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400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS-5664 REV C

Issued 1965-09-01
Revised 1990-10-01

Submitted for recognition as an American National Standard

Superseding AMS-5664B

ALLOY BARS, FORGINGS, AND RINGS, CORROSION AND HEAT RESISTANT 52.5Ni - 19Cr - 3.0Mo - 5.1(Cb+Ta) - 0.90Ti - 0.50Al - 19Fe Consumable Electrode or Vacuum Induction Melted 1950°F (1066°C) Solution Heat Treated, Precipitation Hardenable UNS N07718

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 rotating and structural parts, such as impellers, flanges, and fasteners, requiring high strength at cryogenic temperatures and for short-time service up to 1000°F (538°C) and oxidation resistance up to 1800°F (982°C).

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.

2.1.1 Aerospace Material Specifications:

AMS-2261 - Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars
MAM-2261 - Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt Alloy Bars
AMS-2269 - Chemical Check Analysis Limits, Wrought Nickel Alloys and Cobalt Alloys
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-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 19103-1187.

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 Average Grain Size
ASTM E 354 - Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

2.3 U.S. Government Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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 wet chemical methods in accordance with ASTM E 354, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	min	max
Carbon	--	0.08
Manganese	--	0.35
Silicon	--	0.35
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	17.00	21.00
Nickel	50.00	55.00
Molybdenum	2.80	3.30
Columbium + Tantalum	4.75	5.50
Titanium	0.65	1.15
Aluminum	0.20	0.80
Cobalt	--	1.00
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.

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

3.2.1.2 Forgings shall be rough machined or 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.

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 Ø heat treated to meet the requirements of 3.4.1. No specific heat treating instructions are specified but it is recommended that the product be solution heat treated by heating in a suitable protective atmosphere to 1950°F ± 25 (1066°C ± 14) but in no case lower than 1900°F (1038°C), holding at heat for a time commensurate with section thickness, and cooling at a rate equivalent to air cool or faster.

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 E 10:

3.4.1.1.1.1 Bars: Not higher than the following, determined approximately midway between the outer surface and center (mid-radius):

3.4.1.1.1.1.1 Up to 3.0 Inches (76 mm), Excl, in Nominal Diameter or Distance Between Parallel Sides: 248 HB, or equivalent.

3.4.1.1.1.1.2 3.0 to 5.0 Inches (76 to 127 mm), Excl, in Nominal Diameter or Distance Between Parallel Sides: 285 HB, or equivalent.

3.4.1.1.1.1.3 5.0 to 10.0 Inches (127 to 254 mm), Excl, in Nominal Diameter or Distance Between Parallel Sides: 321 HB, or equivalent.

3.4.1.1.1.1.4 10 Inches (254 mm) and Over in Nominal Diameter or Distance Between Parallel Sides: As agreed upon by purchaser and vendor.

3.4.1.1.1.2 Forgings and Flash Welded Rings: Not higher than 248 HB, or equivalent.

3.4.1.1.2 Grain Size: Shall be as follows, determined in accordance with ASTM E 112 and the following:

3.4.1.1.2.1 Determination shall be made at 1 to 3X magnification on the rough-machined surface of the forging after suitably etching to reveal the macro-grain structure. Acceptance shall be based on correlation of the macro-grain structure with the micro-grain structure that will satisfy the requirements of 3.4.1.1.2.2 or 3.4.1.1.2.3 as applicable.

3.4.1.1.2.2 Bars and Hammer Forgings: Structure shall consist of recrystallized grains of ASTM 4 or finer for product under 4.5 inches (114 mm) in nominal thickness. Occasional grains as large as ASTM 2 are permissible but shall not exceed 10% of any field examined at 100X magnification. Structure for product 4.5 inches (114 mm) and over in nominal thickness shall be as agreed upon by purchaser and vendor.

3.4.1.1.2.3 Extrusions and Press Forgings: Structure shall consist of partially recrystallized grains consisting of 60% or more of ASTM 3 or finer and 40% or less of grains ASTM 1 or finer. A uniform structure of ASTM 3 or finer recrystallized grains shall be acceptable.

