SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

AMS 5701D

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Revised FEB 2007

Superseding AMS 5701C

Nickel Alloy, Corrosion and Heat-Resistant, Bars, Forgings, and Rings
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

AMS 5701D is a Five Year Review and update of this specification.

1. SCOPE

1.1 Form

This specification covers a corrosion and heat-resistant nickel 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 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.

2.1 SAE Publications

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

AMS 2261	Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars, Rods, and Wire
AMS 2269	Chemical Check Analysis Limits, Wrought 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 Forging
AMS 2806	Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat-Resistant Steels and Alloys

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AMS 2808	Identification, Forgings
AMS 7490	Rings, Flash Welded, Corrosion and Heat-Resistant Austenitic Steels and Austenitic-Type Alloys or Precipitation Hardenable Alloys

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 A 751	Methods, Practices, and Definitions for Chemical Analysis of Steel Products
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 11	Determining Average Grain Size
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, 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	

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3.1.1 Check Analysis

Composition variations shall meet the applicable requirements of AMS 2269.

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.

3.3.1.2 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 AMS 7490.

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:

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 E 10.

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 E 112 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 square inches (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 square inches (58 cm^2) in cross-sectional area and in all forgings.

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3.5.1.2 After Precipitation Heat Treatment

The product shall have the following properties after being precipitation heat treated by heating to 1350 °F ± 15 (732 °C ± 8), holding at heat for 8 hours ± 0.25, cooling at a rate not faster than 100 °F (56 °C) degrees per hour to 1150 °F ± 15 (621 °C ± 8), holding at 1150 °F ± 15 (621 °C ± 8) for 8 hours ± 0.25, and cooling in air. Instead of the 100 °F (56 °C) degrees per hour cooling rate to 1150 °F ± 15 (621 °C ± 8), furnace cooling may be at any rate provided the time at 1150 °F ± 15 (621 °C ± 8) is adjusted to give a total precipitation heat treatment time of 18 hours.

3.5.1.2.1 Tensile Properties

Shall be as specified in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 2A - 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 2B - 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 E 10.

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 and 3.5.1.2.2. 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 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 heat treatment as in 3.4.2 and 3.5.1.2 shall conform to the requirements of 3.5.1.2.1 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 reentrant grain flow.

3.7 Tolerances

Bars shall conform to all applicable requirements of AMS 2261.

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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 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 forging stock (3.5.2) and of stock for flash welded rings (3.5.3) 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 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.

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

4.4 Reports

The vendor of the product shall furnish with each shipment a report showing the results of tests for composition of each heat, hardness and average grain size of each lot as solution heat treated, tensile properties and hardness of 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, AMS 5701D, 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.

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