SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS5661 | REV. F

Issued 1964-01
Revised 2005-08
Reaffirmed 2012-02

Superseding AMS5661E

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

RATIONALE

AMS5661F has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE:

1.1 Form:

This specification covers a corrosion and heat-resistant nickel-iron 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 parts, such as turbine discs, shafts, and blades, requiring higher strength than AMS 5660 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.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2261	Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars, Rods, and Wire
AMS 2269	Chemical Check Analysis Limits, Nickel, Nickel Alloys, and Cobalt Alloys
AMS 2371	Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS 2374	Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steel and Alloy Forgings

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

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS5661F

2.1 (Continued):

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, Austenitic-Type Irons, Nickel, or Cobalt Alloys, or Precipitation-Hardenable Alloys
ARP1313	Determination of Trace Elements in High Temperature Alloys

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 or www.astm.org.

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 139	Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E 292	Conducting Time-for-Rupture Notch Tension Tests of Materials
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, by the methods of ARP1313 for lead, bismuth, and selenium, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	min	max	
Carbon	--	0.10	
Manganese	--	0.50	
Silicon	--	0.40	
Phosphorus (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 (3.1.1)	--	1.00	
Aluminum	--	0.35	
Copper	--	0.50	
Lead	--	0.0005	(5 ppm)
Bismuth	--	0.00003	(0.3 ppm)
Selenium	--	0.0003	(3 ppm)
Iron	remainder		

3.1.1 Determination not required for routine acceptance.

3.1.2 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2269; 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 which 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: Hot finished and solution, stabilization, and precipitation heat treated. Rounds shall be rough turned or ground.

3.3.2 Forgings and Flash Welded Rings: Solution, stabilization, and precipitation heat treated.

3.3.2.1 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.

3.3.3 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 heat treated as follows; pyrometry shall be in accordance with AMS 2750:

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.

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, and cool at any convenient rate.

3.5 Properties:

The product shall conform to the following requirements:

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: Shall be ASTM No. 1 or finer, determined in accordance with ASTM E 112; grain size shall be substantially uniform without pronounced segregation of fine and coarse grain areas and shall conform to standards agreed upon by purchaser and vendor.

3.5.1.2 Tensile Properties: Shall be as shown in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M; requirements apply in both the longitudinal and transverse direction but tests in the transverse direction need be made only on product from which a specimen not less than 2.50 inches (63.5 mm) in length can be obtained. Tests in the longitudinal direction are not required on product tested in the 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 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%.

3.5.1.3 Hardness: Shall be 302 to 388 HB, or equivalent (See 8.2) determined in accordance with ASTM E 10. 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): Shall be as follows; testing of notched specimens and of combination smooth-and-notched specimens shall be performed in accordance with ASTM E 292 and of smooth specimens in accordance with ASTM E 139:

3.5.1.4.1 A standard cylindrical combination smooth-and-notched specimen conforming to ASTM E 292, maintained at 1200 °F ± 3 (649 °C ± 2) 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 E 292, 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.

3.5.2 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 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 reentrant grain flow.

3.7 Tolerances:

Bars shall conform to all applicable requirements of AMS 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.

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

4.2.1.3 Tolerances (3.7) of bars.

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

4.3 Sampling and Testing:

Shall be as follows:

4.3.1 Bars, Flash Welded Rings, and Stock for Forging or Flash Welded Rings: In accordance with AMS 2371.

4.3.2 Forgings: In accordance with AMS 2374.