AEROSPACE MATERIAL SPECIFICATION

AMS5664™	REV. G

Issued 1965-09
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Revised 2022-08

Superseding AMS5664F

Nickel Alloy, Corrosion- and Heat-Resistant, Bars, Forgings, Extrusions, Rings, and Stock for Forgings and Rings
52.5Ni - 19Cr - 3.0Mo - 5.1Cb (Nb) - 0.90Ti - 0.50Al - 18Fe
Consumable Electrode or Vacuum Induction Melted
1950 °F (1066 °C) Solution Heat Treated, Precipitation Hardenable
(Composition Similar to UNS N07718)

RATIONALE

AMS5664G is the result of a Five-Year Review and update of the specification. The revision prohibits unauthorized exceptions (3.5.1.2.1.4, (removing) 3.5.1.1.1.1.4, 3.9, 4.4.1.1, 4.4.3, 5.2.1.1, 8.5), updates title to match the scope, updates the description of size and size limits (1.1, 3.5.1.1.1.1, 3.5.1.2.1), revises composition requirement and reporting (3.1, 3.1.1) adds cold finished bars and associated requirements (3.3.1), updates information for extrusions (3.3.2, 8.6), provides for consistent heat treatment requirements between similar specs (3.4), adds strain rate control during testing (3.5.1.2.1.3), adds forging stock options (4.4.2), and allows prior revisions (8.4).

1. SCOPE

1.1 Form

This specification covers a corrosion- and heat-resistant nickel alloy in the form of bars, forgings, flash welded rings in the solution heat treated condition, Product covered by this specification is limited to 10.00 inches (254 mm) and under in nominal diameter or maximum cross-sectional dimension between parallel sides (thickness) and 78.54 square inches (503 cm^2) in cross-sectional area. Stock may be of any size 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 cancelled and no superseding document has been specified, the last published issue of that document shall apply.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS5664G/

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2261 Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars, Rods, and Wire

AMS2269 Chemical Check Analysis Limits, Nickel, Nickel Alloys, and Cobalt Alloys

AMS2371 Quality Assurance Sampling and Testing, Corrosion- and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock

AMS2374 Quality Assurance Sampling and Testing, Corrosion- and Heat-Resistant Steel and Alloy, Forgings

AMS2750 Pyrometry

AMS2806 Identification, Bars, Wire, Mechanical Tubing, and Extrusions Carbon and Alloy Steels and Corrosion- and Heat-Resistant Steels and Alloys

AMS2808 Identification, Forgings

AMS7490 Rings, Flash Welded Corrosion- and Heat-Resistant Austenitic Steels, Austenitic-Type Iron, Nickel, or Cobalt Alloys, or Precipitation-Hardenable Alloys

AS6279 Standard Practices for Production, Distribution, and Procurement of Metal Stock

AS7766 Terms Used in Aerospace Metals Specifications

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E8/E8M Tension Testing of Metallic Materials

ASTM E10 Brinell Hardness of Metallic Materials

ASTM E112 Determining the Average Grain Size

ASTM E140 Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

ASTM E354 Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

2.3 Definitions

Terms used in AMS are defined in AS7766.

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined in accordance with ASTM E354, 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 (Niobium)	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 Producer may test for any element not listed in Table 1 and include this analysis in the report of 4.4. Reporting of any element not listed in the composition table is not a basis for rejection, unless limits of acceptability are specified by the purchaser.

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS2269.

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 and descaled, except as specified below.

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

3.3.1.2 Bars, other than hexagons, over 2.75 inches (69.8 mm) in nominal diameter or thickness shall be hot finished or cold finished.

3.3.1.3 Bars shall not be cut from plate (also see 4.4.1.1).

3.3.1.4 Forgings shall be rough machined or descaled.

3.3.1.5 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 AMS7490.

3.3.2 Extrusions and Stock for Forging or Flash Welded Rings

As ordered.

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 to 1950 °F (1066 °C) (but in no case lower than 1900 °F (1038 °C)), holding at the selected temperature within ±25 °F (±14 °C) 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 AMS2750.

3.4.1 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.

3.5 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 E10 (see 8.2):

3.5.1.1.1.1 Bars

Not higher than the hardness value specified below, 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 Thickness

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 Thickness

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 Thickness

Shall be 321 HB, or equivalent.

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 E112 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 Response to Heat Treatment

Samples from product shall have the following properties after being precipitation heat treated by heating to 1400 °F ± 15 °F (760 °C ± 8 °C), holding at heat for 10 hours ± 0.5 hour, furnace cooling to 1200 °F ± 15 °F (649 °C ± 8 °C), holding at 1200 °F ± 15 °F (649 °C ± 8 °C) until a total precipitation heat treatment time of 20 hours has been reached, and cooled. The samples shall also meet the following requirements after being re-solution heat treated by heating to 1950 °F ± 25 °F (1066 °C ± 14 °C) 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 nominal diameter or thickness (see 1.1) shall have the properties shown in Tables 2 and 3, determined in accordance with ASTM E8/E8M.

3.5.1.2.1.1 Bars shall be as shown in Table 2.

Table 2 - Minimum tensile properties

Property	Value
Tensile Strength	180 ksi (1241 MPa)
Yield Strength at 0.2% Offset	150 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 ksi (1241 MPa)
Yield Strength at 0.2% Offset	150 ksi (1034 MPa)
Elongation in 4D	12%
Reduction of Area	15%

3.5.1.2.1.3 Unless otherwise specified, the strain rate for tensile tests, shall be set at 0.005 in/in/min (0.005 mm/mm/min) and maintained within a tolerance of ±0.002 in/in/min (0.002 mm/mm/min) through 0.2% offset yield strain. After the yield strain, the speed of the testing machine shall be set between 0.05 and 0.5 in/in (0.05 and 0.5 mm/mm) of the length of the reduced section (or distance between the grips for specimens not having a reduced section) per minute. Alternatively, an extensometer and strain rate indicator may be used to set the strain rate between 0.05 and 0.5 in/in/min (0.05 and 0.5 mm/mm/min). The requirement for compliance becomes effective for material produced 1 year after the publication date of this specification.

3.5.1.2.1.4 Mechanical properties for product outside the range covered by 1.1 shall be agreed upon between purchaser and producer and reported as in 4.4.3.

3.5.1.2.2 Hardness

Shall be not lower than 341 HB, or equivalent (see 8.2), determined in accordance with ASTM E10. 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 AMS2261.

3.8 Production, distribution, and procurement of metal stock shall comply with AS6279.

3.9 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.3.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for producer'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.

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 producer 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

4.3.1 Bars, Flash Welded Rings, and Stock for Forgings or Flash Welded Rings

In accordance with AMS2371 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 AMS2374 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 producer.

4.4 Reports

4.4.1 The producer of the product shall furnish with each shipment a report showing the producer's name and the country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations), and the results of tests for composition of each heat and for condition, tensile properties, hardness response, and average grain size of each lot, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS5664G, product form, size and quantity. If forgings are supplied, the size and melt source of stock used to make the forgings shall also be included.

4.4.1.1 Report the nominal metallurgically worked size and cut size, if different (see 3.3.1.3).

4.4.2 The producer of stock for forging or flash welded rings shall furnish with each shipment a report showing the producer's name and the country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations), the results of tests for the composition of each heat and the any additional property requirements imposed by 8.6. This report shall include the purchase order number, heat and lot number, AMS5664G, size, and quantity.