AEROSPACE MATERIAL SPECIFICATION

AMS5661™	REV. H

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Superseding AMS5661G

Nickel-Iron Alloy, Corrosion- and Heat-Resistant, Bars, Forgings, Rings and Stock for Forging or Flash-Welded Rings
42.5Ni - 12.5Cr - 5.8Mo - 2.9Ti - 0.015B - 35Fe (Alloy 901)
Consumable Electrode Remelted or Vacuum Induction Melted
Solution Heat Treated, Stabilized, and Precipitation Heat Treated
(Composition similar to UNS N09901)

RATIONALE

AMS5661H is the result of a Five-Year Review and update of the specification. The revision updates the Title to match the Scope, clarifies and updates the size exception requirements (see 1.1 and 8.5), updates composition testing and reporting (see 3.1 and 3.1.2), introduces standard conditions for bars (see 3.3.1.1), prohibits bar from plate (see 3.3.1.2 and 4.2), clarifies transverse testing requirements (see 3.5.1.2), adds strain rate control (see 3.5.1.2.6), provides for additional forging stock properties (see 4.3 and 8.7), and provides for heat-treat cycle interruptions (see 3.4.2, 3.4.3, and 8.6).

1. SCOPE

1.1 Form

This specification covers a corrosion- and heat-resistant nickel-iron alloy in the form of bars, forgings, and flash-welded rings 5.0 inches (127 mm) and under in nominal diameter, or maximum cross-sectional distance between parallel sides (thickness), and stock of any size for forging or flash-welded rings.

1.2 Application

These products have been used typically for parts, such as turbine discs, shafts, and blades, requiring higher strength than AMS5660 up to 1400 °F (760 °C) and oxidation resistance up to 1600 °F (871 °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/AMS5661H/

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

AMS2283 Composition Testing Methods for Nickel- and Cobalt-Based 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

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 Average Grain Size

ASTM E139 Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

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

ASTM E292 Conducting Time-for-Rupture Notch Tension Tests of Materials

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, in accordance with AMS2283 or by other analytical methods acceptable to the purchaser.

Table 1 - Composition

Element	Min	Max
Carbon	--	0.10
Manganese	--	0.50
Silicon	--	0.40
Phosphorus (see 3.1.1)	--	0.030
Sulfur	--	0.030
Chromium	11.00	14.00
Nickel	40.00	45.00
Molybdenum	5.00	6.50
Titanium	2.70	3.10
Boron	0.010	0.020
Cobalt (see 3.1.1)	--	1.00
Aluminum	--	0.35
Copper	--	0.50
Lead	--	0.0005 (5.0 ppm)
Bismuth	--	0.00003 (0.3 ppm)
Selenium	--	0.0003 (3.0 ppm)
Iron	remainder	

3.1.1 Determination not required for routine acceptance.

3.1.2 The 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.

3.1.3 Check Analysis

Composition variations shall meet the applicable requirements of AMS2269; no variation over maximum is permitted for lead, bismuth, and selenium.

3.2 Melting Practice

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 that have been produced by vacuum induction melting shall be used.

3.3 Condition

The product shall be supplied in the following condition:

3.3.1 Bars

Bars shall be hot finished and solution heat treated, stabilized, and precipitation heat treated. Rounds shall be rough turned or ground.

3.3.1.1 Bars, other than hexagons, over 2.75 inches (69.8 mm) in nominal diameter or least distance between parallel sides shall be hot finished or cold finished.

3.3.1.2 Bar shall not be cut from plate (see 4.4.2).

3.3.2 Forgings and Flash-Welded Rings

Forgings and flash-welded rings shall be solution heat treated, stabilized, and precipitation heat treated.

3.3.2.1 Flash-welded rings shall not be supplied unless specified or permitted on the purchaser's part drawing. When supplied, rings shall be manufactured in accordance with AMS7490.

3.3.3 Stock for Forging or Flash-Welded Rings

Stock shall be as ordered by the forging or flash-welded ring manufacturer.

3.4 Heat Treatment

Bars, forgings, and flash-welded rings shall be heat treated as follows; pyrometry shall be in accordance with AMS2750.

3.4.1 Solution Heat Treatment

Heat to a temperature within the range 1950 to 2000 °F (1066 to 1093 °C), hold at the selected temperature within ±25 °F (±14 °C) for not less than 1 hour, and cool at a rate equivalent to an air cool or faster.

3.4.2 Stabilization Heat Treatment

Heat to a temperature within the range 1425 to 1475 °F (774 to 802 °C), hold at the selected temperature within ±15 °F (±8 °C) for 2 to 4 hours, and cool at a rate equivalent to an air cool or faster (see 8.6).

3.4.3 Precipitation Heat Treatment

Heat to a temperature within the range 1300 to 1375 °F (704 to 746 °C), hold at the selected temperature within ±15 °F (±8 °C) for 24 hours ± 1 hour, and cool at any convenient rate (see 8.6).

3.5 Properties

3.5.1 Bars, Forgings, and Flash-Welded Rings

Product 5.0 inches (127 mm) and under in nominal diameter or least distance between parallel sides shall meet the requirements of 3.5.1.1, 3.5.1.2, 3.5.1.3, and 3.5.1.4.

3.5.1.1 Average Grain Size

Average grain size shall be ASTM 1 or finer, determined in accordance with ASTM E112; grain size shall be substantially uniform without pronounced segregation of fine and coarse grain areas and shall conform to standards agreed upon by the purchaser and producer.

