

**AEROSPACE
MATERIAL
SPECIFICATION**

Submitted for recognition as an American National Standard

SAE AMS 5611B

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Superseding AMS 5611A

STEEL BARS, FORGINGS, TUBING, AND RINGS, CORROSION AND MODERATE HEAT RESISTANT
12Cr (SAE 51410 Modified)
Ferrite Controlled, Consumable Electrode Melted

1. SCOPE:

- 1.1 Form: This specification covers a premium aircraft-quality, corrosion and moderate heat resistant steel in the form of bars, wire, forgings, mechanical tubing, flash welded rings, and stock for forging or flash welded rings.
- 1.2 Application: Primarily for pressure vessels or structural parts requiring uniformly high room-temperature tensile properties with oxidation resistance up to 1000°F (540°C), where control of ferrite is necessary.

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

- 2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

- AMS 2241 - Tolerances, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
- MAM 2241 - Tolerances, Metric, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
- AMS 2243 - Tolerances, Corrosion and Heat Resistant Steel Tubing
- MAM 2243 - Tolerances, Metric, Corrosion and Heat Resistant Steel Tubing
- AMS 2248 - Chemical Check Analysis Limits, Wrought Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
- AMS 2300 - Premium Aircraft-Quality Steel Cleanliness, Magnetic Particle Inspection Procedure
- MAM 2300 - Premium Aircraft-Quality Steel Cleanliness, Magnetic Particle Inspection Procedure, Metric (SI) Measurement
- AMS 2315 - Determination of Free Ferrite Content

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- AMS 2350 - Standards and Test Methods
- AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, Wrought Products Except Forgings and Forging Stock
- AMS 2374 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, 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
- AMS 7493 - Rings, Flash Welded, Non-Austenitic Corrosion Resistant Steels

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 Remelted Steel Bars and Billets
- ASTM E112 - Determining Average Grain Size
- ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

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

2.3.1 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 or by spectrographic or other analytical methods approved by purchaser:

	min	max
Carbon	0.12 -	0.15
Manganese	--	0.60
Silicon	--	0.50
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	11.50 -	12.50
Nickel	--	0.75
Molybdenum	--	0.20
Aluminum	--	0.05
Copper	--	0.50
Tin	--	0.05
Nitrogen	--	0.18

- 3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2248.
- 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: Annealed having hardness not higher than 241 HB, or equivalent.
- 3.2.1.1 Bars over 0.500 to 2.750 in. (12.50 to 70.00 mm), incl, in nominal diameter or distance between parallel sides and all hexagons shall be cold finished.
- 3.2.1.2 Bars, other than hexagons, over 2.750 in. (70.00 mm) in nominal diameter or distance between parallel sides shall be hot finished.
- 3.2.2 Wire: Cold drawn and annealed having tensile strength not higher than 115,000 psi (795 MPa) or equivalent hardness.
- 3.2.3 Forgings and Flash Welded Rings: Normalized and tempered having hardness
Ø not higher than 241 HB, or equivalent.
- 3.2.3.1 Flash welded rings shall not be supplied unless specified or permitted
Ø on purchaser's part drawing. When supplied, they shall be manufactured in accordance with AMS 7493.
- 3.2.4 Mechanical Tubing: Annealed and cold finished having hardness not higher than 241 HB, or equivalent.
- 3.2.5 Stock for Forging or Flash Welded Rings: As ordered by the forging or
Ø flash welded ring manufacturer.
- 3.3 Properties: The product shall conform to the following requirements; tensile and hardness testing shall be performed in accordance with ASTM A370:
- 3.3.1 Bars, Wire, Forgings, Tubing, and Flash Welded Rings:
Ø
- 3.3.1.1 Macrostructure: Visual examination of transverse sections as in 4.3.3
Ø from bars, wire, billets, tube rounds or tubes, and stock for forging or flash welded rings, etched in accordance with ASTM A604 in hot hydrochloric acid (1:1) at 160° - 180°F (70° - 80°C) for sufficient time to develop a well-defined macrostructure, shall show no pipe or cracks. Except as specified in 3.3.1.1.1, porosity, segregation, inclusions, and other imperfections for product 36 sq in. (230 cm²) and under in nominal cross-sectional area shall be no worse than the following macrographs of ASTM A604; macrostructure standards for product over 36 sq in. (230 cm²) in nominal cross-sectional area shall be as agreed upon by purchaser and vendor:

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

3.3.1.1.1 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.

