



AEROSPACE MATERIAL

Society of Automotive Engineers, Inc. SPECIFICATION

TWO PENNSYLVANIA PLAZA, NEW YORK, N. Y. 10001

AMS 5735H

Superseding AMS 5735G

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STEEL BARS, FORGINGS, TUBING, AND RINGS, CORROSION AND HEAT RESISTANT

15Cr - 26Ni - 1.3Mo - 2.1Ti - 0.30V

1800° F (982.2° C) Solution and Precipitation Heat Treated

1. SCOPE:

- 1.1 **Form:** This specification covers a corrosion and heat resistant steel in the form of bars, wire, forgings, mechanical tubing, flash welded rings, and stock for forgings, flash welded rings, or heading.
- 1.2 **Application:** Primarily for parts such as turbine rotors, shafts, blades, bolts, dowels, and fittings, requiring high strength up to 1300° F (704° C) and oxidation resistance up to 1500° F (816° C).

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., Two Pennsylvania Plaza, New York, New York 10001.

2.1.1 Aerospace Material Specifications:

AMS 2241 - Tolerances, Corrosion and Heat Resistant Steel Bars and Wire and 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 2350 - Standards and Test Methods

AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Alloys, Wrought Products except Forgings

AMS 2375 - Approval and Control of Critical Forgings

AMS 2808 - Identification, Forgings

AMS 7490 - Rings, Flash Welded, Corrosion and Heat Resistant, Austenitic Steels, and Austenitic Type Alloys

- 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 E139 - Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

ASTM E292 - Conducting Time-for-Rupture Notched Tension Test of Materials

ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

- 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

SAE Technical Board rules provide that: "All technical reports, including standards approved 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, 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."

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 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	--	0.08
Manganese	--	2.00
Silicon	--	1.00
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	13.50	- 16.00
Nickel	24.00	- 27.00
Molybdenum	1.00	- 1.50
Titanium	1.90	- 2.35
Boron	0.0030	- 0.010
Vanadium	0.10	- 0.50
Aluminum	--	0.35

- 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:

- 3.2.1 Bars, Wire, Forgings, and Flash Welded Rings: Solution and precipitation heat treated. Forgings shall be descaled.

- 3.2.1.1 Bars and wire 2.75 in. (69.8 mm) and less in diameter or distance between parallel sides shall be cold finished. For other sizes, bars shall be hot finished and descaled.

- 3.2.1.2 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 7490.

- 3.2.2 Mechanical Tubing: Cold finished and solution and precipitation heat treated.

- 3.2.3 Stock for Forging, Flash Welded Rings, or Heading: As ordered by the forging, flash welded ring, or heading manufacturer.

- 3.3 Heat Treatment: Bars, wire, forgings, tubing, and flash welded rings shall be heat treated as follows, to produce the properties specified in 3.4.1.1, 3.4.1.2, and 3.4.1.3.

- 3.3.1 Solution Heat Treatment: Heat to 1800° F \pm 25° (982.2° C \pm 14°), hold at heat for not less than 1 hr, and quench in oil or water.

- 3.3.2 Precipitation Heat Treatment: Heat to a temperature within the range 1300° - 1400° F (704.4° - 760° C), hold at the selected temperature within \pm 15° F (\pm 8.3° C) for approximately 16 hr, and cool in air.

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

- 3.4.1 Bars, Wire, Forgings, Tubing, and Flash Welded Rings:

3.4.1.1 Tensile Properties: Shall be as follows:

Tensile Strength, min	130,000 psi (896 MPa)
Yield Strength at 0.2% Offset, min	85,000 psi (586 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	15%
Reduction of Area (round specimens), min	18%

3.4.1.1.1 Disc Forgings: When tensile test specimens are machined from the bore and punchout areas of disc and hub forgings and these areas lie within a 4 in. (102 mm) radius of the disc center, the elongation may be as low as 10% and the reduction of area as low as 12%.

3.4.1.2 Hardness: Should be 248 - 341 HB or equivalent but the product shall not be rejected on the basis of hardness if the tensile property requirements are met.

3.4.1.3 Stress-Rupture Test at 1200° F (648.9° C): Shall be as follows; testing of notched specimens and of combination smooth-and-notched specimens shall be performed in accordance with ASTM E292 and of smooth specimens in accordance with ASTM E139.

3.4.1.3.1 A combination smooth and notched test specimen machined from bars, wire, forgings, tubing, and parent metal of flash welded rings to the dimensions shown in Fig. 1 and Table I, maintained at 1200° F \pm 3° (648.9° C \pm 1.7°) while a load sufficient to produce an initial axial stress of 65,000 psi (448 MPa) is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. Rupture shall occur in the smooth section and elongation of this section after rupture, measured at room temperature, shall be not less than 5% in 4D if the specimen ruptures in 48 hr or less and not less than 3% in 4D if the specimen ruptures in more than 48 hours.

