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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 5702B

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Superseding AMS 5702A

ALLOY BARS, FORGINGS, AND RINGS, CORROSION AND HEAT RESISTANT
41.5Ni - 16Cr - 37Fe - 2.9Cb - 1.8Ti
Consumable Electrode or Vacuum Induction Melted
1750°F (955°C) Solution Heat Treated

UNS N09706

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 or flash welded rings.

1.2 Applications: Primarily for parts requiring a combination of resistance to creep and stress-rupture up to 1300°F (705°C), oxidation resistance up to 1800°F (980°C), and good machinability, particularly parts which are welded and then precipitation heat treated to develop required properties.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2261 - Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars and Forging Stock
MAM 2261 - Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt 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

2.1.1 Aerospace Material Specifications (Cont'd):

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 A751 - Methods, Practices, and Definitions for Chemical Analysis of Steel Products
ASTM E8 - Tension Testing of Metallic Materials
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E112 - Determining Average Grain Size
ASTM E139 - Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E292 - Conducting Time-for-Rupture Notch Tension Tests of Materials

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Specifications:

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 any of the analytical methods specified in ASTM A751:

	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 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 solution heat treated as follows:

3.3.1 Bars: No specific heat treating instructions are specified but it is recommended that the bars be solution heat treated to conform to the requirements of 3.4.1.1.1, 3.4.1.1.2, and 3.4.1.2 by heating to a temperature within the range 1700° - 1800°F (925° - 980°C), holding at the selected temperature within ±25°F (±15°C) for a time commensurate with cross-sectional thickness, and cooling as required.

3.3.2 Forgings and Flash Welded Rings: Shall be heated to a temperature within the range 1700° - 1800°F (925° - 980°C), held at the selected temperature within ±25°F (±15°C) for not less than 30 min., and cooled as required.

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

3.4.1 Bars, Forgings, and Flash Welded Rings:

3.4.1.1 As Solution Heat Treated:

3.4.1.1.1 Hardness: Shall be not higher than 277 HB, or equivalent, determined in accordance with ASTM E10.

3.4.1.1.2 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:

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

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

3.4.1.2 After Stabilization and Precipitation Heat Treatment: The product shall have the following properties after being stabilization heat treated by heating to 1550°F ± 15 (845° ± 8), holding at heat for 3 hr ± 0.25, and cooling in air to room temperature and then precipitation heat treated by heating to 1325°F ± 15 (720°C ± 8), holding at heat for 8 hr ± 0.25, cooling at a rate not faster than 100 F (55 C) deg per hr to 1150°F ± 15 (620°C ± 8), holding at 1150°F ± 15 (620°C ± 8) for 8 hr ± 0.25, and cooling in air. Instead of the 100°F (55°C) deg per hr cooling rate to 1150°F ± 15 (620°C ± 8), the furnace cooling may be at any rate provided the time at 1150°F ± 15 (620°C ± 8) is adjusted to give a total precipitation heat treatment time of 18 hours.

3.4.1.2.1 Tensile Properties: 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 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 Millimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min	Reduction of Area %, min
Up to 62.5, excl	1170	895	12	15
62.5 to 100.0, incl	1140	895	12	15

3.4.1.2.1.1 Tensile property requirements for product over 4.00 in. (100.0 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.1.2.2 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 of 3.4.1.2.1 are met.

3.4.1.2.3 Stress-Rupture Properties at 1200°F (650°C): Shall be as follows; testing of notched specimens and of combination smooth-and-notched specimens shall be performed in accordance with ASTM E292 and of smooth specimens in accordance with ASTM E139:

3.4.1.2.3.1 A standard cylindrical combination smooth-and-notched specimen conforming to ASTM E292, maintained at 1200°F ± 3 (650°C ± 2) while a load sufficient to produce an initial axial stress of 100,000 psi (690 MPa) 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:

Nominal Diameter or Distance Between Parallel Sides		Elongation In 4D
Inches	Millimetres	%, min
Up to 4.00, incl	Up to 100.0 incl	4
Over 4.00	Over 100.0 incl	As agreed upon by purchaser and vendor

3.4.1.2.3.2 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 shown in ASTM E292 may be tested individually under the conditions of 3.4.1.2.3.1. The smooth specimen shall not rupture in less than 23 hr and elongation after rupture, measured at room temperature, shall be as specified in 3.4.1.2.3.1. The notched specimen shall not rupture in less time than the companion smooth specimen but need not be tested to rupture.

3.4.1.2.3.3 The tests of 3.4.1.2.3.1 and 3.4.1.2.3.2 may be conducted using a load higher than required to produce an initial axial stress of 100,000 psi (690 MPa) but load shall not be changed while test is in progress. Time to rupture, rupture location, and elongation requirements shall be as specified in 3.4.1.2.3.1.

3.4.1.2.3.4 When permitted by purchaser, the tests of 3.4.1.2.3.1 and 3.4.1.2.3.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 100,000 psi (690 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 (35 MPa). Time to rupture, rupture location, and elongation requirements shall be as specified in 3.4.1.2.3.1.

3.4.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.3.2 and 3.4.1.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.1.2.1, 3.4.1.2.2, and 3.4.1.2.3. If specimens taken from the stock after heat treatment as in 3.3.2 and 3.4.1.2 conform to the requirements of 3.4.1.2.1, 3.4.1.2.2, and 3.4.1.2.3, 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 3.3.2 and 3.4.1.2 shall conform to the requirements of 3.4.1.2.1, 3.4.1.2.2, and 3.4.1.2.3.

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. If consumable electrode remelting is not performed in vacuum, electrodes which have been produced by vacuum induction melting shall be used.

3.5.2 The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

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

3.5.2.2 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of re-entrant 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 (2 - 7.5 m) but not more than 25% of any shipment shall be supplied in lengths of 6 - 9 ft (2 - 3 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: Bars and forging stock shall conform to all applicable requirements of AMS 2261 or MAM 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 any confirmatory testing deemed 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 Hardness (3.4.1.1.1) and grain size (3.4.1.1.2) of each lot of bars, forgings, and flash welded rings as solution heat treated.

4.2.1.3 Tensile (3.4.1.2.1), hardness (3.4.1.2.2), and stress-rupture (3.4.1.2.3) properties of each lot of bars, forgings, and flash welded rings after precipitation heat treatment.

4.2.1.4 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 (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 prior to or on the first-article shipment of a forging to a purchaser, when a change in material, processing, or both requires reapproval as in 4.4, and when purchaser deems confirmatory testing 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, contracting officer, or 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: AMS 2371.

4.3.2 Forgings and Forging Stock: AMS 2374.

4.3.3 Grain size samples shall be taken from the mid-radius or 1/4-thickness position.

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 a report showing the results of tests for chemical composition of each heat and the results of tests on each lot to determine conformance to the other acceptance test requirements of this specification. This report shall include the purchase order number, heat number, AMS 5702B, solution heat treatment temperature used, size, and quantity. 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 a report showing the purchase order number, AMS 5702B, 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 either a statement that the material conforms or copies of laboratory reports showing the results of tests to determine conformance.

4.6 Resampling and Retesting: Shall be in accordance with the following: