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

AEROSPACE MATERIAL SPECIFICATION

AMS 6543

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Revised

STEEL BARS, FORGINGS, AND FORGED BILLET
2.0Cr - 10Ni - 8.0Co - 1.0Mo (0.10 - 0.14C)
Premium Quality, Vacuum Melted, Solution Heat Treated

1. SCOPE:

1.1 Form: This specification covers a premium-quality, low-alloy steel in the form of bars 0.50 in. (12.7 mm) and over in diameter or distance between parallel sides, forgings, forged billet, and forging stock.

1.2 Application: Primarily for heat treated parts requiring high strength, toughness, and weldability.

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., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2251 - Tolerances, Low-Alloy Steel Bars
AMS 2259 - Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
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

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, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products
ASTM A604 - Macroetch Testing of Consumable Electrode Vacuum Arc Remelted Steel Bars and Billets
ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
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, PA 19120.

2.3.1 Federal Standards:

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

2.3.2 Military Specifications:

MIL-I-8950 - Inspection, Ultrasonic, Wrought Metals, Process for

2.3.3 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 E353, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other approved analytical methods:

	min	max
Carbon	0.10 -	0.14
Manganese	0.05 -	0.25
Silicon	--	0.10
Phosphorus	--	0.010
Sulfur	--	0.006
Chromium	1.80 -	2.20
Nickel	9.50 -	10.50
Cobalt	7.50 -	8.50
Molybdenum	0.90 -	1.10
Titanium	--	0.015
Aluminum	--	0.025
Oxygen	--	0.0025 (25 ppm)
Nitrogen	--	0.0075 (75 ppm)

3.1.1 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2259. No variation is permitted for oxygen and nitrogen.

3.2 Condition: The product shall be supplied in the following condition; hardness shall be determined in accordance with ASTM A370:

3.2.1 Bar, Forgings, and Forged Billet: Hot finished, solution heat treated, and descaled, having hardness not lower than 42 HRC.

3.2.2 Forging Stock: As ordered by the forging manufacturer.

3.3 Heat Treatment: Bars, forgings, and forged billet shall be solution heat treated as in 3.3.1 or 3.3.2, as applicable, holding at heat for sufficient time to ensure complete transformation, and quenching in agitated water sufficiently cool (See 8.1) to develop the mechanical properties specified herein.

3.3.1 Product 2.0 In. or 50 mm and Under in Nominal Section Thickness: Shall be solution heat treated by heating in air to 1525° F ± 25 (829.4° C ± 14) and quenching.

3.3.2 Product Over 2.0 In. or 50 mm in Nominal Section Thickness: Shall be solution heat treated by heating in air to 1650° F ± 25 (898.9° C ± 14), quenching, reheating to 1525° F ± 25 (829.4° C ± 14), and quenching.

3.4 Properties: The product shall conform to the following requirements; tensile and impact testing shall be performed in accordance with ASTM A370:

3.4.1 Bars, Forgings, and Forged Billet:

3.4.1.1 As Solution Heat Treated:

3.4.1.1.1 Macrostructure: Visual examination of transverse sections from bars, forgings, forged billet, and forging stock, 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 imperfections, such as pipe, cracks, porosity, segregation, and inclusions, detrimental to fabrication of parts. Macrostructure shall be equal to or better than the following macrographs of ASTM A604:

Class	Condition	Severity
1	Freckles	B
2	White Spots	C
3	Radial Segregation	C
4	Ring Pattern	D

3.4.1.2 After Aging: Bars, forgings, and forged billets shall meet the requirements of 3.4.2.1, 3.4.2.2, and 3.4.2.3 after being aged by heating to 950° F ± 10 (510° C ± 5.6), holding at heat for not less than 5 hr for sections 2.0 in. or 50 mm and less in nominal thickness, and for 10 hr +0.5, -0, for thicker sections, and cooling in air.

