



AEROSPACE MATERIAL SPECIFICATION

Society of Automotive Engineers, Inc.

400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AMS 5668F

Superseding AMS 5668E

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ALLOY BARS, FORGINGS, AND RINGS, CORROSION AND HEAT RESISTANT

72Ni - 15.5Cr - 7.0Fe - 2.5Ti - 1.0(Cb+Ta) - 0.70Al

2100°F (1095°C) Solution 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, flash welded rings, and stock for forging, flash welded rings, or heading.
- 1.2 Application: Primarily for parts, such as bolts, turbine blades, and turbine seals, requiring oxidation resistance and high strength at 1250° - 1500°F (675° - 815°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
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, PA 19103.

ASTM E8 - Tension Testing of Metallic Materials
ASTM E10 - Brinell 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

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 or their use by governmental agencies is entirely voluntary. There is no agreement to adhere to any SAE standard or 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 infringement of patents."

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 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	--	0.08
Manganese	--	1.00
Silicon	--	0.50
Sulfur	--	0.010
Chromium	14.00 -	17.00
Nickel + Cobalt	70.00	--
Columbium + Tantalum	0.70 -	1.20
Titanium	2.25 -	2.75
Aluminum	0.40 -	1.00
Iron	5.00 -	9.00
Cobalt (3.1.1)	--	1.00
Copper	--	0.50

- 3.1.1 Determination not required for routine acceptance.

- 3.1.2 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, Forgings, and Flash Welded Rings: Solution and precipitation heat treated.

- 3.2.1.1 Bars shall be hot finished: round bars shall be ground or turned.

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

3.3 Heat Treatment:3.3.1 Solution Heat Treatment:

- 3.3.1.1 Bars, and Forgings Other Than Seamless Rolled Rings: Shall be solution heat treated by heating to 2100°F ± 25 (1150°C ± 15), holding at heat for 2 - 4 hr, and cooling in air.

- 3.3.1.2 Flash Welded Rings and Seamless Rolled Rings: Shall be solution heat treated by heating to a temperature within the range 2000° - 2100°F (1095° - 1150°C), holding at the selected temperature within ± 25°F (± 15°C) for 2 - 4 hr, and cooling in air or faster.

- 3.3.2 Precipitation Heat Treatment: Bars, forgings, and flash welded rings shall be precipitation heat treated by heating to 1550°F ± 25 (845°C ± 15), holding at heat for 24 hr ± 1, cooling to 1300°F (705°C) or lower in 2 hr or less, either in air or in the furnace, and then heating to, or continuing at, 1300°F ± 25 (705°C ± 15), holding at heat for 20 hr ± 1, and cooling in air.

3.4 **Properties:** Product 10.0 in. (250 mm) and under in nominal diameter or distance between parallel sides shall conform to the following requirements; properties of product over 10.0 in. (250 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.1 **Bars, Forgings, and Flash Welded Rings:**

3.4.1.1 **Tensile Properties:** Shall be as specified in Table I, determined in accordance with ASTM E8:

TABLE I

	Flash Welded Rings and Seamless Rolled Rings	Bars and Forgings Other than Seamless Rolled Rings
Tensile Strength, min	125,000 psi	140,000 psi
Yield Strength at 0.2% Offset, min	80,000 psi	80,000 psi
Elongation in 4D, min	8.0%	8.0%
Reduction of Area, min	8.0%	8.0%

TABLE I (SI)

Tensile Strength, min	862 MPa	965 MPa
Yield Strength at 0.2% Offset, min	552 MPa	552 MPa
Elongation in 4D, min	8.0%	8.0%
Reduction of Area, min	8.0%	8.0%

3.4.1.2 **Hardness:** Should be 262 - 341 HB or equivalent, determined in accordance with ASTM E10, 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 Properties at 1350°F (732°C):** A tensile test specimen maintained at 1350°F ± 5 (732°C ± 3, while a load sufficient to produce an initial axial stress of 52,500 psi (362 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 less than 5% in 4D. Test 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 52,500 psi (362 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 case the load required to produce an initial axial stress of 52,500 psi (362 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 5000 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, 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.

3.4.3 **Stock for Flash Welded Rings or Heading:** Specimens taken from the stock after heat treatment as in 3.3 shall conform to the requirements of 3.4.1.1, 3.4.1.2, and 3.4.1.3.

3.5 **Quality:** 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.

3.5.1 Forgings shall have substantially uniform macrostructure and grain flow. Standards for acceptance shall be as agreed upon by purchaser and vendor.

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 kg/m), short lengths down to 2 ft (600 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 deem 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 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 Tensile properties (3.4.1.1), hardness (3.4.1.2), and stress-rupture properties (3.4.1.3) of bars, forgings, and flash welded rings from each lot.

4.2.1.3 Tolerances (3.7) of bars and forging stock.

4.2.2 Periodic Tests: Tests of forging stock (3.4.2) and stock for flash welded rings or heading (3.4.3) to demonstrate ability to develop required properties 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 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, 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:

4.3.1 Bars, Flash Welded Rings, and Stock for Flash Welded Rings or Heading: AMS 2371.

4.3.2 Forgings and Forging Stock: AMS 2374.