



AEROSPACE MATERIAL

Society of Automotive Engineers, Inc. SPECIFICATION

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

AMS 5709C

Superseding AMS 5709 B

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ALLOY BARS AND FORGINGS, CORROSION AND HEAT RESISTANT

Nickel Base - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al

Consumable Electrode or Vacuum Induction Melted

1975° F (1079.4° C) Solution, Stabilization, and Precipitation Heat Treated

1. SCOPE:

- 1.1 Form: This specification covers a corrosion and heat resistant nickel-base alloy in the form of bars, forgings, and forging stock.
- 1.2 Application: Primarily for parts, such as pins, nuts, and turbine blades, requiring high strength up to 1500° F (816° C) and oxidation resistance up to 1750° F (954° 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 2261 - Tolerances, Nickel, Nickel-Base and Cobalt-Base Alloy Bars and Forging Stock

AMS 2269 - Chemical Check Analysis Limits, Wrought Nickel and Nickel-Base 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

- 2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

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

ASTM E354 - Chemical Analysis of High-Temperature, Electrical, Magnetic and Other Similar Iron, Nickel, and Cobalt-Base 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

3. TECHNICAL REQUIREMENTS:

- 3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E354, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other approved analytical methods:

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	min	max
Carbon	0.02	0.10
Manganese	--	0.10
Silicon	--	0.15
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	18.00	21.00
Cobalt	12.00	15.00
Molybdenum	3.50	5.00
Titanium	2.75	3.25
Aluminum	1.20	1.60
Zirconium	0.02	0.08
Boron	0.003	0.010
Iron	--	2.00
Copper	--	0.10
Nickel	remainder	

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2269; check analysis limits for zirconium shall be 0.01 under min or over maximum.

3.2 Condition: The product shall be supplied in the following condition:

3.2.1 Bars: Solution, stabilization, and precipitation heat treated and descaled.

3.2.1.1 Bars shall be hot rolled or extruded; round bars shall be ground or turned.

3.2.2 Forgings: Solution, stabilization, and precipitation heat treated.

3.2.3 Forging Stock: As ordered by the forging manufacturer.

3.3 Heat Treatment: Bars and forgings shall be heat treated as follows:

3.3.1 Solution Heat Treatment: Heat to $1975^{\circ}\text{F} \pm 25$ ($1079.4^{\circ}\text{C} \pm 14$), hold at heat for 4 hr \pm 30 min., and cool at a rate equivalent to air cool or faster.

3.3.2 Stabilization Heat Treatment: Heat to $1550^{\circ}\text{F} \pm 15$ ($843.3^{\circ}\text{C} \pm 8.3$), hold at heat for 4 hr \pm 30 min. except that blade forgings shall be held for 24 hr \pm 1, and cool in air.

3.3.3 Precipitation Heat Treatment: Heat to $1400^{\circ}\text{F} \pm 15$ ($760^{\circ}\text{C} \pm 8.3$), hold at heat for 16 hr \pm 1, and cool in air.

3.4 Properties:

3.4.1 Bars and Forgings:

3.4.1.1 Hardness: Shall be 32 - 42 HRC or equivalent, determined in accordance with ASTM E18.

3.4.1.2 Grain Size: Shall be substantially uniform without pronounced segregation of fine and coarse grain areas, conforming to standards agreed upon by purchaser and vendor. Clusters of large germinated grains will be cause for rejection.

3.4.1.3 Stress Rupture Test at 1500° F (815.6° C): A tensile test specimen, maintained at $1500^{\circ}\text{F} \pm 3$ ($815.6^{\circ}\text{C} \pm 1.7$) while a load sufficient to produce an initial axial stress of 47,500 psi (328 MPa) is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. Elongation after rupture, measured at room temperature, shall be not lower than 8% in 4D. Tests shall be conducted in accordance with ASTM E139.

- 3.4.1.3.1 The test of 3.4.1.3 may be conducted using a load higher than required to produce an initial axial stress of 47,500 psi (328 MPa) but load shall not be changed while test is in progress. Time to rupture and elongation requirements shall be as specified in 3.4.1.3.
- 3.4.1.3.2 When permitted by purchaser, the test of 3.4.1.3 may be conducted using incremental loading. In such cases, the load required to produce an initial axial stress of 47,500 psi (328 MPa) shall be used to rupture or for 23 hr, whichever occurs first. After the 23 hr and at intervals of 8 - 16 hr, preferably 8 - 10 hr, thereafter, the stress shall be increased in increments of 5,000 psi (34.5 MPa). Time to rupture and elongation requirements shall be as specified in 3.4.1.3.
- 3.4.2 Forging Stock: 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 and 3.4.1.3.1. If specimens taken from the stock after heat treatment as in 3.3 conform to the requirements of 3.4.1.1 and 3.4.1.3.1, the tests shall be accepted as equivalent to tests of a forged coupon.
- 3.5 Quality:
- 3.5.1 Material shall be produced by multiple melting using consumable electrode practice in the remelt cycle, or shall be induction melted under vacuum, unless otherwise permitted.
- 3.5.2 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. Forgings shall have substantially uniform macrostructure and grain flow.
- 3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, bars will be acceptable in mill lengths of 6 - 24 ft (1.8 - 7.3 m) but not more than 25% of any shipment shall be supplied in lengths of 6 - 9 ft (1.8 - 2.7 m) except that for bars weighing over 25 lb per ft (37.2 kg/m), short lengths down to 2 ft (609 mm) may be supplied.
- 3.7 Tolerances: Unless otherwise specified, tolerances for bars and forging stock shall conform to all applicable requirements of AMS 2261.
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 to determine conformance to the following requirements are classified as acceptance or routine control tests:
- 4.2.1.1 Tests of the product to determine conformance to composition (3.1) requirements.
- 4.2.1.2 Tests of bars and forgings to determine conformance to hardness (3.4.1.1), grain size (3.4.1.2), and stress-rupture (3.4.1.3) requirements.
- 4.2.1.3 Tests of bars and forging stock to determine conformance to tolerance (3.7) requirements.
- 4.2.2 Qualification Tests: Tests of forging stock (3.4.2) to demonstrate capability of developing required properties are classified as qualification or periodic control tests.
- 4.3 Sampling: Shall be as follows; when consumable electrode remelted alloy is supplied, a heat shall be the consumable electrode remelted ingots produced from alloy originally melted as a single furnace charge:

4.3.1 Bars: AMS 2371.

4.3.2 Forgings and Forging Stock: 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 technical requirements of this specification. This report shall include the purchase order number, material specification number and its revision letter, heat number, 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: 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:

5.1.1.1 Each straight bar 0.500 in. (12.70 mm) and over in diameter 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 5709C, 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 less than 0.500 in. (12.70 mm) in diameter 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 5709C, 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 rods shall be securely bundled and identified by a metal or plastic tag embossed with the purchase order number, AMS 5709C, 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 Forging Stock: As agreed upon by purchaser and vendor.