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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5893A

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Superseding AMS 5893

Iron-Nickel Alloy, Bars, Forgings, and Rings
42Fe - 37.5Ni - 14Co - 4.8(Cb + Ta) - 1.6Ti
Solution Heat Treated, Short-Time Precipitation Hardenable
Multiple Melted, High Temperature, Low Expansion

UNS N19909

1. SCOPE:

1.1 Form:

This specification covers an iron-nickel alloy in the form of bars, forgings, flash welded rings, and stock for forging, flash welded rings, or heading.

1.2 Application:

These products have been used typically for parts requiring a combination of high strength and low expansion properties up to 1200 °F (649 °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 canceled 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.

AMS 2261	Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars, Rods, and Wire
MAM 2261	Tolerances, Metric, 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

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7161 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

2.1 (Continued):

AMS 2750	Pyrometry
AMS 2806	Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels, Corrosion and Heat Resistant Steels and Alloys
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, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

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 21	Elevated Temperature Tension Tests of Metallic Materials
ASTM E 103	Rapid Indentation Hardness Testing of Metallic Materials
ASTM E 112	Determining the Average Grain Size
ASTM E 228	Linear Thermal Expansion of Solid Materials with a Vitreous Silica Dilatometer
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
ASTM E 1181	Characterizing Duplex Grain Sizes

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	--	1.0
Silicon	0.25	0.50
Phosphorus	--	0.015
Sulfur	--	0.015
Nickel	35.0	40.0
Cobalt	12.0	16.0
Columbium	4.3	5.2
Tantalum	--	0.05
Titanium	1.3	1.8
Chromium	--	1.0
Aluminum	--	0.15
Boron	--	0.012
Copper	--	0.5
Iron	remainder	

3.1.1 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2269.

3.2 Melting Practice:

Alloy shall be multiple melted using consumable electrode practice in the remelt cycle. If consumable electrode remelting is not performed in vacuum, electrodes which have been produced by vacuum induction melting shall be used for remelting.

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 ground or turned.

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, Flash Welded Rings, of Heading: As ordered by the forging, flash welded ring, or heading manufacturer.

3.4 Solution Heat Treatment:

Bars, forgings, and flash welded rings shall be solution heat treated by heating to a temperature within the range of 1775 to 1850 °F (968 to 1010 °C), holding at a selected temperature within ±25 °F (±14 °C) for a time commensurate with section thickness, and cooling at a rate equivalent to a still air cool (See 8.4). Pyrometry shall be in accordance with AMS 2750.

3.4.1 If forgings are not to be machined all over, heat treatment shall be performed in a vacuum or 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 Heat 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 or ASTM E 103.

3.5.1.1.2 Grain Size Uniformity:

3.5.1.1.2.1 Bars, forgings, and flash welded rings 9 square inches (58 cm^2) and under in cross-sectional area shall exhibit an average grain size, determined in accordance with ASTM E 112, of ASTM No. 5 or finer with no more than 20% of the specimen area as large as ASTM No. 3. No single grain shall be larger than 0.010 inch (0.25 mm).

3.5.1.1.2.2 Bars, forgings, and flash welded rings over 9 square inches (58 cm^2) in cross-sectional area shall exhibit an average grain size, determined in accordance with ASTM E 112, of ASTM No. 4 or finer with no more than 20% of the specimen area as large as ASTM No. 2. No single grain shall be larger than 0.014 inch (0.36 mm).

3.5.1.1.2.3 When agreed upon by purchaser and vendor, the grain size of 20% of the specimen area may be as large as ASTM No. 0. No single grain shall be larger than 0.020 inch (0.51 mm).

3.5.1.1.2.4 Limitations on duplex grain structures as defined by ASTM E 1181 shall be as agreed upon by purchaser and vendor.

3.5.1.2 After Re-Solution and Precipitation Heat Treatment: The product shall have the following properties after being re-solution heat treated (See 8.5) by heating to 1800 °F ± 25 (982 °C ± 14), holding at heat for 60 minutes ± 15, and cooling at a rate equivalent to an air cool and precipitation heat treated by heating to 1375 °F ± 15 (746 °C ± 8), holding at heat for four hours ± 0.5, cooling at a maximum rate of 100 F (56 C) degrees per hour to 1150 °F ± 15 (621 °C ± 8), holding at heat for four hours ± 0.5, and cooling at a rate equivalent to an air cool (See 8.4).

