



AEROSPACE MATERIAL SPECIFICATION

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

AMS 5661B
Superseding AMS 5661A

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ALLOY BARS AND FORGINGS, CORROSION AND HEAT RESISTANT
Nickel Base - 12.5Cr - 5.8Mo - 2.9Ti - 34Fe
Consumable Electrode or Vacuum Induction Melted

1. SCOPE:

- 1.1 Form: This specification covers a corrosion and heat resistant nickel-base alloy in the form of solution, stabilization, and precipitation heat treated bars and forgings, and of forging stock.
- 1.2 Application: Primarily for parts, such as turbine disks, shafts, and blades, requiring high strength up to 1400 F (760 C) and oxidation resistance up to 1600 F (871 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 E8 - Tension Testing of Metallic Materials
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E139 - Conducting Creep and Time-for-Rupture Tension
Tests of Materials
ASTM E292 - Conducting Time-for-Rupture Notch Tension Tests 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

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:

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 is entirely voluntary. There is no agreement to adhere to any SAE standards 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 liability for infringement of patents."

	min	max
Carbon	--	0.10
Manganese	--	0.50
Silicon	--	0.40
Phosphorus	--	0.030
Sulfur	--	0.030
Chromium	11.00	- 14.00
Nickel	40.00	- 45.00
Cobalt	--	1.00
Molybdenum	5.00	- 6.50
Titanium	2.70	- 3.10
Boron	0.010	- 0.020
Aluminum	--	0.35
Copper	--	0.50
Iron	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: Hot finished and solution, stabilization, and precipitation heat treated.

3.2.1.1 Rounds shall be rough turned or ground.

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 to produce the properties specified in 3.4.1.

3.3.1 Solution Heat Treatment: Heat to 2000 F \pm 25 (1093.3 C \pm 14), hold at heat for 2 hr, and cool at a rate equivalent to air cool or faster.

3.3.2 Stabilization Heat Treatment: Heat to a temperature within the range 1425 - 1475 F (773.9 - 801.7 C), hold at the selected temperature within \pm 15 F (\pm 8.3 C) for 2 - 4 hr, and cool at a rate equivalent to air cool or faster.

3.3.3 Precipitation Heat Treatment: Heat to a temperature within the range 1300 - 1375 F (704.4 - 746.1 C), hold at the selected temperature within \pm 15 (\pm 8.3 C) for approximately 24 hr, and cool in air.

3.4 Properties:

3.4.1 Bars and Forgings: Shall conform to the following requirements:

3.4.1.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8:

Tensile Strength, min	165,000 psi (1138 MPa)
Yield Strength at 0.2% Offset, min	120,000 psi (827 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	12%
Reduction of Area, min	15%

- 3.4.1.1.1 **Disk Forgings:** When tensile test specimens are machined from the bore and punchout areas of disk and hub forgings and these areas lie within a 4 in. (102 mm) radius of the disk center, the elongation may be as low as 10% and the reduction of area as low as 12%. The radius of area with the lower properties shall not exceed 25% of the forging radius.
- 3.4.1.2 **Hardness:** Should be 302 - 388 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 1200 F (648.9 C):** A combination smooth and notched test specimen machined to the dimensions shown in Fig. 1 and Table I, maintained at 1200 F \pm 3 (648.9 C \pm 1.7) while a load sufficient to produce an initial axial stress of 90,000 psi (621 MPa) is applied continuously shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. After the 23 hr, if rupture occurs in the notch, the smooth section shall, by suitable means, be continued to rupture, or a separate smooth specimen shall be tested to rupture in not less than 23 hours. Elongation of the smooth section after rupture, measured at room temperature, shall be not less than 5% in 4D if the specimen ruptures in 48 hr or less, and not less than 4% in 4D if the specimen ruptures in more than 48 hours. Test shall be conducted in accordance with ASTM E292.
- 3.4.1.3.1 As an alternate procedure, separate smooth and notched test specimens, machined from adjacent sections of the same piece, with gage sections conforming to the respective dimensions of Table I may be tested individually under the above conditions. The smooth specimen shall not rupture in less than 23 hr and elongation after rupture, measured at room temperature, shall be not less than 5% in 4D. The notched specimen shall not rupture in less than 23 hr but need not be tested to rupture. The smooth specimen shall be tested in accordance with ASTM E139 and the notched specimen in accordance with ASTM E292.
- 3.4.1.3.2 The tests of 3.4.1.3 and 3.4.1.3.1 may be conducted using a load higher than required to produce an initial axial stress of 90,000 psi (621 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 and 3.4.1.3.1. Test procedures shall be as specified in 3.4.1.3 and 3.4.1.3.1.
- 3.4.1.3.3 When permitted by purchaser, the tests 3.4.1.3 and 3.4.1.3.1 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 90,000 psi (621 MPa) shall be used to rupture or for 48 hr, whichever occurs first. After the 48 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 and 3.4.1.3.1. Test procedures shall be as specified in 3.4.1.3 and 3.4.1.3.1.
- 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.
- 3.5 **Quality:** Material shall be produced by multiple melting using consumable electrode practice in the re-melt cycle, or shall be induction melted under vacuum, unless otherwise permitted. 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:

4.2.1 **Acceptance Tests:** Tests of the product to determine conformance to composition (3.1) requirements, of bars and forgings to determine conformance to tensile properties (3.4.1.1), hardness (3.4.1.2), and stress-rupture (3.4.1.3) requirements, and of bars and forging stock to determine conformance to tolerance (3.6) requirements are classified as acceptance or routine control tests.

4.2.2 **Qualification Tests:** Tests of forging stock to demonstrate capability of developing required properties (3.4.2) are classified as qualification or periodic control tests.

4.3 **Sampling:** Bars shall be sampled in accordance with AMS 2371. Forgings and forging stock shall be sampled as agreed upon by purchaser and vendor. 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 **Forgings:** Specimens, from disk forgings shall be cut from any plane perpendicular to the axis of the forging with axis of specimen perpendicular to a radius in the selected plane. When size and shape permit, additional specimens shall be cut with axis of specimen approximately parallel to the axis of the forging. Specific locations of test specimens shall be 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, heat number, material specification number and its revision letter, size, quantity from each heat, and a statement of the specific heat treating temperatures and cycles used to provide the reported properties. 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:**