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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5702C

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Reaffirmed SEP 2000

Superseding AMS 5702B

Nickel Alloy, Corrosion and Heat Resistant, Bars, Forgings, and Rings
41.5Ni - 16Cr - 37Fe - 2.9Cb - 1.8Ti
Consumable Electrode or Vacuum Induction Melted
1750 °F (954 °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:

These products have been used typically for parts requiring a combination of resistance to creep and stress-rupture up to 1300 °F (704 °C), oxidation resistance up to 1800 °F (982 °C), and good machinability, particularly parts which are welded and then precipitation heat treated to develop required properties, but usage is not limited to such applications.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2261	Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars, Rods, and Wire
MAM 2261	Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt Alloy Bars, Rods, and Wire
AMS 2269	Chemical Check Analysis Limits, Wrought Nickel Alloys and Cobalt Alloys
AMS 2371	Quality Assurance Sampling and Testing, Corrosion and Heat ResistantSteels and Alloys, Wrought Products and Forging Stock
AMS 2374	Quality Assurance Sampling and Testing, Corrosion and Heat Resistant Steel and Alloy Forgings

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7161 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

2.1 (Continued):

AMS 2806	Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat Resistant Steels and Alloys
AMS 2808	Identification, Forgings
AMS 7490	Rings, Flash Welded, Corrosion and Heat Resistant Austenitic Steels and Austenitic-Type Alloys or Precipitation Hardenable Alloys

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM A 751	Methods, Practices, and Definitions for Chemical Analysis of Steel Products
ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 10	Brinell Hardness of Metallic Materials
ASTM E 112	Determining the Average Grain Size
ASTM E 139	Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E 292	Conducting Time-for-Rupture Notch Tension Tests of Materials

2.3 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-163	Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined by analytical methods specified in ASTM A 751.

TABLE 1 - Composition

Element	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 Melting Practice:

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.

3.3 Condition:

The product shall be supplied in the following condition:

3.3.1 Bars, Forgings, and Flash Welded Rings: Solution heat treated and descaled.

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

3.3.1.2 Flash welded rings shall not be supplied unless specified or permitted on purchaser's part drawing. When supplied, rings shall be manufactured in accordance with AMS 7490.

3.3.2 Stock for Forging or Flash Welded Rings: As ordered by the forging or flash welded ring manufacturer.

3.4 Heat Treatment:

Bars, forgings, and flash welded rings shall be solution heat treated as follows:

3.4.1 Bars: Shall be solution heat treated by heating to a temperature within the range 1700 to 1800 °F (927 to 982 °C), holding at the selected temperature within ±25 °F (±14 °C) for a time commensurate with cross-sectional thickness, and cooling as required.

3.4.2 Forgings and Flash Welded Rings: Shall be heated to a temperature within the range 1700 to 1800 °F (927 to 982 °C), held at the selected temperature within ±25 °F (±14 °C) for not less than 30 minutes, and cooled as required.

3.5 Properties:

The product shall conform to the following requirements:

3.5.1 Bars, Forgings, and Flash Welded Rings:

3.5.1.1 As Solution Heat Treated:

3.5.1.1.1 Hardness: Shall be not higher than 277 HB, or equivalent, determined in accordance with ASTM E 10 (See 8.2).

3.5.1.1.2 Grain Size: Shall be as follows, determined by comparison of a polished and etched specimen with the chart in ASTM E 112 or, in case of disagreement, by the intercept (Heyn) method:

3.5.1.1.2.1 Shall be ASTM No. 5 or finer in bars and flash welded rings 9 square inches (58 cm^2) and under in cross-sectional area.

3.5.1.1.2.2 Shall be ASTM No. 4 or finer in bars and flash welded rings over 9 square inches (58 cm^2) in cross-sectional area and in all forgings.

3.5.1.2 After Stabilization and Precipitation Heat Treatment: The product shall have the following properties after being stabilization heat treated by heating to 1550 °F ± 15 (843 °C ± 8), holding at heat for 3 hours ± 0.25, and cooling in air to room temperature and precipitation heat treated by heating to 1325 °F ± 15 (718 °C ± 8), holding at heat for 8 hours ± 0.25, cooling at a rate not faster than 100 F (56 C) degrees per hour to 1150 °F ± 15 (621 °C ± 8), holding at 1150 °F ± 15 (621 °C ± 8) for 8 hours ± 0.25, and cooling in air. Instead of the 100 F (56 C) degrees per hour cooling rate to 1150 °F ± 15 (621 °C ± 8), the furnace cooling may be at any rate provided the time at 1150 °F ± 15 (621 °C ± 8) is adjusted to give a total precipitation heat treatment time of 18 hours.

