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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5664E

Issued SEP 1965
Revised JAN 2001
Reaffirmed APR 2006

Superseding AMS 5664D

Nickel Alloy, Corrosion and Heat Resistant, Bars, Forgings, and Rings
52.5Ni - 19Cr - 3.0Mo - 5.1Cb - 0.90Ti - 0.50Al - 18Fe
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:

These products have been used typically for rotating and structural parts 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), but usage is not limited to such applications.

2. APPLICABLE DOCUMENTS:

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been canceled and no superseding document has been specified, the last published issue of that document shall apply.

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 Resistant Steels and Alloys, Wrought Products and Forging Stock

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 2374	Quality Assurance Sampling and Testing, Corrosion and Heat Resistant Steel and Alloy Forgings
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, Austenitic-Type Iron, Nickel, or Cobalt Alloys, or Precipitation Hardenable Alloys

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

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 354	Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 354, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	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	4.75	5.50
Titanium	0.65	1.15
Aluminum	0.20	0.80
Cobalt	--	1.00
Tantalum (3.1.1)	--	0.05
Boron	--	0.006
Copper	--	0.30
Iron	remainder	

3.1.1 Determination of tantalum content not required for routine acceptance.

3.1.2 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2269.

3.2 Melting Practice:

Alloy shall be multiple melted 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 for remelting.

3.3 Condition:

The product shall be supplied in the following condition:

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

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

3.3.1.2 Forgings shall be rough machined or descaled.

3.3.1.3 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.

3.3.2 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 to meet the requirements of 3.5.1. 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 cross-sectional thickness, and cooling at a rate equivalent to an air cool or faster.

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 as follows; determined in accordance with ASTM E 10 (See 8.2):

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

3.5.1.1.1.1.1 Up to 3.0 Inches (76 mm), Exclusive, in Nominal Diameter or Least Distance Between Parallel Sides: Shall be 248 HB, or equivalent.

3.5.1.1.1.1.2 3.0 to 5.0 Inches (76 to 127 mm), Exclusive, in Nominal Diameter or Least Distance Between Parallel Sides: Shall be 285 HB, or equivalent.

3.5.1.1.1.1.3 5.0 to 10.0 Inches (127 to 254 mm), Exclusive, in Nominal Diameter or Least Distance Between Parallel Sides: Shall be 321 HB, or equivalent.

3.5.1.1.1.1.4 10 Inches (254 mm) and Over in Nominal Diameter or Least Distance Between Parallel Sides: As agreed upon by purchaser and vendor.

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

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

3.5.1.1.2.1 Determination shall be made at 1 to 3X magnification on the rough-machined surface of the product 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 3.5.1.1.2.2 or 3.5.1.1.2.3 as applicable.

3.5.1.1.2.2 Bars, Hammer Forgings, and Flash Welded Rings: Structure shall consist of recrystallized grains of ASTM No. 4 or finer for product under 4.5 inches (114 mm) in nominal thickness. Occasional grains as coarse as ASTM No. 2 are permissible but shall not exceed 10% of any field examined at 100X magnification.

3.5.1.1.2.3 Extrusions and Press Forgings: Structure shall consist of partially recrystallized grains consisting of 60% or more of ASTM No. 3 or finer and 40% or less of grains ASTM No. 1 or finer. A uniform structure of ASTM No. 3 or finer recrystallized grains is acceptable.

3.5.1.2 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 to 2 hours, and cooling at a rate equivalent to an air cool or faster and then precipitation heat treated as previously stated.

3.5.1.2.1 Tensile Properties: Product 10 inches (254 mm) and under in least nominal cross-sectional dimension shall have the properties shown in Table 2 and Table 3, determined in accordance with ASTM E 8 or ASTM E 8M.

3.5.1.2.1.1 Bars: Shall be as shown in Table 2.

TABLE 2 - Minimum Tensile Properties

Property	Value
Tensile Strength	180.0 ksi (1241 MPa)
Yield Strength at 0.2% Offset	150.0 ksi (1034 MPa)
Elongation in 4D	10%
Reduction of Area	12%

3.5.1.2.1.2 Forgings and Flash Welded Rings: Shall be as shown in Table 3.

TABLE 3 - Minimum Tensile Properties

Property	Value
Tensile Strength	180.0 ksi (1241 MPa)
Yield Strength at 0.2% Offset	150.0 ksi (1034 MPa)
Elongation in 4D	12%
Reduction of Area	15%

3.5.1.2.2 Hardness: Shall be not lower than 341 HB, or equivalent (See 8.2), determined in accordance with ASTM E 10. The product shall not be rejected on the basis of hardness if the tensile properties determined on specimens taken from the same sample as that with nonconforming hardness, or another sample with similar nonconforming hardness, are acceptable.

3.5.2 Forging Stock: When a sample of stock is forged to a test coupon and solution and precipitation heat treated as in 3.4 and 3.5.1.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.1.2.1.2 and 3.5.1.2.2. If specimens taken from the stock after heat treatment as in 3.4 and 3.5.1.2 conform to the requirements of 3.5.1.2.1.2 and 3.5.1.2.2, 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 solution and precipitation heat treatment as in 3.4 and 3.5.1.2 shall conform to the requirements of 3.5.1.2.1.2 and 3.5.1.2.2.

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 the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: 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, except for tantalum (See 3.1.1).

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 properties (3.5.1.2.1) and hardness (3.5.1.2.2) 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: 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 (3.5.1.2.1) and hardness (3.5.1.2.2) of bars, forgings, and flash welded rings after re-solution and precipitation heat treatment as in 3.5.1.2.

4.2.2.2 Forging stock (3.5.2) or stock for flash welded rings (3.5.3) to develop required properties.

4.2.2.3 Grain flow (3.6.1) of die forgings.

4.3 Sampling and Testing:

Shall be as follows:

4.3.1 Bars, Flash Welded Rings, and Stock for Forgings or Flash Welded Rings: In accordance with AMS 2371 and the following:

4.3.1.1 Specimens for tensile tests of bars (3.5.1.2.1.1) 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 (3.5.1.2.1.2) shall be taken with the axis of the specimen in the circumferential direction.

4.3.2 Forgings: In accordance with AMS 2374 and the following:

4.3.2.1 Specimens for tensile testing of forgings (3.5.1.2.1.2) 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.

4.3.2.1.1 Specimens for tensile tests of disk 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 agreed upon by purchaser and vendor.