AEROSPACE MATERIAL SPECIFICATION

AMS5893™	REV. C

Issued 1992-04
Reaffirmed 2012-02
Revised 2018-08

Superseding AMS5893B

Iron-Nickel Alloy, Bars, Forgings, and Rings
42Fe - 37.5Ni - 14Co - 4.8 (Cb + Ta)(Nb + Ta) - 1.6Ti
Solution Heat Treated, Short-Time Precipitation Hardenable
Multiple Melted, High Temperature, Low Expansion
(Composition similar to UNS N19909)

RATIONALE

AMS5893C prohibits unauthorized exceptions, (3.8), revises Properties (3.5.1.1.1, Tables 2 and 3), Reports (4.4), and Identification (5.2.1.1), and is a Five-Year Review and update of this specification.

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 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**

SAE values your input. To provide feedback on this Technical Report, please visit
http://standards.sae.org/AMS5893C

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

ARP1917 Clarification of 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 E21 Elevated Temperature Tension Tests 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 E228 Linear Thermal Expansion of Solid Materials with a Pushrod Dilatometer

ASTM E292 Conducting Time-for-Rupture Notch Tension Tests of Materials

ASTM E354 Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

ASTM E1181 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 E354, 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 (Niobium)	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 AMS2269.

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 AMS7490.

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 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 AMS2750.

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 E10.

3.5.1.1.2 Grain Size Uniformity

3.5.1.1.2.1 Bars, forgings, and flash-welded rings 9 in^2 (58 cm^2) and under in cross-sectional areas shall exhibit an average grain size, determined in accordance with ASTM E112, of ASTM 5 or finer, with no more than 20% of the specimen area as large as ASTM 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 in^2 (58 cm^2) in cross-sectional area shall exhibit an average grain size, determined in accordance with ASTM E112, of ASTM 4 or finer, with no more than 20% of the specimen area as large as ASTM 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 producer, the grain size of 20% of the specimen area may be as large as ASTM 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 E1181 shall be as agreed upon by purchaser and producer.

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 8.4) by heating to 1800 °F ± 25 °F (982 °C ± 14 °C), holding at heat for 60 minutes ± 15 minutes, and cooling at a rate equivalent to an air cool and precipitation heat treated by heating to 1375 °F ± 15 °F (746 °C ± 8 °C), holding at heat for 4 hours ± 0.5 hour, cooling at a maximum rate of 100 °F (56 °C) per hour to 1150 °F ± 15 °F (621 °C ± 8 °C), holding at heat for 4 hours ± 0.5 hour, and cooling at a rate equivalent to an air cool (see 8.3).

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 E8/E8M.

Table 2 - Minimum tensile properties

Property	Value
Tensile Strength	170 ksi (1172 MPa)
Yield Strength at 0.2% Offset	125 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 E21 on specimens heated to 1200 °F ± 5 °F (649 °C ± 3 °C), held at heat for 20 to 30 minutes before testing, and tested at 1200 °F ± 5 °F (649 °C ± 3 °C).

Table 3 - Minimum tensile properties

Property	Value
Tensile Strength	130 ksi (896 MPa)
Yield Strength at 0.2% Offset	95 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 producer.

3.5.1.2.2 Hardness

Shall be not lower than 331 HB, or equivalent (see 8.2), determined in accordance with ASTM E10 or ASTM E103. 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 E292.

3.5.1.2.3.1 A notched specimen maintained at 1000 °F ± 3 °F (538 °C ± 2 °C) 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 E228 on each heat of alloy.

3.5.1.2.4.1 Coefficient of Expansion

Shall be 4.00 to 4.50 × 10^{-6} in/in/°F (7.2 to 8.1 × 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 reentrant grain flow.

3.7 Tolerances

Bars shall conform to all applicable requirements of AMS2261.

3.8 Any exceptions shall be authorized by purchaser and reported as in 4.4.1.

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) 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 producer unless frequency of testing is specified by the purchaser:

4.2.2.1 Tensile properties at 1200 ºF (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 (3.5.3) 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 AMS2371.

4.3.2 Forgings

In accordance with AMS2374.

4.4 Reports

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 the case of metal processed by multiple melting operations) and the results of tests for composition and thermal expansion properties of each heat and for hardness, grain size uniformity, and room temperature tensile properties of each lot, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS5893C, size, and quantity. If forgings are supplied, the size and melt source of stock used to make the forgings shall also be included.

4.4.1 When material produced to this specification has exceptions authorized by purchaser 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 AMS5893C(EXC) because of the following exceptions," and the specific exceptions shall be listed.

4.4.2 The producer of stock for forging or 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 of tests for composition and thermal expansion properties of each heat. This report shall include the purchase order number, heat number, AMS5893C, size, and quantity.

4.5 Resampling and Retesting

Shall be as follows:

4.5.1 Bars, Flash-Welded Rings, and Stock for Forging, Flash-Welded Rings, or Heading

In accordance with AMS2371.

4.5.2 Forgings

In accordance with AMS2374.

5. PREPARATION FOR DELIVERY

5.1 Sizes

Except when exact lengths or multiples of exact lengths are ordered, straight bars will be acceptable in mill lengths of 6 to 24 feet (1.8 to 7.3 m), but not more than 25% of any shipment shall be supplied in lengths of 6 to 9 feet (1.8 to 2.7 m) except that for bars weighing over 25 lb/ft (37 kg/m), short lengths down to 2 feet (610 m) may be supplied.

5.2 Identification

Shall be as follows:

5.2.1 Bars

In accordance with AMS2806.

5.2.1.1 When technical exceptions are taken (see 4.4.1), the material shall be marked with AMS5893C(EXC).

5.2.2 Forgings

In accordance with AMS2808.