



AEROSPACE MATERIAL SPECIFICATION

AMS5702™**REV. F**

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Superseding AMS5702E

(R) Nickel Alloy, Corrosion- and Heat-Resistant, Bars, Forgings, Rings
and Stock for Forging
41.5Ni - 16Cr - 37Fe - 2.9Cb (Nb) - 1.8Ti
Consumable Electrode Remelted or Vacuum Induction Melted
1750 °F (954 °C) Solution Heat Treated
(Composition similar to UNS N09706)

RATIONALE

AMS5702F is the result of a Five-Year Review and update of the specification. The revision updates the Title to match the Scope, clarifies the maximum cross section covered by the specification (see 1.1), updates the testing and reporting of composition (see 3.1 and 3.1.1), adds alternate product finishes (see 3.3.1.1.1), prohibits bar cut from plate (see 3.3.1.1.2 and 4.4.4), adds pyrometry control (see 3.4 and 3.5.1.2), removes reference to ASTM E140 conversions and provides appropriate conversion tests and values (see 3.5.1.1.1 and 3.5.1.2.2), updates grain size referee method, includes forgings in grain size limit and adds maximum cross-sectional area (see 3.5.1.1.2), heat treatment paragraph replaced by table (see 3.5.1.2), adds strain rate control to tensile testing (see 3.5.1.2.1.1), adds allowance for nonconforming hardness (see 3.5.1.2.2), and prohibits unauthorized exceptions (see 1.1, 3.8, and 8.5).

1. SCOPE

1.1 Form

This specification covers a corrosion- and heat-resistant nickel alloy in the form of bars, forgings, and flash-welded rings up to 4.00 inches (101.6 mm), inclusive, in nominal thickness or distance between parallel sides and having a maximum cross-sectional area of less than 12.6 square inches (81 cm²). Stock for forging or flash-welded rings may be of any size and condition as ordered.

1.2 Applications

These products have been used typically for parts requiring a combination of resistance to creep and stress-rupture up to 1300 °F (704 °C), oxidation resistance up to 1800 °F (982 °C), and good machinability, 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.

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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 E18	Rockwell Hardness of Metallic Materials
ASTM E112	Determining Average Grain Size
ASTM E139	Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
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, determined in accordance with AMS2283 or by other analytical methods acceptable to the 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 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.

3.1.2 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; round bars shall be turned or ground.

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 Bars shall not be cut from plate (see 4.4.4).

3.3.1.2 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.

3.3.2 Stock for Forging or Flash-Welded Rings

As ordered by the forging or flash-welded ring manufacturer.

3.4 Heat Treatment

Pyrometry shall be in accordance with AMS2750. Bars, forgings, and flash-welded rings shall be solution heat treated as follows:

3.4.1 Bars

Shall be solution heat treated by heating to a temperature within the range 1700 to 1800 °F (927 to 982 °C), holding at the selected temperature within ± 25 °F (± 14 °C) for a time commensurate with cross-sectional thickness, and cooling as required.

3.4.2 Forgings and Flash-Welded Rings

Shall be heated to a temperature within the range 1700 to 1800 °F (927 to 982 °C), held at the selected temperature within ± 25 °F (± 14 °C) for not less than 30 minutes, and cooled as required.

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 not higher than 277 HBW, or 30 HRC, determined in accordance with ASTM E10 or ASTM E18 respectively.

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 planimetric (Jeffries') method:

3.5.1.1.2.1 Shall be ASTM No. 5 or finer for product 9 square inches (58 cm²) and under in cross-sectional area.

3.5.1.1.2.2 Shall be ASTM No. 4 or finer for product over 9 square inches (58 cm²) in cross-sectional area and up to 12.6 square inches (81 cm²).

3.5.1.2 Response to Stabilization and Precipitation Heat Treatment

Samples from product 4.00 inches (101.6 mm) and under shall have the following properties after being heat treated in accordance with Table 2. Pyrometry shall be in accordance with AMS2750.

Table 2 - Response to Stabilization and Precipitation Heat Treatment

Processing Step ¹		Temperature	Time at Temperature
1	Heat	1550 °F ± 25 °F (843°C ± 14°C)	3 hours ± 0.25 hour
2	Cooling in air to room temperature		
3	Heat	1325 °F ± 15 °F (718 °C ± 8 °C)	8 hours ± 0.25 hour
	Cooling at a rate not faster than 100 °F (56 °C) ² per hour to	1150 °F ± 15 °F (621 °C ± 8 °C)	
4	Hold at temperature	1150 °F ± 15 °F (621 °C ± 8 °C)	8 hours ± 0.25 hour
5	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 minimum.			

