



AEROSPACE MATERIAL SPECIFICATION

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

AMS 6526A

Superseding AMS 6526

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STEEL BARS, FORGINGS, TUBING, AND RINGS
1.0Cr - 7.5Ni - 4.5Co - 1.0Mo - 0.09V (0.29 - 0.34C)
Premium Quality, Consumable Electrode Vacuum Melted, Annealed

1. SCOPE:

1.1 Form: This specification covers a premium-quality high-strength, low-alloy steel in the form of \emptyset bars, forgings, mechanical tubing, flash welded rings, and stock for forging or flash welded rings.

1.2 Application: Primarily for heat treated parts, such as pressure vessels, requiring through hardening to high strength levels and when such parts may require welding. Certain processing procedures and service conditions may cause this material to be subject to stress-corrosion cracking; ARP 1110 recommends practices to minimize such conditions.

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), Aerospace Standards (AS), and Aerospace Recommended Practices (ARP) 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., 400 Commonwealth Drive, Warrendale, Pennsylvania 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 2300 - Premium 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 - 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

2.1.3 Aerospace Recommended Practices:

ARP 1110 - Minimizing Stress-Corrosion Cracking in Heat Treatable Wrought Low-Alloy and Martensitic Corrosion-Resistant Steels

SAE Technical Board rules provide that: "All technical reports, including standards, approvals, and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

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

- ASTM A370 - Mechanical Testing of Steel Products
- ASTM A604 - Macroetch Testing of Consumable Electrode Vacuum Arc Remelted Steel Bars and Billets
- ASTM E45 - Determining the Inclusion Content of Steel
- 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 E399 - Plane-Strain Fracture Toughness of Metallic Materials

2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, 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:

Ø		min	max
	Carbon	0.29	- 0.34
	Manganese	0.10	- 0.35
	Silicon	--	0.20
	Phosphorus	--	0.010
	Sulfur	--	0.010
	Chromium	0.90	- 1.10
	Nickel	7.00	- 8.00
	Cobalt	4.25	- 4.75
	Molybdenum	0.90	- 1.10
	Vanadium	0.06	- 0.12
	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. (12.70 mm) and Under in Diameter or Distance Between Parallel Sides: Annealed and cold finished having tensile strength not higher than 165,000 psi (1138 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, annealed, and descaled having hardness not higher than 341 HB or equivalent.

3.2.2 Forgings and Flash Welded Rings: Annealed and descaled having hardness not higher than 341 HB or equivalent.

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

3.2.3 Mechanical Tubing: Annealed and descaled having hardness not higher than 341 HB or equivalent.

3.2.4 Stock for Forging or Flash Welded Rings: As ordered by the forging or flash welded ring manufacturer.
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3.3 Heat Treatment: Bars, forgings, mechanical tubing, and flash welded rings shall be annealed by heating to 1150° F + 25 (621.1° C + 14), holding at heat for 8 - 24 hr commensurate with section thickness, and cooling in air.
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3.4 Properties: The product shall conform to the following requirements; hardness, tensile, and impact testing shall be performed in accordance with ASTM A370:
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3.4.1 Grain Size: Predominantly 5 or finer with occasional grains as large as 3 permissible, ASTM E112, McQuaid-Ehn test.

3.4.2 Macrostructure: Visual examination of transverse sections from bars, billets, stock for forging or flash welded rings, and tube rounds or tubes, etched in accordance with ASTM A604 in hot hydrochloric acid (1:1) at 160° - 180° F (71.1° - 82.2° 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 A604:
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Class	Condition	Severity
1	Freckles	B
2	White Spots	A
3	Radial Segregation	C
4	Ring Pattern	B

3.4.2.1 Macrostructure of Tubes: If tubes are produced directly from ingots or large blooms, transverse sections may be taken from tubes rather than tube rounds and macrostructure standards shall be as agreed upon by purchaser and vendor.
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3.4.3 Inclusion Rating: Radial specimens, approximately 0.28 sq in. (1.8 cm²) in surface area shall be polished, on a face longitudinal to the direction of rolling, for microinclusion rating in accordance with the Jernkontoret Chart, Method D, Plate III of ASTM E45. Two thirds of all specimens as well as the average of all specimens shall not exceed the following limits, except that the length of any inclusion shall be not greater than 0.015 in. (0.38 mm):

Type	Inclusion Rating			
	A	B	C	D
Thin	1.5	1.5	1.5	2.0
Heavy	1.0	1.0	1.0	1.5

3.4.4 Decarburization:

3.4.4.1 Bars, tubing, and flash welded rings 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 shown in Table II.
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3.4.4.2 Allowable decarburization of bars, billets, and tube rounds ordered for redrawing, forging, or flash welding or to specified microstructural requirements shall be as agreed upon by purchaser and vendor.
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3.4.4.3 Decarburization of bars and flash welded rings to which 3.4.4.1 or 3.4.4.2 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 5.000, 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 127.00, incl	1.14

3.4.4.3.1 Limits for depth of decarburization of bars and flash welded rings over 5.000 in. (127.00 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.4.4 Decarburization of tubing to which 3.4.4.1 or 3.4.4.2 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

3.4.4.5 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.

