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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

# AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 5701B

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Superseding AMS 5701A

## ALLOY BARS, FORGINGS, AND RINGS, CORROSION AND HEAT RESISTANT
## 41.5Ni - 16Cr - 37Fe - 2.9Cb - 1.8Ti
## Consumable Electrode or Vacuum Induction Melted
## 1800°F (980°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 Application: Primarily for parts requiring good machinability and high strength at room and cryogenic temperatures for short-time use up to 1000°F (540°C), particularly parts which are welded and then precipitation heat treated to develop required properties.

2. APPLICABLE DOCUMENTS: The following publication 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, Forging and Forging Stock
AMS 2375 - Control of Forgings Requiring First Article Approval

2.1.1 Aerospace Material Specifications (Cont'd):

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

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 Standards:

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, Ø 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 meet 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 1750° - 1850°F (955° - 1010°C), holding at the selected temperature within ±25°F (±15°C) for a time commensurate with cross-sectional thickness, and cooling at a rate equivalent to air cool or faster.

3.3.2 Forgings and Flash Welded Rings: Shall be heated to a temperature within the range 1750° - 1850°F (955° - 1010°C), held at the selected temperature within ±25°F (±15°C) for not less than 30 min., and cooled 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.

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

3.4.1 Bars, Forgings, and Flash Welded Rings:

3.4.1.1 As Solution 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 Precipitation Heat Treatment: The product shall have the following properties after being precipitation heat treated by heating to 1350°F ± 15 (735°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), 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 | 140,000 | 12 | 15 |
| 2.50 to 4.00, incl | 170,000 | 135,000 | 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 | 965 | 12 | 15 |
| 62.5 to 100.0, incl | 1170 | 930 | 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 303 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.

3.4.2 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 and 3.4.1.2.2. 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 and 3.4.1.2.2, 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 and 3.4.1.2.2.

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 properties (3.4.1.2.1) and hardness (3.4.1.2.2) 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 Test: 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 to be required.