



AEROSPACE MATERIAL SPECIFICATION

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

AMS6294E

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STEEL BARS AND FORGINGS, CARBURIZING
1.8Ni - 0.25Mo (0.17 - 0.22C) (SAE 4620)

1. SCOPE:

- 1.1 **Form:** This specification covers an aircraft-quality, low-alloy steel in the form of bars, forgings, and forging stock.
- 1.2 **Application:** Primarily for carburized parts which require high minimum core hardness and allow wide hardness range in sections 0.375 in. (9.5 mm) and under in nominal thickness. The core may or may not be machinable after hardening.

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 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, Mechanical Tubing, and Extrusions, 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

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 Steels
- 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 - Rating Macroetched Steel

2.3 **Government Publications:** Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

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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:

		min	max
Ø	Carbon	0.17	0.22
	Manganese	0.45	0.65
	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. (12.70 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. (12.70 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 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 as in 4.3.3 from bars, billets, 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. 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 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

- 3.3.2 **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 J48=1 max and J27=3 min, determined on the standard end-quench test specimen in accordance with ASTM A255 except that the steel shall be normalized at 1700°F ± 10 (925°C ± 5) and the test specimen austenitized at 1700°F ± 10 (925°C ± 5). 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.

3.4 **Quality:**

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

- 3.4.2 The product, as received by 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.

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

- 3.4.2.2 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 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 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 for bars shall conform to all applicable requirements of AMS 2251.

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:** Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed on each lot.

4.2.2 Preproduction Tests: Tests of forgings to determine conformance to all technical requirements of this specification 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: 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.

4.4 Approval: When specified, approval and control of 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 showing the results of tests for chemical composition, macrostructure, grain size, hardenability, and AMS 2301 frequency-severity rating of each heat. 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.

4.5.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number and its revision letter, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.6 Resampling and Retesting: Shall be in accordance with the following:

4.6.1 Bars: AMS 2370.

4.6.2 Forgings and Forging Stock: AMS 2372.

5. PREPARATION FOR DELIVERY:

5.1 Identification: The product shall be identified as follows:

5.1.1 Bars: In accordance with AMS 2806.

5.1.2 Forgings: In accordance with AMS 2808.

5.1.3 Forging Stock: As agreed upon by purchaser and vendor.

5.2 Protective Treatment: Bars ordered cold drawn, cold rolled, ground, turned, or polished shall be coated with a suitable corrosion-preventive compound prior to shipment.