

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 5671E

Issued 9-1-65
Revised 7-1-89

Superseding AMS 5671D

ALLOY BARS, FORGINGS, AND RINGS, CORROSION AND HEAT RESISTANT

72Ni - 15.5Cr - 0.95(Cb + Ta) - 2.5Ti - 0.70Al - 7.0Fe

Consumable Electrode or Vacuum Induction Melted

1800°F (982°C) Solution Heat Treated, Precipitation Hardenable

UNS N07750

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 and flash welded rings.

1.2 Application: Primarily for parts, such as flanges, cases, and turbine rotors, requiring high strength at temperatures in the range 800° - 1100°F (427° - 593°C), particularly those which are formed or welded and then 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 SAE publications 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.

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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
- AMS 2375 - Control of Forgings Requiring First-Article Approval
- AMS 2750 - Pyrometry
- 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

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

- ASTM E8 - Tension Testing of Metallic Materials
- ASTM E8M - Tension Testing of Metallic Materials (Metric)
- ASTM E10 - Brinell Hardness of Metallic Materials
- ASTM E354 - Chemical Analysis of High-Temperature, Electrical, Magnetic, and other Similar Iron, Nickel, and Cobalt Alloys

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, determined by wet chemical methods in accordance with ASTM E354, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	min	max
Carbon	--	0.08
Manganese	--	0.35
Silicon	--	0.35
Phosphorus (3.1.1)	--	0.015
Sulfur	--	0.010
Chromium	14.00 - 17.00	
Nickel + Cobalt	70.00	--
Columbium + Tantalum	0.70 - 1.20	
Titanium	2.25 - 2.75	
Aluminum	0.40 - 1.00	
Iron	5.00 - 9.00	
Cobalt (3.1.1)	--	1.00
Copper	--	0.50

- 3.1.1 Determination not required for routine acceptance.

- 3.1.2 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.

- 3.2.1.1 Bars shall be hot finished; round bars shall be ground or turned except that bars under 0.50 inch (12.7 mm) in nominal diameter, when so ordered, shall be cold drawn.

- 3.2.1.2 Forgings: Shall be descaled.

- 3.2.1.3 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. During manufacture of flash welded rings, the stock shall not be heated to a temperature higher than 1825°F (996°C).

- 3.2.2 Stock for Forgings and 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 by heating to 1800°F $\pm$ 25 (982°C $\pm$ 14), holding at heat for a time commensurate with cross-sectional thickness, and cooling at a rate equivalent to an air cool or faster. Pyrometry shall be in accordance with AMS 2750.

- 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 as follows; determined in accordance with ASTM E10:

3.4.1.1.1.1 Bars: Not higher than 320 HB, or equivalent, determined approximately midway between outer surface and center.

3.4.1.1.1.2 Forgings and Flash Welded Rings: Not higher than 320 HB, or equivalent.

3.4.1.2 After Precipitation Heat Treatment: The product shall have the following properties after being precipitation heat treated by heating to $1350^{\circ}\text{F} \pm 15$ ($732^{\circ}\text{C} \pm 8$), holding at heat for 8 hours ± 0.25 , cooling at a rate of $100^{\circ}\text{F} \pm 15$ ($56^{\circ}\text{C} \pm 8$) per hour to $1150^{\circ}\text{F} \pm 15$ ($621^{\circ}\text{C} \pm 8$), holding at $1150^{\circ}\text{F} \pm 15$ ($621^{\circ}\text{C} \pm 8$) for 8 hours ± 0.25 , and air cooling. Instead of the 100°F (56°C) per hour cooling rate to $1150^{\circ}\text{F} \pm 15$ ($621^{\circ}\text{C} \pm 8$), product may be furnace cooled at any rate provided the time at $1150^{\circ}\text{F} \pm 15$ ($621^{\circ}\text{C} \pm 8$) 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, Table II, and 3.4.1.2.1.3, determined in accordance with ASTM E8 or ASTM E8M.

