AEROSPACE MATERIAL SPECIFICATION

AMS5934™	REV. C

Issued 2004-07
Reaffirmed 2011-10
Revised 2025-04

Superseding AMS5934B

(R) Steel, Extra High Toughness, Corrosion-Resistant, Bars, Wire, Forgings, Rings, and Extrusions
13Cr - 8.0Ni - 2.2Mo - 1.1Al
Vacuum Induction Plus Consumable Electrode Melted
Solution Heat Treated, Precipitation-Hardenable
(Composition similar to UNS S13800)

RATIONALE

AMS5934C is the result of a Five-Year Review and update of the specification. The revision prohibits unauthorized exceptions and clarifies those limitations (see 1.1, 3.5.2.2.1, 3.8, 4.4.4, 5.2.1, and 8.8), moves material types to Scope, updates composition testing and reporting (see 3.1 and 3.1.1), updates finish requirements for bar (see 3.1.1), adds heat-treatment controls (3.4), adds strain rate control for tensile testing (see 3.5.2.2.1), updates tensile and fracture toughness testing and invalidity requirements (see 3.5.2.2.2 and 3.5.2.2.3), adds quality requirements for bar product (see 3.6.2 and 8.6), adds requirements for testing of stock (see 4.2.1.5), addresses additional forging properties (see 4.4.7 and 8.9), clarifies condition (see 8.5), allows the use of prior revisions (see 8.7), and adds material type to ordering information (see 8.9)

1. SCOPE

1.1 Form

This specification covers an extra high toughness, corrosion-resistant steel in the form of bars, wire, forgings, flash-welded rings, and extrusions up to 12 inches (305 mm) in nominal diameter or least distance between parallel sides (thickness) in the solution heat-treated condition and stock of any size for forging, flash-welded rings, or extrusion.

1.1.1 For purchase of solution-treated and aged product, use the applicable AMS slash specification (see 8.5). If a slash sheet description is not specified, solution-annealed material shall be supplied. A specific example of a slash specification is: AMS5934/H1000 - Precipitation Hardened to H1000 condition.

1.2 Application

These products have been used typically for parts requiring extra high toughness, corrosion resistance, stress-corrosion resistance, high strength up to 600 °F (316 °C), and good ductility and strength in the transverse direction in large section sizes, but usage is not limited to such applications.

1.2.1 Certain design and processing procedures may cause these products to become susceptible to stress-corrosion cracking; ARP1110 recommends practices to minimize such conditions.

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/AMS5934C/

1.3 Maximum Delta Ferrite Content

Type 1 - 1.0% maximum, free ferrite

Type 2 - 0.5% maximum, free ferrite

1.3.1 Type 1 shall be supplied unless Type 2 is specified.

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.

AMS2241	Tolerances, Corrosion- and Heat-Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
AMS2248	Chemical Check Analysis Limits, Corrosion- and Heat-Resistant Steels and Alloys, Maraging and Other Highly Alloyed Steels, and Iron Alloys
AMS2300	Steel Cleanliness, Premium Aircraft-Quality, Magnetic Particle Inspection Procedure
AMS2315	Determination of Delta Ferrite Content
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
AMS2761	Heat Treatment of Steel Raw Materials
AMS2806	Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels, and Corrosion and Heat-Resistant Steels and Alloys
AMS2808	Identification, Forgings
AMS5934/H1000	Steel, Extra High Toughness, Corrosion-Resistant, Bars, Wire, Forgings, Rings, and Extrusions, 13Cr - 8.0Ni - 2.2Mo - 1.1Al, Vacuum Induction Plus Consumable Electrode Melted, Solution Heat Treated, Precipitation Hardened (H1000)
AMS7490	Rings, Flash Welded, Corrosion and Heat-Resistant Austenitic Steels, Austenitic-Type Iron, Nickel, or Cobalt Alloys, or Precipitation-Hardenable Alloys
ARP1110	Minimizing Stress Corrosion Cracking in Wrought Forms of Steels and Corrosion Resistant Steels and Alloys
AS1182	Standard Stock Removal Allowance, Aircraft-Quality and Premium Aircraft-Quality Steel, Bars and Mechanical Tubing
AS6279	Standard Practice for Production, Distribution, and Procurement of Metal Stock
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 A370 Mechanical Testing of Steel Products

ASTM A604 Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets

ASTM A751 Chemical Analysis of Steel Products

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 E399 Plane-Strain Fracture Toughness of Metallic Materials

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, in accordance with ASTM A751, or by other analytical methods acceptable to the purchaser.

