AEROSPACE MATERIAL SPECIFICATION

AMS5884™	REV. E

Issued 1992-04
Reaffirmed 2006-04
Revised 2022-09

Superseding AMS5884D

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

RATIONALE

AMS5584E is the result of a Five-Year review and update of the document. The revision prohibits unauthorized exceptions (3.8, 4.4.3, 5.2.1, 8.4), updates composition and reporting requirements (3.1, 3.1.1), limits hardness testing procedures (3.5.1.1.1, 3.5.1.2.2), adds strain rate control for tensile tests (3.5.1.2.1.1), revises largest allowable grain size (3.5.1.1.2), updates limiting bar sizes (4.4.1), and allows prior revisions (8.5).

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.

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

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**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS5884E/

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, 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 E21 Elevated Temperature Tension Tests of Metallic Materials

ASTM E112 Determining Average Grain Size

ASTM E139 Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

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 Push-Rod 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 E930 Estimating the Largest Grain Observed in a Metallographic Section (ALA Grain Size)

ASTM E1181 Characterizing Duplex Grain Sizes

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 ASTM E354 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
Titanium	1.3	1.8
Chromium	--	1.0
Tantalum	--	0.05
Aluminum	--	0.15
Boron	--	0.012
Copper	--	0.5
Iron	remainder	

3.1.1 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 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 or cold finished; round bars shall be ground or turned.

3.3.1.2 Bar shall not be cut from plate (also see 4.4.1).

3.3.1.3 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 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 8.2).

3.4.1 Pyrometry shall be in accordance with AMS2750.

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 277 HB, or equivalent (see 8.6), determined in accordance with ASTM E10.

3.5.1.1.2 Average Grain Size

3.5.1.1.2.1 Bars, forgings, and flash welded rings 9 in^2 (58 cm^2) and under in cross-sectional area shall exhibit an average grain size, determined in accordance with ASTM E112, 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 ASTM No. 1, determined in accordance with ASTM E930.

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 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 ASTM No. 0, determined in accordance with ASTM E930.

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 No. 0. No single grain shall be larger than ASTM No. 00, determined in accordance with ASTM E930.

3.5.1.1.2.4 Limitations on duplex grain structures, as defined by ASTM E1181, shall be 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 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 1325 °F ± 15 °F (718 °C ± 8 °C), holding at heat for 8 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 8 hours ± 0.5 hour, and cooling at a rate equivalent to an air cool (see 8.2 and 8.3).

3.5.1.2.1 Tensile Properties

3.5.1.2.1.1 At Room Temperature

Shall be shown in Table 2, determined in accordance with ASTM E8/E8M. 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. The strain rate after yield may be increased to any value up to 0.5 in/in/min (or 0.5 mm/mm/min) or equivalent crosshead speed as a function of gage length.

Table 2 - Minimum tensile properties

Property	Value
Tensile Strength	175 ksi (1207 MPa)
Yield Strength at 0.2% Offset	140 ksi (965 MPa)
Elongation in 4D	8%
Reduction of Area	12%

3.5.1.2.1.2 At 1200 °F (649 °C)

Shall be 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 elevated temperature tensile properties

Property	Value
Tensile Strength	135 ksi (931 MPa)
Yield Strength at 0.2% Offset	105 ksi (724 MPa)
Elongation in 4D	10%
Reduction of Area	15%

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

3.5.1.2.2 Hardness

Shall be not lower than 331 HB, or equivalent (see 8.6), determined in accordance with ASTM E10.

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 testing of smooth specimens shall be performed 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 ± 3 °F (649 °C ± 2 °C) while a load sufficient to produce an initial axial stress of 74.0 ksi (510 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 less than 4% in 4D for product 5.0 inches (127 mm) and under in nominal diameter or least distance between parallel sides; elongation of the smooth section, after rupture, for product over 5.0 inches (127 mm) in nominal diameter or least distance between parallel sides, shall be agreed upon by purchaser and producer.

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 74.0 ksi (510 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 74.0 ksi (510 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 Thermal Expansion Properties

Shall be determined in accordance with ASTM E228 on each heat of alloy.

3.5.1.2.4.1 Mean Coefficient of Linear Expansion

Shall be 4.00 to 4.50 x 10^{-6} in/in/°F (7.2 to 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 3.5.1.2, 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 3.5.1.2 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 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.3.

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 average grain size (3.5.1.1.2) of each lot as solution heat treated.

4.2.1.3 Tensile properties (3.5.1.2.1), hardness (3.5.1.2.2), and stress rupture properties (3.5.1.2.3) of each lot after re-solution and precipitation heat treatment.

4.2.1.4 Tolerances (3.7) of each lot.

4.2.2 Periodic Tests

Grain flow of die forgings (3.6.1) is a periodic test and shall be performed at a frequency selected by the producer 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, 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 and average grain size as solution heat treated and for tensile properties, hardness, and stress rupture properties re-solutioned and precipitation heat treated 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, AMS5884E, solution heat treatment temperature used, product form, 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 Report the nominal metallurgically worked size and the cut size, if different (see 3.3.1.2).

4.4.2 The producer of forging stock 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, thermal expansion of each heat. This report shall include the purchase order number, heat number, AMS5884E, size and quantity.

4.4.3 When material produced to this specification has exceptions taken to the technical requirements listed in Section 3, the report shall contain a statement "This material is certified as AMS5884E(EXC) because of the following exceptions:" and the specific exceptions shall be listed (also see 5.2.1).

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.