3.5.1.2 Tensile Properties

Tensile properties shall be as shown in Table 2, determined in accordance with ASTM E8/E8M; requirements apply in both the longitudinal and transverse direction.

Table 2 - Minimum tensile properties

Property	Value
Tensile Strength	165 ksi (1138 MPa)
Yield Strength at 0.2% Offset	120 ksi (827 MPa)
Elongation in 4D	12%
Reduction of Area	15%

3.5.1.2.1 Tensile properties shall be taken in the short transverse direction, except as noted below.

3.5.1.2.2 If the product cross section does not allow a 2-1/2-inch (63.5-mm) long specimen to be taken in the short transverse direction, then tensile properties shall be determined in the long transverse direction.

3.5.1.2.3 If the product cross section does not allow a 2-1/2-inch (63.5-mm) long specimen to be taken in the short or the long transverse direction, then tensile properties shall be determined in the longitudinal direction.

3.5.1.2.4 Products tested in the transverse direction need not be tested in the longitudinal direction.

3.5.1.2.5 When tensile specimens are machined from the center area of disc and hub forgings and this area lies within a 4-inch (102-mm) radius or 25% of the forging radius, whichever is the smaller dimension, elongation may be as low as 10% and reduction of area as low as 12%.

3.5.1.2.6 Unless otherwise specified, the strain rate 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 in/in and 0.5 in/in (0.05 mm/mm and 0.5 mm/mm) of the length of the reduced parallel 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 in/in/min and 0.5 in/in/min (0.05 mm/mm/min and 0.5 mm/mm/min). The requirement for compliance becomes effective for material produced 1 year after the publication date of this specification.

3.5.1.3 Hardness

Hardness shall be 302 to 388 HBW 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 of 3.5.1.2 are acceptable, determined on specimens taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness.

3.5.1.4 Stress-Rupture Properties at 1200 °F (649 °C)

Stress-rupture properties at 1200 °F (649 °C) shall be as follows. Testing of notched specimens and of combination smooth-and-notched specimens shall be performed in accordance with ASTM E292 and of smooth specimens in accordance with ASTM E139.

3.5.1.4.1 A standard cylindrical combination smooth-and-notched specimen conforming to ASTM E292, maintained at 1200 °F ± 3 °F (649 °C ± 2°C) while a load sufficient to produce an initial axial stress of 90.0 ksi (621 MPa) or higher is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. After the 23 hours, if rupture occurs in the notch, the smooth section shall, by suitable means, be continued to rupture, or a separate smooth specimen shall be tested to rupture. Elongation of the smooth section after rupture, measured at room temperature, shall be not less than 5% in 4D if the specimen ruptures in 48 hours or less and not less than 4% in 4D if the specimen ruptures in more than 48 hours.

3.5.1.4.2 As an alternate procedure, separate smooth-and-notched specimens, machined from adjacent sections of the same piece, with gage sections conforming to the respective dimensions shown in ASTM E292, may be tested individually under the conditions of 3.5.1.4.1. The smooth specimen shall not rupture in less than 23 hours, and elongation after rupture, measured at room temperature, shall be not less than 5% in 4D. The notched specimen shall not rupture in less than 23 hours but need not be tested to rupture.

3.5.1.4.3 The tests of 3.5.1.4.1 and 3.5.1.4.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 90.0 ksi (621 MPa) or higher shall be used to rupture or for 48 hours, whichever occurs first. After the 48 hours and at intervals of 8 hours minimum, preferably 8 to 10 hours thereafter, the stress shall be increased in increments of 5.0 ksi (34.5 MPa). Time to rupture and elongation requirements shall be as specified in 3.5.1.4.1.

3.5.1.5 Mechanical property requirements for product outside the range covered by 1.1 shall be agreed upon between the purchaser and producer.

3.5.2 Forging Stock

When a sample of stock is forged to a test coupon and heat treated as in 3.4, specimens taken from the heat-treated coupon shall conform to the requirements of 3.5.1.2, 3.5.1.3, and 3.5.1.4. If specimens taken from the stock after heat treatment as in 3.4 conform to the requirements of 3.5.1.2, 3.5.1.3, and 3.5.1.4, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.3 Stock for Flash-Welded Rings

A sample of stock heat treated as in 3.4 shall conform to the requirements of 3.5.1.2, 3.5.1.3, and 3.5.1.4.

3.6 Quality

The product, as received by the 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 that contain flash-line end grain, shall follow the general contour of the forgings, showing no evidence of reentrant grain flow.

3.7 Tolerances

Bars shall conform to all applicable requirements of AMS2261.

3.8 Any exceptions shall be authorized by the purchaser and reported as in 4.4.1.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for the producer's tests and shall be responsible for the performance of all required tests. The 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:

a. Composition (see 3.1) of each heat.

b. Average grain size (see 3.5.1.1), tensile properties (see 3.5.1.2), hardness (see 3.5.1.3), and stress-rupture properties (see 3.5.1.4) of each lot of bars, forgings, and flash-welded rings.

c. Tolerances (see 3.7) of bars.

4.2.2 Periodic Tests

Forging stock (see 3.5.2) and stock for flash-welded rings (see 3.5.3) to demonstrate ability to develop required properties and of grain flow of die forgings (see 3.6.1) are periodic tests and shall be performed at a frequency selected by the producer, unless frequency of testing is specified by the purchaser.

4.3 Sampling and Testing

4.3.1 Bars, Flash-Welded Rings, and Stock for Forging or Flash-Welded Rings

Sampling and testing shall be in accordance with AMS2371.