Table 1 - Composition

Element	Min	Max
Carbon	--	0.05
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.010
Sulfur	--	0.008
Chromium	12.25	13.25
Nickel	7.50	8.50
Molybdenum	2.00	2.50
Aluminum	0.90	1.35
Nitrogen	--	20 ppm

3.1.1 The 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 AMS2248, except that no variation over maximum is permitted for nitrogen.

3.2 Melting Practice

The steel covered by this specification shall be double melted using vacuum induction melting in the first melt cycle and vacuum-arc consumable process in the second melt cycle.

3.3 Condition

The product shall be supplied in the following condition:

3.3.1 Bars and Wire

3.3.1.1 Rounds

Cold finished after solution heat treatment. Hot finished, solution heat treated, and descaled when ordered (see 8.9).

3.3.1.2 Hexagons, Squares, and Flats

Cold finished, solution heat treated, straightened, and descaled, or hot finished, solution heat treated, straightened, and descaled, as ordered.

3.3.1.3 Bar shall not be cut from plate (see 4.4.8).

3.3.2 Forgings and Flash-Welded Rings

Solution heat treated and descaled.

3.3.2.1 Flash-welded rings shall not be supplied unless specified or permitted on the purchaser's part drawing. When supplied, rings shall be manufactured in accordance with AMS7490.

3.3.3 Extrusions

Solution heat treated, straightened, and descaled.

3.3.4 Stock for Forging, Flash-Welded Rings, or Extrusion

As ordered by the forging, flash-welded ring, or extrusion manufacturer.

3.4 Heat Treatment

Bars, wire, forgings, flash-welded rings, and extrusions shall be solution heat treated, in accordance with AMS2761, by heating to 1700 °F ± 25 °F (927 °C ± 14 °C), holding at heat for a time commensurate with section thickness, heating equipment, and procedure used, and cooling to below 60 °F (16 °C).

3.5 Properties

The product shall conform to the following requirements; hardness and tensile testing shall be performed in accordance with ASTM A370:

3.5.1 All Products

3.5.1.1 Macrostructure

Visual examination of transverse full cross sections from bars, billets, extrusions, and stock for forging, flash-welded rings, or extrusions, etched in hot hydrochloric acid in accordance with ASTM A604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM A604 shown in Table 2.

Table 2 - Macrostructure limits

Class	Condition	Severity
1	Freckles	A
2	White Spots	A
3	Radial Segregation	A
4	Ring Pattern	B

3.5.1.2 Microstructure

The product shall contain no more than the following amount of delta ferrite in appropriate Type (see 1.3), determined in accordance with AMS2315:

3.5.2 Bars, Wire, Forgings, Flash-Welded Rings, and Extrusions

3.5.2.1 As Solution Treated

3.5.2.1.1 Tensile Strength

Wire shall have tensile strength not higher than 175 ksi (1207 MPa), or equivalent hardness (see 8.2).

3.5.2.1.2 Hardness

3.5.2.1.2.1 Bars

Shall be not higher than 363 HBW, or equivalent (see 8.3), determined at mid-radius or quarter thickness.

3.5.2.1.2.2 Forgings, Flash-Welded Rings, and Extrusions

Shall be not higher than 363 HBW, or equivalent (see 8.3).

3.5.2.1.3 Average Grain Size

Shall be ASTM No. 5 or finer for product up to 3.00 inches (76.2 mm) in nominal diameter or least distance between parallel sides and shall be ASTM No. 4 or finer for product 3.00 inches (76.2 mm) and over in diameter or least distance between parallel sides, determined in accordance with ASTM E112.

3.5.2.2 Response to Precipitation Heat Treatment

Samples from solution heat-treated product 12 inches (305 mm) and under in nominal diameter or least distance between parallel sides, when precipitation heat treated for 4 hours ± 0.25 hour to a particular condition at the temperatures shown in Table 3 and cooled at a rate equivalent to air cooling, shall have the properties specified in 3.5.2.2.2 and 3.5.2.2.3 for that particular condition. Tensile tests need be made in only the H1000 precipitation heat-treated condition unless the purchaser specifies a different heat-treated condition.

3.5.2.2.1 Mechanical property requirements for product outside of the range covered by 1.1 shall be agreed upon between the purchaser and producer and reported in 4.4.4.

Table 3 - Precipitation-hardening conditions

Condition	Temperature
H950	950 °F ± 10 °F (510 °C ± 6 °C)
H1000	1000 °F ± 10 °F (538 °C ± 6 °C)
H1025	1025 °F ± 10 °F (552 °C ± 6 °C)
H1050	1050 °F ± 10 °F (566 °C ± 6 °C)
H1100	1100 °F ± 10 °F (593 °C ± 6 °C)
H1150	1150 °F ± 10 °F (621 °C ± 6 °C)

3.5.2.2.2 Tensile Properties

Shall be as shown in Table 4.