3.4.1.3.2 As an alternate procedure, separate smooth and notched test specimens, machined from adjacent sections of the same piece with gage sections conforming to the respective dimensions of Table I, may be tested individually under the above conditions. The smooth specimen shall not rupture in less than 23 hr and elongation after rupture, measured at room temperature, shall be as specified in 3.4.1.3.1. The notched specimen shall not rupture in less time than the companion smooth specimen but need not be tested to rupture.

3.4.1.3.3 The tests of 3.4.1.3.1 and 3.4.1.3.2 may be conducted using a load higher than required to produce an initial axial stress of 65,000 psi (448 MPa) but load shall not be changed while test is in progress. Time to rupture, rupture location, and elongation requirements shall be as specified in 3.4.1.3.1.

3.4.1.3.4 When permitted by purchaser, the tests of 3.4.1.3.1 and 3.4.1.3.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 65,000 psi (448 MPa) shall be used to rupture or for 48 hr, whichever occurs first. After the 48 hr and at intervals of 8 - 16 hr, preferably 8 - 10 hr, thereafter, the stress shall be increased in increments of 5000 psi (34.5 MPa). Time to rupture, rupture location, and elongation requirements shall be as specified in 3.4.1.3.1.

3.4.1.3.5 For tubing from which a solid round test specimen cannot be cut, a full section of tubing shall be tested and shall meet the smooth bar requirements of 3.4.1.3.1.

3.4.2 Stock for Forging, Flash Welded Rings, and Heading: When a sample of stock is forged to a test coupon and heat treated as in 3.3, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.1.1, 3.4.1.2, and 3.4.1.3. If specimens taken from the stock after heat treatment as in 3.3 conform to the requirements of 3.4.1.1, 3.4.1.2 and 3.4.1.3, the tests shall be accepted as equivalent to tests of a forged coupon.

- 3.5 Quality: 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.
- 3.6 Sizes: Except when exact length or multiples of exact lengths are ordered, bars, straight wire, 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 and Wire: AMS 2241.
- 3.7.2 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 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, wire, forgings, tubing, and flash welded rings to determine conformance to tensile properties (3.4.1.1), hardness (3.4.1.2), and stress-rupture (3.4.1.3) requirements, and of bars, wire, and tubing to determine conformance to tolerance (3.7) requirements are classified as acceptance or routine control tests.
- 4.2.2 Qualification Tests: Tests of stock for forging, flash welded rings, or heading to demonstrate capability of developing required properties (3.4.2) are classified as qualification or periodic control tests.
- 4.3 Sampling: Shall be in accordance with the following:
- 4.3.1 Bars, Wire, Mechanical Tubing, Flash Welded Rings, and Stock for Flash Welded Rings or Heading: AMS 2371.
- 4.3.1.1 Flash Welded Rings: Specimens shall be cut from parent metal not including the heat affected zone of the flash weld.
- 4.3.2 Forgings and Forging Stock: As agreed upon by purchaser and vendor except as follows:
- 4.3.2.1 Forgings: Specimens for tensile and stress-rupture tests shall be cut from any plane perpendicular to the axis of the forging with axis of specimen in the selected plane perpendicular to a radius. When size and shape permit, additional specimens shall be cut with axis of specimen approximately parallel to the axis of the forging. Specific locations of test specimens shall be as agreed upon by purchaser and vendor.
- 4.4 Approval: When specified, approval and control of critical 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 of the results of tests for chemical composition of each heat in the shipment and the results of tests on each size from each heat to determine conformance to the other acceptance test requirements of this specification.

This report shall include the purchase order number, material specification number and its revision letter, heat number, size, quantity from each heat, and the precipitation heat temperature used. 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: If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

- 5.1 Identification: The product shall be identified as follows:

5.1.1 Bars, Wire, and Tubing:

- 5.1.1.1 Each straight bar and tube 0.500 in. (12.70 mm) and over in OD or least width of flat surface shall be marked in a row of characters recurring at intervals not greater than 3 ft (914 mm) with AMS 5735H, heat number, and manufacturer's identification. The characters shall be of such size as to be clearly legible, shall be applied using a suitable marking fluid, and shall be capable of being removed in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the material or its performance and shall be sufficiently stable to withstand normal handling.

- 5.1.1.2 Straight bars, wire, and tubes less than 0.500 in. (12.70 mm) in OD or least width of flat surface shall be securely bundled and identified by a metal or plastic tag embossed with the purchase order number, AMS 5735H, heat number, nominal size, and manufacturer's identification and attached to each bundle or shall be boxed and the box marked with the same information.

- 5.1.1.3 Coiled bars and wire shall be securely bundled and identified by a metal or plastic tag embossed with the purchase order number, AMS 5735H, heat number, nominal size, and manufacturer's identification and attached to each coil or shall be boxed and the box marked with the same information.

- 5.1.2 Forgings: In accordance with AMS 2808.

- 5.1.3 Flash Welded Rings and Stock for Forging, Flash Welded Rings, or Heading: As agreed upon by purchaser and vendor.

- 5.2 Packaging: The product shall be prepared for shipment in accordance with commercial practice to assure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.