AEROSPACE MATERIAL SPECIFICATION

AMS5701™	REV. F

Issued 1971-11
Reaffirmed 2000-09
Revised 2022-03

Superseding AMS5701E

Nickel Alloy, Corrosion- and Heat-Resistant, Bars, Forgings, Flash Welded Rings and Forging Stock
41.5Ni - 16Cr - 37Fe - 2.9Cb (Nb) - 1.8Ti
Consumable Electrode Remelted or Vacuum Induction Melted
1800 °F (982 °C) Solution Heat Treated
(Composition similar to UNS N09706)

RATIONALE

AMS5701F is the result of a Five-Year Review and update of the specification. The revision updates the title to match the scope, prohibits unauthorized exceptions (1.1, 3.6, 3.9, 4.4.2, 4.4.4, 5.2.1.1, 8.6), updates composition (3.1), standardizes bar condition (3.3.1.1), allows grain size option (3.5.1.1.2.3), updates heat treatment to table format (3.5.1.2), adds strain rate control (3.5.1.2.1.1), combines forging stock for flash welded rings with forging stock (title, 3.5.2, 4.2.2), adds option to prescribe forging stock properties (4.4.3, 8.7), updates definitions (8.3), and allows prior revisions (8.5).

1. SCOPE

1.1 Form

This specification covers a corrosion- and heat-resistant nickel alloy in the form of bars, forgings, flash welded rings up to 4.00 inches (101.6 mm), inclusive, and stock for forging or flash welded rings of any size.

1.2 Application

These products have been used typically for parts requiring good machinability and high strength at room and cryogenic temperatures for short-time use up to 1000 °F (538 °C), particularly parts which are welded and then precipitation heat treated to develop required properties, 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/AMS5701F/

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

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 A751 Methods, Practices, and Definitions for Chemical Analysis of Steel Products

ASTM E8/E8M Tension Testing of Metallic Materials

ASTM E10 Brinell Hardness of Metallic Materials

ASTM E112 Determining Average Grain Size

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 E354 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 in accordance with ASTM E354, or by other analytical methods acceptable to purchaser.

Table 1 - Composition

Element	Min	Max
Carbon	--	0.06
Manganese	--	0.35
Silicon	--	0.35
Phosphorus	--	0.020
Sulfur	--	0.015
Chromium	14.50	17.50
Nickel	39.00	44.00
Columbium (Niobium)	2.50	3.30
Titanium	1.50	2.00
Tantalum	--	0.05
Aluminum	--	0.40
Boron	--	0.006
Copper	--	0.30
Iron	remainder	

3.1.1 Check Analysis

Composition variations shall meet the applicable requirements of AMS2269.

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, Forgings, and Flash Welded Rings

Solution heat treated and descaled.

3.3.1.1 Bars shall be hot finished.

3.3.1.1.1 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.

3.3.1.1.2 Round bars shall be turned or ground.

3.3.1.2 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.

3.3.1.3 Bars shall not be cut from plate (see also 4.4.2).

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 as follows. Pyrometry shall be in accordance with AMS2750.

3.4.1 Bars

Shall be solution heat treated by heating to a temperature within the range 1750 to 1850 °F (954 to 1010 °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.

3.4.2 Forgings and Flash Welded Rings

Shall be heated to a temperature within the range 1750 to 1850 °F (954 to 1010 °C), held at the selected temperature within ±25 °F (±14 °C) for not less than 30 minutes, and cooled at a rate equivalent to an air cool or faster. 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 Treated

3.5.1.1.1 Hardness

Shall be not higher than 277 HB, or equivalent (see 8.2), determined in accordance with ASTM E10.

3.5.1.1.2 Average Grain Size

Shall be as follows, determined by comparison of a polished and etched specimen with the chart in ASTM E112 or, in case of disagreement, by the intercept (Heyn) method:

3.5.1.1.2.1 Shall be ASTM No. 5 or finer in bars and flash welded rings 9 in^2 (58 cm^2) and under in cross-sectional area.

3.5.1.1.2.2 Shall be ASTM No. 4 or finer in bars and flash welded rings over 9 in^2 (58 cm^2) in cross-sectional area and in all forgings.