3.5.1.2.1 Tensile Properties

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

Table 3A - Minimum tensile properties – response to heat treatment, inch/pound units

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 inches or 4D	Reduction of Area %
			%	
Up to 2.50, excl	170	130	12	15
2.50 to 4.00, incl	165	130	12	15

Table 3B - Minimum tensile properties – response to heat treatment, SI units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50mm or 4D	Reduction of Area %
			%	
Up to 63.5, excl	1172	896	12	15
63.5 to 101.6, incl	1138	896	12	15

- 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. 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 document.

3.5.1.2.2 Hardness

Shall be not lower than 285 HBW or 30 HRC, determined in accordance with ASTM E10 or ASTM E18 respectively. 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.

3.5.1.2.3 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:

- 3.5.1.2.3.1 A standard cylindrical combination smooth-and-notched specimen conforming to ASTM E292, maintained at 1200 °F $\pm$ 3 °F (649 °C $\pm$ 2 °C) while a load sufficient to produce an initial axial stress of 100 ksi (689 MPa) is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. Rupture shall occur in the smooth section and elongation of this section after rupture, measured at room temperature, shall be not lower than 4% in 4D for product 4.00 inches (101.6 mm) and under in nominal diameter or least distance between parallel sides.
- 3.5.1.2.3.2 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 3.5.1.2.3.1. The smooth specimen shall not rupture in less than 23 hours and elongation after rupture, measured at room temperature, shall be as specified in 3.5.1.2.3.1. The notched specimen shall not rupture in less time than the companion smooth specimen but need not be tested to rupture.
- 3.5.1.2.3.3 The tests of 3.5.1.2.3.1 and 3.5.1.2.3.2 may be conducted using a load higher than required to produce an initial axial stress of 100 ksi (689 MPa) but load shall not be changed while test is in progress. Time to rupture, rupture location, and elongation requirements shall be as specified in 3.5.1.2.3.1.
- 3.5.1.2.3.4 The tests of 3.5.1.2.3.1 and 3.5.1.2.3.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 100 ksi (689 MPa) shall be used to rupture or for 23 hours, whichever occurs first. After the 23 hours and at intervals of 8 hours minimum, thereafter, the stress shall be increased in increments of 5.0 ksi (34.5 MPa). Time to rupture, rupture location, and elongation requirements shall be as specified in 3.5.1.2.3.1.
- 3.5.1.2.4 Mechanical property requirements for product outside of the range covered by 1.1 shall be agreed upon between the producer and purchaser.

3.5.2 Forging Stock

When a sample of stock is forged to a test coupon and heat treated as in 3.4.2 and 3.5.1.2, specimens taken from the heat-treated coupon shall conform to the requirements of 3.5.1.2.1, 3.5.1.2.2, and 3.5.1.2.3. If specimens taken from the stock after heat treatment as in 3.4.2 and 3.5.1.2 conform to the requirements of 3.5.1.2.1, 3.5.1.2.2, and 3.5.1.2.3, 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 heat treatment as in 3.4.2 and 3.5.1.2 shall conform to the requirements of 3.5.1.2.1, 3.5.1.2.2, and 3.5.1.2.3.

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 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 AMS2261.

3.8 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.2.

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.

4.2.1.1 Composition (see 3.1) of each heat.

4.2.1.2 Hardness (see 3.5.1.1.1) and average grain size (see 3.5.1.1.2) of each lot of bars, forgings, and flash-welded rings as solution heat treated.

4.2.1.3 Tensile (see 3.5.1.2.1), hardness (see 3.5.1.2.2), and stress-rupture (see 3.5.1.2.3) properties of each lot of bars, forgings, and flash-welded rings after precipitation heat treatment.

4.2.1.4 Tolerances (see 3.7) of bars.

4.2.2 Periodic Tests

The ability of forging stock (see 3.4.2) and of stock for flash-welded rings (see 3.4.3) to develop required properties and 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

Shall be in accordance with the following:

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

AMS2371.

4.3.2 Forgings

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, 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, for hardness and average grain size as solution treated, for tensile, hardness and stress-rupture properties 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, AMS5702F, 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 When material produced to this specification is beyond the sizes allowed in the scope of tables, or other exceptions are taken to the technical requirements listed in Section 3 (see 5.2.1.1), the report shall contain a statement "This material is certified as AMS5702F(EXC) because of the following exceptions:" and the specific exceptions shall be listed.