3.4.1.2.1 Tensile Properties: Shall be as shown in Table I.

TABLE I

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 2 in. or 4D %, min	Reduction of Area %, min
0.500 to 2.000, incl	190,000	180,000	12	60
Over 2.000 to 4.000, incl	190,000	175,000	15	60
Over 4.000 to 8.000, incl	190,000	170,000	15 (See 3.4.1.2.1.1)	50 (See 3.4.1.2.1.1)

TABLE I (SI)

Nominal Diameter or Distance Between Parallel Sides Millimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 50.8 mm or 4D %, min	Reduction of Area %, min
12.70 to 50.80, incl	1310	1241	12	60
Over 50.80 to 101.60, incl	1310	1207	15	60
Over 101.60 to 203.20, incl	1310	1172	15 (See 3.4.1.2.1.1)	50 (See 3.4.1.2.1.1)

3.4.1.2.1.1 These values are tentative until more data are available; failure to meet these requirements shall not be cause for rejection.

3.4.1.2.1.2 Tensile properties for product over 8.00 in. (203.20 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.1.2.2 Impact Strength: Shall be as shown in Table II.

TABLE II

Nominal Diameter or Distance Between Parallel Sides Inches	Charpy V-Notch at 0° F ft-lb
0.500 to 2.000, incl	60
Over 2.000 to 4.000, incl	50
Over 4.000 to 8.000, incl	40 (See 3.4.1.2.1.1)

TABLE II (SI)

Nominal Diameter or Distance Between Parallel Sides Millimetres	Charpy V-Notch at -18° C N·m
12.70 to 50.80, incl	81
Over 50.80 to 101.60, incl	68
Over 101.60 to 203.20, incl	54 (See 3.4.1.2.1.1)

3.4.1.2.2.1 Impact strength for product over 8.00 in. (203.20 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.1.2.3 Fracture Toughness: Shall be not lower than 175,000 psi$\sqrt{\text{in.}}$ (192 MPa$\sqrt{\text{m}}$), determined in accordance with ASTM E399 using the compact tension specimen.

3.4.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.3 and 3.4.1.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.1.2.1 and 3.4.1.2.2. If specimens taken from the stock after heat treatment as in 3.3 and 3.4.1.2 conform to the requirements of 3.4.1.2.1 and 3.4.1.2.2, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5 Quality:

3.5.1 Steel shall be multiple melted using vacuum induction melting plus vacuum consumable electrode remelting, unless otherwise permitted.

3.5.2 The product shall be uniform in quality and condition and free from foreign materials and from internal and external imperfections detrimental to fabrication of parts.

3.5.2.1 Bars 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 imperfections exposed to the machined surfaces. Standard machining allowance shall be in accordance with AS 1182.

3.5.3 All product shall be inspected ultrasonically in accordance with MIL-I-8950 and shall meet Class AA quality requirements as defined therein. Hot-finished surfaces shall be suitably prepared prior to ultrasonic inspection.

3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, bars will be acceptable in mill lengths of 6 - 20 ft or 2 - 6 m but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft or 3 m. Size limitations for other forms shall be as ordered.

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 Forged Billet and Forging Stock: As ordered by the purchaser.

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 ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: The following are classified as acceptance tests:

4.2.1.1 Tests of the product to determine conformance to composition (3.1), macrostructure (3.4.1.1.1), and ultrasonic (3.5.3) requirements.

4.2.1.2 Tests of bars, forgings, and forged billet to determine conformance to hardness (3.2.1), tensile property (3.4.1.2.1), impact strength (3.4.1.2.2), and tolerance (3.7) requirements.

4.2.2 Periodic Tests: The following are classified as periodic tests:

4.2.2.1 Tests of bars, forgings, and forged billet to determine conformance to fracture toughness (3.4.1.2.3) requirements.

4.2.2.2 Tests of forging stock to demonstrate ability to develop specified properties (3.4.2).

4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests.

4.2.3.1 For direct U.S. Military procurement, test material and supporting test data 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 Acceptance Tests:

4.3.1.1 Bars: AMS 2370, except that samples for composition shall be taken from a vacuum consumable electrode remelted ingot.

4.3.1.2 Forgings, Forged Billet, and Forging Stock: AMS 2372.