3.5.1.2.1 Tensile Properties:

3.5.1.2.1.1 At Room Temperature: Shall be as shown in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 2 - Minimum Tensile Properties

Property	Value
Tensile Strength	170.0 ksi (1172 MPa)
Yield Strength at 0.2% Offset	125.0 ksi (862 MPa)
Elongation in 4D %	10%
Reduction of Area %	15%

3.5.1.2.1.2 At 1200 °F (649 °C): Shall be as shown in Table 3, determined in accordance with ASTM E 21 on specimens heated to 1200 °F ± 5 (649 °C ± 3), held at heat for 20 to 30 minutes before testing, and tested at 1200 °F ± 5 (649 °C ± 3).

TABLE 3 - Minimum Tensile Properties

Property	Value
Tensile Strength	130.0 ksi (896 MPa)
Yield Strength at 0.2% Offset	95.0 ksi (655 MPa)
Elongation in 4D %	10%
Reduction of Area %	20%

3.5.1.2.1.3 Specific location of specimens from forgings and flash welded rings shall be as agreed upon by purchaser and vendor.

3.5.1.2.2 Hardness: Shall be not lower than 331 HB, or equivalent (See 8.2), determined in accordance with ASTM E 10 or ASTM E 103. Product shall not be rejected on the basis of hardness if the tensile property requirements of 3.5.1.2.1.1 are acceptable. Tensile properties shall be determined on material taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness.

3.5.1.2.3 Stress-Rupture Properties at 1000 °F (538 °C): Shall be as follows: testing of notched specimens shall be performed in accordance with ASTM E 292.

3.5.1.2.3.1 A notched specimen maintained at 1000 °F ± 3 (538 °C ± 2) while a load sufficient to produce an initial axial stress of 120.0 ksi (827 MPa) is applied continuously, shall not rupture in less than 60 hours. Tests may be discontinued after 120 hours.

3.5.1.2.3.2 The test may be conducted using a load higher than required to produce an initial stress of 120.0 ksi (827 MPa) but the load shall not be changed while the test is in progress. The minimum time to rupture shall be as specified in 3.5.1.2.3.1.

3.5.1.2.4 Thermal Expansion: Shall be determined in accordance with ASTM E 228 on each heat of alloy.

3.5.1.2.4.1 Coefficient of Expansion: Shall be 4.00 - 4.50 x 10^{-6} inch/inch/°F (7.2 - 8.1 x 10^{-6}mm/mm/°C) at 780 °F (416 °C) using 77 °F (25 °C) as a reference temperature.

3.5.1.2.4.2 Inflection Temperature: Shall be 750 to 850 °F (399 to 454 °C), determined by establishing the intersection of the tangents of the upper and lower portions of the dilatometric expansion curve.

3.5.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.4 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, 3.5.1.2.3, and 3.5.1.2.4. If specimens taken from the stock after heat treatment as in 3.4 and 3.5.1.2 conform to the requirements of 3.5.1.2.1, 3.5.1.2.2, 3.5.1.2.3, and 3.5.1.2.4, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.3 Stock for Flash Welded Rings or Heading: Specimens taken from the stock after heat treatment as in 3.4 and 3.5.1.2 shall conform to the requirements of 3.5.1.2.1, 3.5.1.2.2, 3.5.1.2.3, and 3.5.1.2.4.

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 re-entrant grain flow.

3.7 Tolerances:

Bars shall conform to all applicable requirements of AMS 2261 or MAM 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) and thermal expansion (3.5.1.2.4) of each heat.

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

4.2.1.3 Room temperature tensile properties (3.5.1.2.1.1) of bars, forgings and flash welded rings after resolution and precipitation heat treatment.

4.2.1.4 Tolerances (3.7) of bars.

4.2.2 Periodic Tests: The following requirements are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser:

4.2.2.1 Tensile properties at 1200 °F (3.5.1.2.1.2), hardness (3.5.1.2.2), and stress rupture properties (3.5.1.2.3) of each lot of bars, forgings and flash welded rings after resolution and precipitation heat treatment.

4.2.2.2 Ability of forging stock (3.5.2) and stock for flash welded rings (3.5.2) to develop required properties.

4.2.2.3 Grain flow (3.6.1) of die forgings.

4.3 Sampling and Testing:

Shall be as follows:

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

4.3.2 Forgings: In accordance with AMS 2374.