

Superseding AMS 6418C

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STEEL BARS, FORGINGS, TUBING, AND RINGS
1.3Mn - 1.5Si - 0.30Cr - 1.8Ni - 0.40Mo (0.23 - 0.28C)

1. SCOPE:

1.1 Form: This specification covers an aircraft-quality low-alloy steel in the form of bars, forgings, mechanical tubing, flash welded rings, and stock for forging and flash welded rings.

1.2 Application: Primarily for parts requiring high tensile strength and good ductility with relatively high impact strength and 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 as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, New York 10001.

2.1.1 Aerospace Material Specifications:

AMS 2251 - Tolerances, Alloy Steel Bars

AMS 2253 - Tolerances, Carbon and Alloy Steel Tubing

AMS 2259 - Chemical Check Analysis Limits, Wrought Low Alloy and Carbon Steel

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

AMS 2372 - Quality Assurance Sampling of Carbon and Low Alloy Steels, Forgings and Forging Stock

AMS 2375 - Approval and Control of Critical Forgings

AMS 2808 - Identification, Forgings

AMS 7496 - Rings, Flash Welded, Carbon and Low Alloy Steel

2.1.2 Aerospace Standards:

AS 1182 - Standard Machining Allowance, Aircraft Quality and Premium Quality Steel Products

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

ASTM A255 - End-Quench Test for Hardenability of Steel

ASTM A370 - Mechanical Testing of Steel Products

ASTM E23 - Notched Bar Impact Testing of Metallic Materials

ASTM E112 - Estimating 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 - Rating Macroetched Steel

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2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, Pennsylvania 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

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 approved analytical methods:

	min	max
Carbon	0.23	0.28
Manganese	1.20	1.50
Silicon	1.30	1.70
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	0.20	0.40
Nickel	1.65	2.00
Molybdenum	0.35	0.45
Copper	--	0.35

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2259, paragraph titled "Low Alloy Steels".

3.2 Condition: The product shall be supplied in the following condition; hardness and tensile strength, as applicable, shall be determined in accordance with ASTM A370:

3.2.1 Bars:

3.2.1.1 Bars 0.500 In. (12.70 mm) and Under in Diameter or Distance Between Parallel Sides: Cold finished having tensile strength not higher than 140,000 psi (965 MPa) or equivalent hardness.

3.2.1.2 Bars Over 0.500 In. (12.70 mm) in Diameter or Distance Between Parallel Sides: Hot finished having hardness not higher than 241 HB or equivalent, except that bars ordered cold finished may have hardness as high as 248 HB or equivalent.

3.2.2 Forgings and Flash Welded Rings: As ordered.

3.2.2.1 Flash welded rings shall not be supplied unless specified or permitted on purchaser's part drawing. When supplied, they shall be manufactured in accordance with AMS 7496.

3.2.3 Mechanical Tubing: Cold finished having hardness not higher than 25 HRC or equivalent, except that tubing ordered hot finished shall have hardness not higher than 99 HRB or equivalent.

3.2.4 Stock for Forging or Flash Welded Rings: As ordered by the forging or flash welded ring 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 Hardenability: Shall be J45=24 min, determined on the standard end-quench test specimen in accordance with ASTM A355 except that the steel shall be normalized at $1700\text{ F} \pm 10$ ($926.7\text{ C} \pm 5.6$) and the test specimen austenitized at $1575\text{ F} \pm 10$ ($857.2\text{ C} \pm 5.6$). The hardenability test is not required on a product which will not yield a suitable specimen but the steel from which the product is made shall conform to the hardenability specified.

3.3.2 Grain Size: Predominantly 5 or finer with occasional grains as large as 3 permissible, ASTM E112, McQuaid-Ehn test modified by cooling from the carburizing temperature to $1300\text{ F} \pm 25$ ($704.4\text{ C} \pm 14$) and holding for 1 hr before cooling to room temperature.