3.4.1.2 After Precipitation Heat Treatment: The product shall have the following properties after being precipitation heat treated by heating to 1400°F ± 15 (760°C ± 8), holding at heat for 10 hours ± 0.5, furnace cooling to 1200°F ± 15 (649°C ± 8), holding at 1200°F ± 15 (649°C ± 8) until a total precipitation heat treatment time of 20 hours has been reached, and cooled. The product shall also meet the following requirements after being re-solution heat treated by heating to 1950°F ± 25 (1066°C ± 14) in a suitable protective atmosphere, holding at heat for 1 - 2 hours, and cooling at a rate equivalent to an air cool or faster and then precipitation heat treated as above.

3.4.1.2.1 Tensile Properties: Product 10 inches (254 mm) and under in least nominal cross-sectional dimension shall have properties as specified in 3.4.1.2.1.1 and 3.4.1.2.1.2, determined in accordance with ASTM E 8 or ASTM E 8M; tensile property requirements for product over 10 inches (254 mm) in least nominal cross-sectional dimension shall be as agreed upon by purchaser and vendor.

3.4.1.2.1.1 Bars:

Tensile Strength, minimum	180,000 psi (1241 MPa)
Yield Strength at 0.2% Offset, minimum	150,000 psi (1034 MPa)
Elongation in 4D, minimum	10%
Reduction of Area, minimum	12%

3.4.1.2.1.2 Forgings and Flash Welded Rings:

Tensile Strength, minimum	180,000 psi (1241 MPa)
Yield Strength at 0.2% Offset, minimum	150,000 psi (1034 MPa)
Elongation in 4D, minimum	12%
Reduction of Area, minimum	15%

3.4.1.2.2 Hardness: Should be not lower than 341 HB, or equivalent, determined in accordance with ASTM E 10, but the product shall not be rejected on the basis of hardness if the tensile property requirements of 3.4.1.2.1.1 and 3.4.1.2.1.2 are met.

3.4.2 Forging Stock: When a sample of stock is forged to a test coupon and solution and precipitation heat treated as in 3.3 and 3.4.1.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.1.2.1.2 and 3.4.1.2.2. If specimens taken from the stock after heat treatment as in 3.3 and 3.4.1.2 conform to the requirements of 3.4.1.2.1.2 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 solution and precipitation heat treatment as in 3.3 and 3.4.1.2 shall conform to the requirements of 3.4.1.2.1.2 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.

3.5.3 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. Ø

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. 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. Ø

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 (3.4.1.1.1) 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.

4.2.2 Periodic Tests: Tests for the following requirements are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser:

4.2.2.1 Tensile properties (3.4.1.2.1) and hardness (3.4.1.2.2) of bars, forgings, and flash welded rings after re-solution and precipitation heat treatment as in 3.4.1.2.

4.2.2.2 Ability of forging stock (3.4.2) or stock for flash welded rings (3.4.3) to develop required properties.

4.3 Sampling and Testing: Shall be in accordance with the following; when Ø consumable electrode remelted alloy is supplied, 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 and the following:

4.3.1.1 Specimens for tensile tests of bars (3.4.1.2.1.1) shall be taken with the axis in the short-transverse direction except that if the short-transverse direction is under 2-1/2 inches (63.5 mm), specimens shall be taken in the long-transverse direction. If both transverse directions are under 2-1/2 inches (63.5 mm), specimens shall be taken with the axis in the longitudinal direction.

4.3.1.2 Specimens for tensile testing of flash welded rings (3.4.1.2.1.2) shall be taken with the axis of the specimen in the circumferential direction.

4.3.2 Forgings and Forging Stock: AMS-2374 and the following:

4.3.2.1 Except as specified in 4.3.2.2, specimens for tensile testing of forgings (3.4.1.2.1.2) shall be taken with the axis in the transverse direction except that if the forging is under 2-1/2 inches (63.5 mm) in the transverse direction, specimens shall be taken with the axis in the longitudinal direction.

4.3.2.2 Specimens for tensile tests of disc forgings shall be cut from any plane perpendicular to the axis of the forging with axis of specimen in the selected plane perpendicular to a radius. When size and shape permit, additional specimens shall be cut with the axis of specimen approximately parallel to the axis of the forging. Size, location, and number of specimens shall be as agreed upon by purchaser and vendor.

4.4 Reports:

4.4.1 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 tests requirements and, when performed, the periodic test requirements. This report shall include the purchase order number, lot number, AMS-5664C, 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.