3.3.1.2 Decarburization: Bars, wire, tubing, and flash welded rings ordered Ø ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces, determined microscopically at a magnification not exceeding 100X.

3.3.1.3 Properties After Heat Treatment: Bars, wire, forgings, tubing, and flash welded rings shall have the following properties, determined on full-section specimens taken from product 0.500 in. (12.50 mm) and under in nominal diameter or distance between parallel sides or on specimens 0.500 in. + 0.010 (12.50 mm + 0.25) in diameter cut from larger product after being hardened by heating in a neutral atmosphere to 1735°F + 10 (945°C + 5) holding at heat for 1 hr + 0.1, and cooling in still air and double tempered by heating to 600°F + 10 (315°C + 5), holding at heat for 2 hr + 0.25, and cooling in air:

3.3.1.3.1 Longitudinal Tensile Properties:

Tensile Strength, min	180,000 psi (1240 MPa)
Yield Strength at 0.2% Offset, min	145,000 psi (1000 MPa)
Elongation in 4D, min	10%
Reduction of Area, min	30%

3.3.1.3.2 Hardness: Should be 39 - 44 HRC, or equivalent, but the product shall Ø not be rejected on the basis of hardness if the tensile property requirements are met.

3.3.1.3.3 Grain Size: Predominantly 5 or finer with occasional grains as large as 3 permissible, determined by comparison of a polished and etched specimen with the chart in ASTM E112.

3.3.1.3.4 Ferrite Content: Shall be not more than 5%, determined in accordance with AMS 2315.

3.3.2 Forging Stock: When a sample of stock is forged to a test coupon and heat Ø treated as in 3.3.1.3, specimens taken from the heat treated coupon shall conform to the requirements of 3.3.1.3.1, 3.3.1.3.2, 3.3.1.3.3, and 3.3.1.3.4. If specimens taken from the stock after heat treatment as in 3.3.1.3 conform to the requirements of 3.3.1.3.1, 3.3.1.3.2, 3.3.1.3.3, and 3.3.1.3.4, the tests shall be acceptable as equivalent to tests of a forged coupon.

- 3.3.3 Stock for Flash Welded Rings: Specimens taken from the stock after heat treatment as in 3.3.1.3 shall conform to the requirements of 3.3.1.3.1, 3.3.1.3.2, 3.3.1.3.3, and 3.3.1.3.4.

3.5 Quality:

- 3.5.1 Steel shall be premium aircraft-quality conforming to AMS 2300 or MAM 2300; it shall be multiple melted using vacuum consumable electrode practice in the remelt cycle.
- 3.5.2 The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.
- 3.5.3 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forgings, showing no evidence of re-entrant grain flow.
- 3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars, wire, and tubing will be acceptable in mill lengths of 6 - 20 ft (2 - 6 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft (3 m).
- 3.7 Tolerances: Shall conform to all applicable requirements of the following:
- 3.7.1 Bars and Wire: AMS 2241 or MAM 2241.
- 3.7.2 Mechanical Tubing: AMS 2243 or MAM 2243.

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 any confirmatory testing deemed 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 prior to or on the first-article shipment of a forging to a purchaser, when a change in material, processing, or both 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, 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; a heat shall be the consumable electrode remelted ingots produced from steel originally melted as a single furnace charge.

4.3.1 Bars, Wire, Mechanical Tubing, Flash Welded Rings, and Stock for Flash Welded Rings: AMS 2371.

4.3.1.1 Specimens for grain size of flash welded rings shall be cut from parent metal not including the weld-heat-affected zone.

4.3.2 Forgings and Forging Stock: AMS 2374.

4.3.3 Samples for macrostructure (3.3.1.1) 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 a report showing the results of tests for chemical composition, macrostructure, grain size, and frequency-severity cleanliness rating of each heat and the results of tests on each lot to determine conformance to the other technical requirements of this specification. This report shall include the purchase order number, heat number, AMS 5611B, size, and quantity. 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 a report showing the purchase order number, AMS 5611B, 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 either a statement that the material conforms or 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, Wire, Mechanical Tubing, Flash Welded Rings, and Stock for Flash Welded Rings: AMS 2371.

4.6.2 Forgings and Forging Stock: AMS 2374.