SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5940A

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Superseding AMS 5940

Alloy, Corrosion and Heat-Resistant, Bars, Forgings, and Rings
34Co - 3.0Cr - 28Ni - 3.0Cb(Nb) - 5.5Al - 0.008B - 25.5Fe
Multiple Melted, High Temperature, Oxidation-Resistant, Low Expansion
Solution Heat Treated, Precipitation-Hardenable

(Composition similar to UNS R30783)

1. SCOPE:

1.1 Form:

This specification covers a cobalt-nickel-iron 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 1300 °F (704 °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: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

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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 and Austenitic-Type Alloys, or Precipitation-Hardenable 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 18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E 21	Elevated Temperature Tension Tests 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 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	--	0.03
Manganese	--	0.50
Silicon	--	0.50
Phosphorus	--	0.015
Sulfur	--	0.005
Chromium (Niobium)	2.5	3.5
Nickel	26.0	30.0
Columbium	2.5	3.5
Aluminum	5.0	6.0
Boron	0.003	0.012
Iron	24.0	27.0
Titanium	--	0.40
Tantalum	--	0.05
Copper	--	0.50
Cobalt	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, or 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 2025 to 2050 °F (1107 to 1121 °C), holding at the 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 8.2).

3.4.1 Pyrometry shall be in accordance with AMS 2750.

3.4.2 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 Heat Treated:

3.5.1.1.1 Hardness: Shall be not higher than 29 HRC, or equivalent (See 8.3), determined in accordance with ASTM E 18.

3.5.1.1.2 Average Grain Size: Shall be as follows, determined by the comparative method of ASTM E 112. In case of disagreement, the intercept (Heyn) procedure shall be used.

3.5.1.1.2.1 Bars and flash welded rings under 9 square inches (58 cm^2) in cross-sectional area shall exhibit average grain size of ASTM No. 5 or finer. Areas of nonrecrystallized grains with an average grain size, determined by the intercept method, of ASTM No. 3 to 5 are permitted but shall not account for more than 20% of the cross-section.

3.5.1.1.2.2 Bars and flash welded rings 9 to 50 square inches (58 to 323 cm^2), inclusive, in cross-sectional area and all forgings shall exhibit average grain size of ASTM No. 4 or finer. Areas of nonrecrystallized grains with an average grain size, determined by the intercept method, of ASTM No. 2 to 4 are permitted but shall not account for more than 20% of the cross-section.

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

3.5.1.2 Response to Heat Treatment: The product shall have the following properties after being precipitation heat treated by heating to 1550 °F ± 15 (843 °C ± 8), holding at heat for 2 to 4 hours, cooling at a rate equivalent to an air cool to room temperature, heating to 1325 °F ± 15 (718 °C ± 8), holding at heat for eight hours ± 0.5, cooling at a rate of approximately 100 F (56 C) degrees per hour to 1150 °F ± 15 (621 °C ± 8), holding at 1150 °F ± 15 (621 °C ± 8) for eight hours ± 0.5, and cooling at a rate equivalent to an air cool (See 8.2).

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 Room Temperature Tensile Properties

Property	Value
Tensile Strength	160 ksi (1103 MPa)
Yield Strength at 0.2% Offset	105 ksi (724 MPa)
Elongation in 4D	12%
Reduction of Area	20%

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 not less than 20 minutes before testing, and tested at 1200 °F ± 5 (649 °C ± 3).

TABLE 3 - Minimum 1200 °F (649 °C) Tensile Properties

Property	Value
Tensile Strength	130 ksi (896 MPa)
Yield Strength at 0.2% Offset	90 ksi (621 MPa)
Elongation in 4D	15%
Reduction of Area	25%

3.5.1.2.2 Hardness: Shall be not lower than 27 HRC, or equivalent (See 8.3), determined in accordance with ASTM E 18. Product shall not be rejected on the basis of hardness if the tensile properties of 3.5.1.2.1.1 are acceptable, determined on product 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 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 testing of smooth specimens shall be performed in accordance with ASTM E 139:

3.5.1.2.3.1 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 85.0 ksi (586 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. Rupture shall occur in the smooth section and elongation of this section after rupture, measured at room temperature, shall be not less than 8% in 4D for product 5.0 inches (127 mm) and under in nominal diameter or least distance between parallel sides and shall be reported for product over 5.0 inches (127 mm) in nominal diameter and 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 E 292, 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, measure 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 incremental loading. In such case, the load required to produce an initial axial stress of 85.0 ksi (586 MPa) or higher 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 Mean Coefficient of Linear Expansion: Shall not exceed 7.5 x 10^{-6} inch/inch/°F (13.5 x 10^{-6} mm/mm/°C) at 1200 °F (649 °C) using 77 °F (25 °C) as the reference temperature, determined in accordance with ASTM E 228.

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 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: Tests for 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 mean coefficient of linear expansion (3.5.1.2.4) 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 Room-temperature tensile properties (3.5.1.2.1.1), 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 precipitation heat treatment.

4.2.1.4 Tolerances (3.7) of bars.

4.2.2 Periodic Tests: Tests for 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 (649 °C) (3.5.1.2.1.2) of bars, forgings, and flash welded rings after precipitation heat treatment.

4.2.2.2 Ability of forging stock (3.5.2) and of stock for flash welded rings or heading (3.5.3) 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.

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

4.4 Reports:

The vendor of the product shall furnish with each shipment a report showing the following results of tests and relevant information:

4.4.1 For each heat:

Composition
Mean coefficient of linear expansion.

4.4.2 For each lot of bars, forgings, and flash welded rings:

As solution treated:

Hardness
Average grain size.

After precipitation heat treatment:

Room temperature tensile properties
Hardness
Stress-rupture properties.

4.4.3 A statement that the product conforms to the other technical requirements.

4.4.4 Purchase order number
Heat and lot numbers
AMS 5940A
Size
Quantity.

4.4.5 If forgings are supplied, the size and melt source of stock used to make the forgings.

4.4.6 The vendor of stock for forging, flash welded rings, or heading shall furnish with each shipment a report showing the results of tests for composition of each heat. This report shall include the purchase order number, heat number, AMS 5940A, size, and quantity.