3.4.4.5.1 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.

3.4.5 Properties After Heat Treatment: Bars, forgings, mechanical tubing, and parent metal of flash welded rings, heat treated as in 3.4.5.1, shall conform to the requirements of 3.4.5.2 and, when specified, 3.4.5.4 and shall be capable of meeting the requirements of 3.4.5.3. Product need not be annealed as in 3.3 before heat treatment to determine conformance to these requirements.

3.4.5.1 Heat Treatment:

3.4.5.1.1 Normalizing: Heat to $1650^{\circ}\text{F} \pm 50$ ($898.9^{\circ}\text{C} \pm 28$), hold at heat for not less than 1 hr per inch (25 mm) of maximum section thickness, and cool in air to room temperature.

3.4.5.1.2 Hardening: Heat to $1550^{\circ}\text{F} \pm 15$ ($843.3^{\circ}\text{C} \pm 8.3$), hold at heat for 1 hr per inch (25 mm) of maximum section thickness but not less than 1 hr, quench sections up to 4.0 in. (102 mm), incl, in thickness into room temperature oil or water and sections over 4.0 in. (102 mm) in thickness into room temperature oil, cool to $-100^{\circ}\text{F} \pm 10$ ($-73.3^{\circ}\text{C} \pm 5.6$), hold at $-100^{\circ}\text{F} \pm 10$ ($-73.3^{\circ}\text{C} \pm 5.6$) for not less than 2 hr, and warm to room temperature.

3.4.5.1.3 Tempering: Heat to $1000^{\circ}\text{F} \pm 10$ ($537.8^{\circ}\text{C} \pm 5.6$), hold at heat for not less than 2 hr, suitably cool to below 125°F (52°C), reheat to $1000^{\circ}\text{F} \pm 10$ ($537.8^{\circ}\text{C} \pm 5.6$), hold at heat for not less than 2 hr, and cool in air to room temperature.

3.4.5.2 Longitudinal Tensile Properties:

Tensile Strength, min	220,000 psi (1517 MPa)
Yield Strength at 0.2% Offset, min	190,000 psi (1310 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	10%
Reduction of Area (round specimens), min	40%

3.4.5.3 Impact Strength: The product shall be capable of having a Charpy impact value not less than 20 ft-lb (27 N·m), determined at room temperature using a V-notched specimen.

3.4.5.4 Fracture Toughness: When specified, shall be determined by a suitable method. The method of testing and standards for acceptance shall be as agreed upon by purchaser and vendor. ASTM E399 is a suggested method of test for product having nominal section thicknesses of 0.50 in. (12.7 mm) and over.

3.4.6 Stock for Forging or Flash Welded Rings: When a sample of stock is forged to a test coupon and heat treated as in 3.4.5.1, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.5.2 and 3.4.5.3 and, when specified 3.4.5.4. If specimens taken from the stock after heat treatment as in 3.4.5.1 conform to the requirements of 3.4.5.2 and 3.4.5.3 and, when specified, 3.4.5.4, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5 Quality:

3.5.1 Steel shall be premium quality conforming to AMS 2300. It shall be multiple melted using vacuum consumable electrode practice in the remelt cycle.

3.5.2 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.

3.5.2.1 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.

3.5.2.2 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 surface. Standard machining allowance shall be in accordance with AS 1182.

3.6 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).

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

3.7.1 Bars: AMS 2251.

3.7.2 Mechanical Tubing: AMS 2253.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product 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:

4.2.1 Acceptance Tests: Tests of the product to determine conformance to composition (3.1) requirements; of bars, forgings, tubing, and flash welded rings to determine conformance to condition (3.2), grain size (3.4.1), macrostructure (3.4.2), inclusion rating (3.4.3), decarburization (3.4.4), and after-heat-treatment tensile property (3.4.5.2) and, when specified, fracture toughness (3.4.5.4) requirements; and of bars and tubing to determine conformance to tolerance (3.7.1 and 3.7.2) requirements are classified as acceptance or routine control tests.