3.5.1.2.1 Tensile Properties: Shall be as specified in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 2A - Minimum Tensile Properties, Inch/Pound Units

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

TABLE 2B - Minimum Tensile Properties, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 4D %	Reduction of Area %
Up to 63.5, excl	1172	896	12	15
63.5 to 101.6, incl	1138	896	12	15

3.5.1.2.2 Hardness: Shall be not lower than 285 HB, or equivalent, determined in accordance with ASTM E 10 (See 8.2).

3.5.1.2.3 Stress-Rupture Properties at 1200 °F (649 °C): Shall be as follows; testing of notched specimens and of combination smooth-and-notched specimens shall be performed in accordance with ASTM E 292 and of smooth specimens in accordance with ASTM E 139:

3.5.1.2.3.1 A standard cylindrical combination smooth-and-notched specimen conforming to ASTM E 292, maintained at 1200 °F ± 3 (649 °C ± 2) while a load sufficient to produce an initial axial stress of 100 ksi (689 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 not lower than 4% in 4D for product 4.00 inches (101.6 mm) and under in nominal diameter or least distance between parallel sides.

3.5.1.2.3.2 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 E 292, may be tested individually under the conditions of 3.5.1.2.3.1. The smooth specimen shall not rupture in less than 23 hours and elongation after rupture, measured at room temperature, shall be as specified in 3.5.1.2.3.1. The notched specimen shall not rupture in less time than the companion smooth specimen but need not be tested to rupture.

3.5.1.2.3.3 The tests of 3.5.1.2.3.1 and 3.5.1.2.3.2 may be conducted using a load higher than required to produce an initial axial stress of 100 ksi (689 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 3.5.1.2.3.1.

3.5.1.2.3.4 The tests of 3.5.1.2.3.1 and 3.5.1.2.3.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 100 ksi (689 MPa) shall be used to rupture or for 23 hours, whichever occurs first. After the 23 hours and at intervals of 8 to 16 hours, preferably 8 to 10 hours, thereafter, the stress shall be increased in increments of 5.0 ksi (34.5 MPa). Time to rupture, rupture location, and elongation requirements shall be as specified in 3.5.1.2.3.1.

3.5.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.4.2 and 3.5.1.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.1.2.1, 3.5.1.2.2, and 3.5.1.2.3. If specimens taken from the stock after heat treatment as in 3.4.2 and 3.5.1.2 conform to the requirements of 3.5.1.2.1, 3.5.1.2.2, and 3.5.1.2.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.3 Stock for Flash Welded Rings: Specimens taken from the stock after heat treatment as in 3.4.2 and 3.5.1.2 shall conform to the requirements of 3.5.1.2.1, 3.5.1.2.2, and 3.5.1.2.3.

3.6 Quality:

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.

3.6.1 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.

3.7 Tolerances:

Bars 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. 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 for the following requirements are 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 (3.5.1.1.1) and grain size (3.5.1.1.2) of each lot of bars, forgings, and flash welded rings as solution heat treated.

4.2.1.3 Tensile (3.5.1.2.1), hardness (3.5.1.2.2), and stress-rupture (3.5.1.2.3) properties of each lot of bars, forgings, and flash welded rings after precipitation heat treatment.

4.2.1.4 Tolerances (3.7) of bars.

4.2.2 Periodic Tests: Tests of forging stock (3.4.2) and of stock for flash welded rings (3.4.3) to demonstrate ability to develop required properties and tests for grain flow of die forgings (3.6.1) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing:

Shall be in accordance with the following:

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

4.3.2 Forgings: AMS 2374.

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

4.4 Reports:

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. This report shall include the purchase order number, heat and lot number, AMS 5702C, 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 Resampling and Retesting:

Shall be in accordance with the following:

4.5.1 Bars, Flash Welded Rings, and Stock for Forging or Flash Welded Rings: AMS 2371.

4.5.2 Forgings: AMS 2374.

5. PREPARATION FOR DELIVERY:

5.1 Sizes:

Except when exact lengths or multiples of exact lengths are ordered, straight bars will be acceptable in mill lengths of 6 to 24 feet (1.8 to 7.3 m) but not more than 25% of any shipment shall be supplied in lengths of 6 to 9 feet (1.8 to 2.7 m) except that for bars weighing over 25 pounds per foot (37 kg/m), short lengths down to 2 feet (610 mm) may be supplied.