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

AEROSPACE MATERIAL SPECIFICATION

AMS 5703

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Revised

ALLOY BARS, FORGINGS, AND RINGS, CORROSION AND HEAT RESISTANT
Nickel Base - 16Cr - 37Fe - 2.9Cb - 1.8Ti
Consumable Electrode or Vacuum Induction Melted,
1750 F (954.4 C) Solution, Stabilization, and Precipitation Heat Treated

1. SCOPE:

1.1 Form: This specification covers a corrosion and heat resistant nickel-base alloy in the form of bars, forgings, flash welded rings, and stock for forging and flash welded rings.

1.2 Application: Primarily for parts requiring high resistance to creep and stress-rupture up to 1300 F (704 C), oxidation resistance up to 1800 F (982 C), and good machinability.

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 E112 - Estimating Average Grain Size of Metals
ASTM E139 - Conducting Creep and Time-For-Rupture 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 Ave., 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.

	min	max
Carbon	--	0.06
Manganese	--	0.35
Silicon	--	0.35
Phosphorus	--	0.020
Sulfur	--	0.015
Chromium	14.50	17.50
Nickel	39.00	44.00
Columbium + Tantalum	2.50	3.30
Titanium	1.50	2.00
Aluminum	--	0.40
Boron	--	0.006
Copper	--	0.30
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, Forgings, and Flash Welded Rings: Solution, stabilization, and precipitation heat treated and descaled.

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

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 or Flash Welded Rings: As ordered by the forging or flash welded ring manufacturer.

3.3 Heat Treatment: Bars, forgings, and flash welded rings shall be heat treated as follows:

3.3.1 Solution Heat Treatment:

3.3.1.1 Bars: No specific heat treating instructions are specified but it is recommended that the product be solution heat treated by heating to a temperature within the range 1700 - 1800 F (926.7 - 982.2 C), holding at the selected temperature within ± 25 F (± 14 C) for a time commensurate with the thickness, and cooling at a rate equivalent to air cool or faster.

3.3.1.2 Forgings and Flash Welded Rings: Shall be heated to a temperature within the range 1700 - 1800 F (926.7 - 982.2 C), held at the selected temperature within ± 25 F (± 14 C) for not less than 30 min., and cool at a rate equivalent to air cool or faster. If forgings are not to be machined all over, heat treatment shall be performed in a suitable protective atmosphere or, when permitted by purchaser, a suitable protective coating may be applied to the forgings in lieu of using a protective atmosphere.

3.3.2 Stabilization Heat Treatment: Heat to 1550 F ± 25 (843.3 C ± 8.3), hold at heat for 3 hr, and air cool to room temperature.

3.3.3 Precipitation Heat Treatment: Heat to 1325 F ± 15 (718.3 C ± 8.3), hold at heat for 8 hr, furnace cool at a rate not faster than 100 F (55.6 C) deg per hr to 1150 F ± 15 (621.1 C ± 8.3), hold at 1150 F ± 15 (621.1 C ± 8.3) for 8 hr, and air cool. Instead of the 100 F (55.6 C) deg per hr cooling rate to 1150 F ± 15 (621.1 C ± 8.3), the furnace cooling may be at any rate provided the time at 1150 F ± 15 (621.1 C ± 8.3) is adjusted to give a total precipitation heat treatment time of 18 hours.

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 at Room Temperature: Shall be as specified in Table I, determined in accordance with ASTM E8:

TABLE I

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset, psi, min	Elongation in 2 in. or 4D %, min	Reduction of Area %, min
Up to 2.50, excl	170,000	130,000	12	15
2.50 to 4.00, incl	165,000	130,000	12	15

TABLE I (SI)

Nominal Diameter or Distance Between Parallel Sides Millimeters	Tensile Strength MN/m^2, min	Yield Strength at 0.2% Offset, MN/m^2, min	Elongation in 50.8 mm or 4D %, min	Reduction of Area %, min
Up to 63.5, excl	1172	896	12	15
63.5 to 101.6, incl	1138	896	12	15

3.4.1.1.1 Properties of products over 4.00 in (101.60 mm) in diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.1.2 Hardness: Should be not lower than 285 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 Grain Size: Shall be as follows, determined by comparison of a polished and etched specimen with the chart in ASTM E112 or, in case of disagreement, by the intercept (Heyn) method:

3.4.1.3.1 Shall be predominantly 5 or finer in bars and flash welded rings 9 sq in. (58 cm^2) and under in cross-sectional area.