3.4.1.2.1.1 Bars Under 2.50 Inches (63.5 mm) in Nominal Diameter or Thickness, Forgings Under 2.50 Inches (63.5 mm) in Nominal Thickness, and Flash Welded Rings Under 2.50 Inches (63.5 mm) in Nominal Radial Thickness:

TABLE I

Specimen Orientation	Tensile Strength psi minimum	Yield Strength at 0.2% Offset psi, minimum	Elongation in 4D %, minimum	Reduction of Area %, minimum
Longitudinal	170,000	115,000	18	18
Transverse	165,000	110,000	15	15

TABLE I (SI)

Specimen Orientation	Tensile Strength MPa minimum	Yield Strength at 0.2% Offset MPa, minimum	Elongation in 4D %, minimum	Reduction of Area %, minimum
Longitudinal	1172	793	18	18
Transverse	1138	758	15	15

- 3.4.1.2.1.2 Bars 2.50 to 4.00 Inches (63.5 to 101.6 mm), Excl, in Nominal Diameter or Thickness, Forgings 2.50 to 4.00 Inches (63.5 to 101.6 mm), Excl, in Nominal Thickness, and Flash Welded Rings 2.50 to 4.00 Inches (63.5 to 101.6 mm), Excl, in Nominal Radial Thickness:

TABLE II

Specimen Orientation	Tensile Strength psi minimum	Yield Strength at 0.2% Offset psi, minimum	Elongation in 4D %, minimum	Reduction of Area %, minimum
Longitudinal	170,000	115,000	15	15
Transverse	160,000	105,000	12	12

TABLE II (SI)

Specimen Orientation	Tensile Strength MPa minimum	Yield Strength at 0.2% Offset MPa, minimum	Elongation in 4D %, minimum	Reduction of Area %, minimum
Longitudinal	1172	793	15	15
Transverse	1103	724	12	12

- 3.4.1.2.1.3 Tensile property requirements for bars 4.00 inches (101.6 mm) and over in nominal diameter or thickness, forgings 4.00 inches (101.6 mm) and over in nominal thickness, and flash welded rings 4.00 inches (101.6 mm) and over in nominal radial thickness shall be as agreed upon by purchaser and vendor.
- 3.4.1.2.1.4 Longitudinal tensile property requirements of 3.4.1.2.1.1 and 3.4.1.2.1.2 apply to specimens taken with the axis approximately parallel to the grain flow, and to specimens taken in the radial direction and in the tangential direction at the rim of disc forgings. All other specimens shall be considered to be in the transverse direction.
- 3.4.1.2.1.5 Transverse tensile property requirements of 3.4.1.2.1.1 and 3.4.1.2.1.2 apply only to product from which tensile specimens not less than 2.50 inches (63.5 mm) long can be obtained.
- 3.4.1.2.1.6 Tensile tests in the longitudinal direction are not required from product tested in the transverse direction.
- 3.4.1.2.1.7 Specific locations of specimens shall be as agreed upon by purchaser and vendor.
- 3.4.1.2.2 Hardness: Should be 302 – 401 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 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 stock after heat treatment as in 3.3 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 acceptable 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 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 feet (1.8 - 7.3 m) but not more than 25% of any shipment shall be supplied in lengths of 6 - 9 feet (1.8 - 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.

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. 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) 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.
- 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 and/or processing requires reapproval as in 4.4, and when purchaser deems confirmatory testing to 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; a heat shall be the consumable electrode remelted ingots produced from alloy originally melted as a single furnace charge:
 - 4.3.1 Bars, Flash Welded Rings, and Stock for Flash Welded Rings: AMS 2371.
 - 4.3.2 Forgings and Forging Stock: AMS 2374.
- 4.4 Approval: When specified, approval and control of forgings shall be in accordance with AMS 2375.
- 4.5 Reports:
 - 4.5.1 The vendor of bars, forgings, and flash welded rings 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, lot number, AMS 5671E, 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.