



# AEROSPACE MATERIAL SPECIFICATION

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

## AMS 5609A

Superseding AMS 5609

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UNS S41040

STEEL BARS, FORGINGS, TUBING, AND RINGS, CORROSION AND MODERATE HEAT RESISTANT  
12Cr - 0.12Cb (SAE 51410 Modified)  
Ferrite Controlled

### 1. SCOPE:

- 1.1 Form: This specification covers an 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 parts and assemblies, requiring uniformly high room temperature tensile properties along with oxidation resistance up to 1000° F (540° C), where control of ferrite content 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 (AMS) 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 2241 - Tolerances, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
- AMS 2243 - Tolerances, Corrosion and Heat Resistant Steel Tubing
- AMS 2248 - Chemical Check Analysis Limits, Wrought Heat and Corrosion Resistant Steels and Alloys
- AMS 2303 - Aircraft Quality Steel Cleanliness, Martensitic Corrosion Resistant Steels, Magnetic Particle Inspection Procedure
- AMS 2315 - Free Ferrite Content, Method for Determining Percent
- AMS 2350 - Standards and Test Methods
- AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Alloys, Wrought Product Except Forgings
- 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 E112 - Estimating the Average Grain Size of Metals
- ASTM E340 - Macroetching Metals and Alloys
- ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

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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 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 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 |
| Columbium  | 0.05  | 0.20  |
| Nickel     | --    | 0.75  |
| Molybdenum | --    | 0.20  |
| Aluminum   | --    | 0.05  |
| Copper     | --    | 0.50  |
| Tin        | --    | 0.05  |
| Nitrogen   | --    | 0.08  |

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2248, except that check analysis limits for columbium shall be 0.02 under min and 0.05 over maximum.

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 Round bars shall be ground or turned.

3.2.1.2 Bars, other than rounds, over 0.500 to 2.750 in. (12.70 to 69.85 mm), incl, in nominal distance between parallel sides and all hexagons shall be cold finished.

3.2.1.3 Bars, other than rounds and hexagons, over 2.750 in. (69.85 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 (793 MPa) ∅ or equivalent hardness.

∅ 3.2.3 Forgings and Flash Welded Rings: Annealed having hardness not higher than 241 HB or equivalent.

3.2.3.1 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 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 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 Macrostructure: Visual examination of transverse sections from bars, wire, billets, tube rounds or tubes, and stock for forging or flash welded rings, etched in accordance with ASTM E340 in hot  
 ∅ hydrochloric acid at 160° - 180° F (70° - 80° 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 macrostructure standards agreed upon by purchaser and vendor.

3.3.1.1 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.

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

3.3.3 Properties After Heat Treatment: Product 0.500 in. (12.70 mm) and under in nominal diameter or distance between parallel sides and specimens 0.500-in.  $\pm$  0.010 (12.70-mm  $\pm$  0.25) thick cut from larger product shall have the following properties after being hardened by heating to 1700° F  $\pm$  10 (925° C  $\pm$  5) holding at heat for 1 hr  $\pm$  0.1, and cooling in still air and double tempered by heating to 600° F  $\pm$  10 (315° C  $\pm$  5), holding at heat for 2 hr  $\pm$  0.25, and cooling in air:

3.3.3.1 Tensile Properties:

|                                    |                        |
|------------------------------------|------------------------|
| Tensile Strength, min              | 185,000 psi (1276 MPa) |
| Yield Strength at 0.2% Offset, min | 152,000 psi (1048 MPa) |
| Elongation in 4D, min              | 10%                    |
| Reduction of Area, min             | 30%                    |

3.3.3.2 Hardness: 40 - 45 HRC or equivalent.

3.3.3.3 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.

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

3.4 Quality:

∅ 3.4.1 Steel shall be aircraft quality conforming to AMS 2303.

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.

3.5 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars, wire, and  $\emptyset$  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 and Wire: AMS 2241.

3.6.2 Mechanical Tubing: AMS 2243.

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  $\emptyset$  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  $\emptyset$  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  $\emptyset$  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, substantiating test data and, when requested, pre-production 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:

$\emptyset$  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 and tensile properties of flash welded rings shall be cut from parent  $\emptyset$  metal not including the weld-heat-affected zone.

$\emptyset$  4.3.2 Forgings and Forging Stock: AMS 2374.

4.3.3 Samples for macrostructure (3.3.1) testing shall be full cross-sectional specimens obtained from  $\emptyset$  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.

$\emptyset$  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, and AMS 2303 frequency-severity rating of each heat and the results of tests for response to heat treatment of each size from 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.