3.3.3 Macrostructure: Visual examination of transverse sections from bars, billets, stock for forging or flash welded rings, and tube rounds, etched in accordance with ASTM E381 in hot hydrochloric acid (1:1) at $160 - 180\text{ F}$ ($71.1 - 82.2\text{ C}$) for sufficient time to develop a well-defined macrostructure shall show no injurious imperfections such as pipe, cracks, porosity, segregation, and inclusions detrimental to fabrication or to performance of parts. Macrostructure shall be equal to or better than the following macrographs of ASTM E381:

Section Size		Macrographs
Square Inches	(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
Over 100	(Over 645)	As agreed upon

3.3.4 Impact Strength: The Izod impact value shall be not less than 20 ft-lb (27 N.m), determined at room temperature in accordance with ASTM E23 using a V-notched specimen. Specimens, before test, shall have hardness not lower than 46 HRC after being quenched in oil from $1575\text{ F} \pm 10$ ($857.2\text{ C} \pm 5.6$) and tempered at $525 - 550\text{ F}$ ($273.9 - 287.8\text{ C}$). Before heat treatment, specimens shall be to size or approximately to size, except for the notch.

3.3.5 Decarburization:

3.3.5.1 Bars, tubing, and flash welded rings ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces. Inside decarburization of such tubing shall not exceed the maximum depth specified in Table II.

3.3.5.2 Allowable decarburization of bars, billets, and tubing ordered for redrawing, forging, or flash welding or to specified microstructural requirements shall be as agreed upon by purchaser and vendor.

3.3.5.3 Decarburization of bars and flash welded rings to which 3.3.5.1 or 3.3.5.2 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 Millimeters	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

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

3.3.5.4 Decarburization of tubing to which 3.3.5.1 or 3.3.5.2 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 Millimeters	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

3.3.5.5 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.

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

- 3.4 Quality: Steel shall be aircraft quality conforming to AMS 2301. The product shall be uniform in quality and condition, clean, sound, and free from foreign materials and from internal and external imperfections detrimental to fabrication or to performance of parts.
- 3.4.1 Bars, tubing, and flash welded rings ordered ground, turned, or polished shall be free from seams, laps, tears, and cracks open to the ground, turned, or polished surfaces.
- 3.4.2 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 imperfections exposed to the machined surfaces. Standard machining allowance shall be in accordance with values shown in AS 1182.
- 3.5 Sizes: Except when exact lengths or multiples of exact lengths are ordered, 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 Tubing: AMS 2253.
4. QUALITY ASSURANCE PROVISIONS:
- 4.1 Responsibility for Inspection: The vendor shall supply all samples 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 perform such confirmatory testing as he deems necessary to assure that the product conforms to the requirements of this specification.
- 4.2 Classification of Tests: Tests to determine conformance to all technical requirements of this specification are classified as acceptance or routine control tests.
- 4.3 Sampling: Shall be in accordance with the following:
- 4.3.1 Bars, Mechanical Tubing, and Stock for Flash Welded Rings: AMS 2370.
- 4.3.2 Forgings and Forging Stock: AMS 2372.
- 4.3.3 Flash Welded Rings: As agreed upon by purchaser and vendor.
- 4.3.4 Specimens for impact testing shall be taken longitudinally from sections rolled or forged from full cross section to not over 2.0 in. (51 mm) round or square.
- 4.4 Approval: When specified, approval and control of critical forgings shall be in accordance with AMS 2375.
- 4.5 Reports:
- 4.5.1 The vendor of the product shall furnish with each shipment three copies of a report of the results of tests for chemical composition, hardenability, grain size, macrostructure, impact value, and AMS 2301 frequency-severity rating of each heat in the shipment. This report shall include the purchase order number, heat number, material specification number and its revision letter, size, and quantity from each heat. If forgings are supplied, the part number and the size and melt source of stock used to make the forgings shall also be included.