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

AEROSPACE MATERIAL SPECIFICATION

AMS 5709D
Superseding AMS 5709C
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UNS N07001

ALLOY BARS AND FORGINGS, CORROSION AND HEAT RESISTANT
58Ni - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al
Consumable Electrode or Vacuum Induction Melted
1975°F (1080°C) Solution, Stabilization, and Precipitation Heat Treated

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: Primarily for parts, such as pins, nuts, and turbine blades, requiring high strength up to 1500°F (815°C) and oxidation resistance up to 1750°F (955°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., 400 Commonwealth Drive, Warrendale, PA 15096.

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 Alloys and Cobalt Alloys
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

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 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 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 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 Military Standards:

MIL-STD-163 - Steel Mill Products, Preparations 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 E354, 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	0.02	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.

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°F ± 25 (1080°C ± 15), hold at heat for 4 hr ± 0.5, and cool at a rate equivalent to air cool or faster.

3.3.2 Stabilization Heat Treatment: Heat to 1550°F ± 15 (845°C ± 8), hold at heat for 4 hr ± 0.5, except that blade forgings shall be held for 24 hr ± 1, and cool in air.

3.3.3 Precipitation Heat Treatment: Heat to 1400°F ± 15 (760°C ± 8), hold at heat for 16 hr ± 1, and cool in air.

3.4 Properties: The product shall conform to the following requirements:

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 Properties at 1500°F (815°C): A tensile test specimen, maintained at 1500°F ± 3 (815°C ± 2) 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. 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, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5 Quality:

3.5.1 Alloy 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, 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.

3.5.3 Forgings shall have substantially uniform macrostructure and grain flow.

3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight 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 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 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 the following requirements are Ø classified as 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 (3.4.1.1), grain size (3.4.1.2), and stress-rupture properties (3.4.1.3) of each lot of bars and forgings.

4.2.1.3 Tolerances (3.7) of bars and forging stock.

4.2.2 Periodic Tests: Tests of forging stock (3.4.2) to demonstrate ability to develop required properties Ø are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests: Tests of forgings to determine conformance to all applicable technical requirements Ø of this specification when AMS 2375 is specified are classified as preproduction tests and shall be performed on the first-article 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.

4.2.3.1 For direct U.S. Military procurement of forgings, substantiating test data and, when requested, Ø 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 alloy originally melted as a single furnace charge or the ingots produced from a single vacuum induction melt.

4.3.1 Bars: AMS 2371.

4.3.2 Forgings and Forging Stock: AMS 2374.

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 of each heat and the results of tests for hardness and stress-rupture properties of each lot. This report shall include the purchase order number, heat number, AMS 5709D, 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, AMS 5709D, 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: Shall be in accordance with the following:

Ø 4.6.1 Bars: AMS 2371.

Ø 4.6.2 Forgings and Forging Stock: AMS 2374.