

AEROSPACE MATERIAL SPECIFICATION

SAE

AMS 5709F

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Superseding AMS 5709E

Submitted for recognition as an American National Standard

NICKEL ALLOY, CORROSION AND HEAT RESISTANT, BARS AND FORGINGS
58Ni - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al - 0.05Zr - 0.006B
Consumable Electrode or Vacuum Induction Melted
1975 °F (1079 °C) Solution, Stabilization, and Precipitation Heat Treated
UNS N07001

1. SCOPE:

1.1 Form:

This specification covers a corrosion and heat resistant nickel alloy in the form of bars, forgings, and forging stock.

1.2 Application:

These products have been used typically 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), but usage is not limited to such applications.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2261 Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars, Rods, and Wire

MAM 2261 Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt Alloy Bars, Rods, and Wire

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2.1 (Continued):

- AMS 2269 Chemical Check Analysis Limits, Wrought Nickel Alloys and Cobalt Alloys
- AMS 2371 Quality Assurance Sampling and Testing, Corrosion and Heat Resistant Steels and Alloys, Wrought Products and Forging Stock
- AMS 2374 Quality Assurance Sampling and Testing, Corrosion and Heat Resistant Steel and Alloy Forgings
- AMS 2750 Pyrometry
- AMS 2806 Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat Resistant Steels and Alloys
- AMS 2808 Identification, Forgings

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

- ASTM E 18 Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
- ASTM E 139 Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
- ASTM E 354 Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 354, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	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
Lead	--	0.0005 (5 ppm)
Bismuth	--	0.0003 (0.3 ppm)
Selenium	--	0.0003 (3 ppm)
Nickel	remainder	

3.1.1 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2269.

3.2 Melting Practice:

Alloy shall be produced by multiple melting using consumable electrode practice in the remelt cycle or shall be induction melted under vacuum.

3.3 Condition:

The product shall be supplied in the following condition:

3.3.1 Bars: Hot rolled or extruded, solution, stabilization, and precipitation heat treated and descaled. Round bars shall be ground or turned.

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

3.3.3 Forging Stock: As ordered by the forging manufacturer.

3.4 Heat Treatment:

(R)

Bars and forgings shall be heat treated as follows; pyrometry shall be in accordance with AMS 2750.

3.4.1 Solution Heat Treatment: Heat to $1975^{\circ}\text{F} \pm 25$ ($1079^{\circ}\text{C} \pm 14$), hold at heat for 4 hours ± 0.5 , and cool at a rate equivalent to an air cool or faster.

3.4.2 Stabilization Heat Treatment: Heat to $1550^{\circ}\text{F} \pm 15$ ($843^{\circ}\text{C} \pm 8$), hold at heat for 4 hours ± 0.5 , except that blade forgings shall be held at heat for 24 hours ± 1 , and cool in air.

3.4.3 Precipitation Heat Treatment: Heat to $1400^{\circ}\text{F} \pm 15$ ($760^{\circ}\text{C} \pm 8$), hold at heat for 16 hours ± 1 , and cool in air.

3.5 Properties:

The product shall conform to the following requirements:

3.5.1 Bars and Forgings:

3.5.1.1 Hardness: Shall be 32 to 42 HRC, or equivalent (See 8.2), determined in accordance with ASTM E 18.

3.5.1.2 Grain Size: Uniformly mixed structures are permissible. Segregated areas of coarse or fine grains shall not exceed 20% of any field at 100X magnification. Standards for acceptance may be agreed upon by purchaser and vendor.

3.5.1.3 Stress-Rupture Properties at 1500°F (816°C): A tensile specimen, maintained at $1500^{\circ}\text{F} \pm 3$ ($816^{\circ}\text{C} \pm 2$) while a load sufficient to produce an initial axial stress of 47.5 ksi (328 MPa) or higher 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 E 139.

3.5.1.3.1 The test of 3.5.1.3 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 47.5 ksi (328 MPa) or higher shall be used to rupture or for 23 hours, whichever occurs first. After the 23 hours and at intervals of 8 to 16 hours, preferably 8 to 10 hours, thereafter, the stress shall be increased in increments of 5.0 ksi (34.5 MPa). Time to rupture and elongation requirements shall be as specified in 3.5.1.3.

3.5.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.4, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.1.1, 3.5.1.2, and 3.5.1.3. If specimens taken from the stock after heat treatment as in 3.4 conform to the requirements of 3.5.1.1, 3.5.1.2, and 3.5.1.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.6 Quality:

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.

3.6.1 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.

3.7 Tolerances:

(R)

Bars shall conform to all applicable requirements of AMS 2261 or MAM 2261.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

(R)

The vendor of the product shall supply all samples for vendor's tests and shall be responsible for performing all required tests. 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 for the following requirements are acceptance tests and shall be performed on each heat or lot as applicable:

4.2.1.1 Composition (3.1) of each heat.

4.2.1.2 Hardness (3.5.1.1), grain size (3.5.1.2), and stress-rupture properties (3.5.1.3) of each lot of bars and forgings.

4.2.1.3 Tolerances (3.7) of bars.

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4.2.2 Periodic Tests: Tests of forging stock (3.5.2) to demonstrate ability to develop required properties are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing:

(R)

Shall be as follows:

4.3.1 Bars and Forging Stock: In accordance with AMS 2371.

4.3.2 Forgings: In accordance with AMS 2374.

4.4 Reports:

4.4.1 The vendor of bars and forgings shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and for hardness, grain size, and stress-rupture properties of each lot. This report shall include the purchase order number, heat and lot number, AMS 5709F, 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.