3.5.1.2 Response to Precipitation Heat Treatment

Samples from product 4.00 inches (101.6 mm) and under shall have the following properties after being precipitation heat treated in accordance with Table 2:

Table 2 - Response to precipitation heat treatment

Processing Step[1]		Temperature	Time at Temperature
1	Heat	1350 °F ± 15 °F (732 °C ± 8 °C)	8 hours ± 0.25 hour
2	Cooling at a rate not faster than 100 °F (56 °C)[2] per hour to	1150 °F ± 15 °F (621 °C ± 8 °C)	
3	Hold at temperature	1150 °F ± 15 °F (621 °C ± 8 °C)	8 hours ± 0.25 hour
4	Cool in air		

[1] Note that all processing must be performed in the order noted.
[2] Instead of 100 °F (56 °C) per hour cooling rate, furnace cooling may be at any rate, provided the time at 1150 °F ± 15 °F (621 °C ± 8 °C) is adjusted to give a total precipitation heat treatment time of 18 hours maximum.

3.5.1.2.1 Tensile Properties

Shall be as specified in Table 3, determined in accordance with ASTM E8/E8M.

3.5.1.2.1.1 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. The strain rate after yield may be increased to any value up to 0.5 in/in/min (or 0.5 mm/mm/min) or equivalent crosshead speed as a function of gage length. The requirement for compliance becomes effective for material produced 1 year after the publication date of this specification.

Table 3A - Minimum tensile properties, inch/pound units

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 4D %	Reduction of Area %
Up to 2.50, excl	170	140	12	15
2.50 to 4.00, incl	170	135	12	15

Table 3B - Minimum tensile properties, SI units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 4D %	Reduction of Area %
Up to 63.5, excl	1172	965	12	15
63.5 to 101.6, incl	1172	931	12	15

3.5.1.2.2 Hardness

Shall be not lower than 303 HB, or equivalent (see 8.2), determined in accordance with ASTM E10.

3.5.2 Stock for Forging or Flash Welded Rings

When a sample of stock is heat treated as in 3.4.2 and 3.5.1.2, specimens taken from the heat treated sample shall conform to the requirements of 3.5.1.2.1 and 3.5.1.2.2.

3.6 Mechanical property requirements for product outside the size range covered by 1.1 shall be agreed upon between purchaser and producer and reported per 4.4.4.

3.7 Quality

3.7.1 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.

3.7.2 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.

3.8 Tolerances

Bars shall conform to all applicable requirements of AMS2261.

3.9 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.4.

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 average 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 ability of stock for forging or flash welded rings (3.5.2) to develop required properties and grain flow of forgings (3.6.1) are periodic tests and shall be performed at a frequency selected by the producer 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 Forgings

In accordance with AMS2371.

4.3.2 Forgings

In accordance with AMS2374.

4.3.3 Grain size samples shall be taken from the mid-radius or quarter-thickness position.

4.4 Reports

4.4.1 The producer of the product shall furnish with each shipment a report showing the producer's name and country where the metal was melted (e.g., final melt in case of metal processed by multiple melting operations) and the results of tests for composition of each heat, and for hardness and average grain size of each lot as solution heat treated, and for tensile properties and hardness of samples from each lot after precipitation heat treatment, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS5701F, solution heat treatment temperature used, size, and quantity. If forgings are supplied, the size and melt source of stock used to make the forgings shall also be included.

4.4.2 If the ship size/shape is cut from a larger cross section, report the cut size and the nominal metallurgically worked size (see 3.3.1).

4.4.3 The producer of stock for forgings and flash welded rings shall furnish with each shipment a report showing the producer's name and country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations) and the results for composition of each heat and the results of any additional property requirements imposed by 8.7. This report shall include the purchase order number, AMS5701F, size, and quality.

4.4.4 When material produced to this specification is beyond the sizes allowed in the scope or has exceptions are taken to the technical requirements listed in Section 3, the report shall contain a statement "This material is certified as AMS5701F(EXC) because of the following exceptions:" and the specific exceptions shall be listed (also see 5.2.1.1).