



# AEROSPACE MATERIAL

Society of Automotive Engineers, Inc.  
TWO PENNSYLVANIA PLAZA, NEW YORK, N. Y. 10001

# SPECIFICATION

**AMS 5668E**  
Superseding AMS 5668D

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ALLOY BARS, FORGINGS, AND RINGS, CORROSION AND HEAT RESISTANT  
Nickel Base - 15.5Cr - 7.0Fe - 2.5Ti - 1.0(Cb+Ta) - 0.70Al  
2100 F (1093.3 C) Solution and Precipitation Heat Treated

1. SCOPE:

- 1.1 Form: This specification covers a corrosion and heat resistant nickel-base alloy in the form of solution and precipitation heat treated bars, forgings, and flash welded rings and of stock for forgings or flash welded rings.
- 1.2 Application: Primarily for parts, such as bolts, turbine blades, and turbine seals, requiring oxidation resistance and high strength at 1250 - 1500 F (677 - 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 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
- 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 E8 - Tension Testing of Metallic Materials
- ASTM E10 - Brinell Hardness of Metallic Materials
- ASTM E139 - Conducting Creep and Time-for-Rupture Tension Test of 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

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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:

	min	max
Carbon	--	0.08
Manganese	--	1.00
Silicon	--	0.50
Sulfur	--	0.010
Chromium	14.00 - 17.00	
Nickel + Cobalt	70.00	--
Cobalt, if determined	--	1.00
Columbium + Tantalum	0.70 - 1.20	
Titanium	2.25 - 2.75	
Aluminum	0.40 - 1.00	
Iron	5.00 - 9.00	
Copper	--	0.50

- 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: Hot finished, solution and precipitation heat treated.

- 3.2.1.1 Round bars shall be ground or turned.

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

- 3.2.2.1 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.

- 3.2.3 Stock for Forging or Flash Welded Rings: As ordered by the forging or flash welded ring 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  $\pm$  25 (1148.9 C  $\pm$  14), 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 (1093.3 - 1148.9 C), holding at the selected temperature within  $\pm$  25 F ( $\pm$  14 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  $\pm$  25 (843.3 C  $\pm$  14), holding at heat for approximately 24 hr, cooling to 1300 F (704.4 C) or lower in 2 hr or less, either in air or in the furnace, and then heating to, or continuing at, 1300 F  $\pm$  25 (704.4 C  $\pm$  14), holding at heat for approximately 20 hr, and cooling in air.

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

- 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 2 in. or 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 50.8 mm or 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 Test at 1350 F (732.2 C):** A tensile test specimen maintained at 1350 F  $\pm$  5 (732.2 C  $\pm$  2.8), 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 process. 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:** 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 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 **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: Tests to determine conformance to all technical requirements of this specification are classified as acceptance or routine control tests.
- 4.3 Sampling: Bars, flash welded rings, and stock for flash welded rings shall be sampled in accordance with AMS 2371. Forgings and forging stock shall be sampled as agreed upon by purchaser and vendor.
- 4.3.1 Specimens from flash welded rings shall be cut from the parent metal not including the weld heat affected zone.
- 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 5668E, 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 5668E, 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.