3.4.1.3.2 Shall be predominantly 4 or finer in bars and flash welded rings over 9 sq in. (58 cm^2) in cross-sectional area and all forgings.

3.4.1.4 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 II, maintained at 1200 F ± 3 (648.9 C ± 1.7) while a load sufficient to produce an initial axial stress of 100,000 psi (690 MN/m^2) is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. Rupture shall occur in the smooth section and elongation of this section after rupture, measured at room temperature, shall be as specified below. Tests shall be conducted in accordance with ASTM E139.

Nominal Diameter or Distance Between Parallel Sides		Elongation, % in 4D, min
Inches	(Millimeters)	
Up to 4.00, incl	(Up to 101.60, incl)	4
Over 4.00	(Over 101.60)	As agreed upon by purchaser and vendor

3.4.1.4.1 As an alternate procedure, separate smooth and notched specimens, machined from adjacent sections of the same piece, with gage sections conforming to the respective dimensions of Table II 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 as specified above. The notched specimen shall not rupture in less time than the companion smooth specimen but need not be tested to rupture.

3.4.1.4.2 The tests of 3.4.1.4 and 3.4.1.4.1 may be conducted using a load higher than required to produce an initial axial stress of 100,000 psi (690 MN/m^2) but load shall not be changed while test is in process. Time to rupture and elongation requirements shall be as specified in 3.4.1.4.

3.4.1.4.3 When permitted by purchaser, the tests of 3.4.1.4 and 3.4.1.4.1 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 100,000 psi (690 MN/m^2) 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 5,000 psi (34.5 MN/m^2). Time to rupture, rupture location, and elongation requirements shall be as specified in 3.4.1.4.

3.4.2 Stock for Forging and Flash Welded Rings: When a sample of stock is forged to a test coupon, solution heat treated as in 3.3.1.2, stabilization heat treated as in 3.3.2, and precipitation heat treated as in 3.3.3, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.1.1, 3.4.1.2, 3.4.1.3, and 3.4.1.4. If specimens taken from the stock after heat treatment as specified above conform to the requirements of 3.4.1.1, 3.4.1.2, 3.4.1.3, and 3.4.1.4, the tests shall be accepted as equivalent to tests of the forged coupon.

3.5 Quality: Material shall be produced by multiple melting using consumable electrode practice in the remelt cycle or shall be induction melted under vacuum, unless otherwise permitted. If consumable electrode remelting is not performed in vacuum, electrodes which have been produced by vacuum induction melting shall be used. 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. Forgings shall have substantially uniform macrostructure and grain flow.

3.6 Tolerances: Unless otherwise specified, tolerances for bars shall conform to all applicable requirements of AMS 2261.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor 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 Routine Control Tests: The following tests are classified as routine control tests:

4.2.1.1 Tests of the product to determine conformance to composition (3.1) requirements.

4.2.1.2 Tests of bars, forgings, and flash welded rings to determine conformance to tensile (3.4.1.1), hardness (3.4.1.2), grain size (3.4.1.3), and stress-rupture (3.4.1.4) requirements.

4.2.1.3 Tests of bars to determine conformance to tolerance (3.6) requirements.

4.2.2 Periodic Control Tests: Tests of stock for forging and flash welded rings to demonstrate capability of developing required properties (3.4.2) are classified as qualification and/or periodic 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 Grain size samples shall be taken from the mid-radius or 1/4 thickness position.

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 tensile property, hardness, grain size, and stress-rupture requirements of this specification. This report shall include the purchase order number, material specification number, heat number, solution heat treatment temperature used, size, and quantity from each heat. If forgings are supplied, the part number and the size and 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, 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: Unless otherwise specified, the product shall be identified as follows:

5.1.1 Bars:

5.1.1.1 Each straight bar 0.500 in. (12.700 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 5703, 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. (12.700 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 5703, 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.

5.1.1.3 Coiled bars shall be securely bundled and identified by a metal or plastic tag embossed with the purchase order number, AMS 5703, heat number, nominal size, and manufacturer's identification and attached to each coil or shall be boxed and the box marked with the same information.

5.1.2 Forgings: In accordance with AMS 2808.

5.1.3 Flash Welded Rings and Stock for Forging or Flash Welded Rings: As agreed upon by purchaser and vendor.

5.2 Packaging: The product shall be prepared for shipment in accordance with commercial practice to assure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Material not conforming to this specification or to authorized modifications will be subject to rejection.

8. NOTES: None.