Table 4A - Minimum tensile properties after precipitation heat treatment, inch/pound units

Condition	Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 4D or 2 Inches %	Reduction of Area %
H950	Longitudinal	220	205	10	45
	Transverse	220	205	10	35
H1000	Longitudinal	205	190	10	50
	Transverse	205	190	10	40
H1025	Longitudinal	185	175	11	50
	Transverse	185	175	11	45
H1050	Longitudinal	175	165	12	50
	Transverse	175	165	12	45
H1100	Longitudinal	150	135	14	50
	Transverse	150	135	14	50
H1150	Longitudinal	135	90	14	50
	Transverse	135	90	14	50

Table 4B - Minimum tensile properties after precipitation heat treatment, SI units

Condition	Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 4D or 50 mm %	Reduction of Area %
H950	Longitudinal	1517	1413	10	45
	Transverse	1517	1413	10	35
H1000	Longitudinal	1413	1310	10	50
	Transverse	1413	1310	10	40
H1025	Longitudinal	1276	1207	11	50
	Transverse	1276	1207	11	45
H1050	Longitudinal	1207	1138	12	50
	Transverse	1207	1138	12	45
H1100	Longitudinal	1034	931	14	50
	Transverse	1034	931	14	50
H1150	Longitudinal	931	621	14	50
	Transverse	931	621	14	50

3.5.2.2.2.1 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. After the yield strain, the speed of the testing machine shall be set between 0.05 and 0.5 in/in (0.05 and 0.5 mm/mm) of the length of the reduced section (or distance between the grips for specimens not having a reduced section) per minute. Alternatively, an extensometer and strain rate indicator may be used to set the strain rate between 0.05 and 0.5 in/in/min (0.05 and 0.5 mm/mm/min).

3.5.2.2.2.2 Tensile properties shall be taken in the short-transverse direction, except as noted below.

3.5.2.2.2.3 If the product cross section does not allow a 2-1/2 inch (63.5 mm) long specimen to be taken in the short-transverse direction, then tensile properties shall be determined in the long-transverse direction.

3.5.2.2.2.4 If the product cross section does not allow a 2-1/2 inch (63.5 mm) long specimen to be taken in the short-transverse or the long-transverse direction, then tensile properties shall be determined in the longitudinal direction.

3.5.2.2.2.5 Products tested in the transverse direction need not be tested in the longitudinal direction.

3.5.2.2.3 Fracture Toughness

Shall be not lower than 120 ksi-in$^{1/2}$ (132 MPa-m$^{1/2}$) K_{IC}, determined in accordance with ASTM E399 on specimens in all orientations from product 3.00 inches (76.2 mm) and over in nominal diameter or least distance between parallel sides on product tested in the H1000 condition. Unless otherwise specified by the purchaser, the product will be tested in the longitudinal LT or LR orientation. If product size precludes use of specimens that will provide valid K_{IC} results, use of K_Q values for acceptance is permissible. For product under 3.00 inches (76.2 mm), fracture toughness testing is not required.

3.5.2.2.3.1 Invalid test results in accordance with ASTM E399 shall be considered meaningful and the material shall be accepted to K_{IC} requirements if the thickest possible specimen was used, the calculated K_Q equals or exceeds the required K_{IC}, and invalidity is due to one or both of the following conditions:

a. $W\text{-}a < 2.5 (K_Q/\sigma_{YS})^2$

b. $P_{max}/P_Q > 1.10$

3.5.2.2.3.2 Minimum fracture toughness values for product in other than the H1000 condition shall be agreed upon between the purchaser and supplier.

3.5.3 Forging Stock

When a sample of stock is forged to a test coupon and heat treated as in 3.4 and 3.5.2.2, specimens taken from the heat-treated coupon shall conform to the requirements of 3.5.2.2.2 and 3.5.2.2.3. If specimens taken from the stock after heat treatment as in 3.4 and 3.5.2.2 conform to the requirements of 3.5.2.2.2 and 3.5.2.2.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.4 Stock for Flash-Welded Rings or Extrusion

A sample of stock heat treated as in 3.4 and 3.5.2.2 shall conform to the requirements of 3.5.2.2.2 and 3.5.2.2.3.

3.6 Quality

The product, as received by the 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 Steel shall be premium aircraft-quality conforming to AMS2300.

3.6.2 Bars shall be free from seams, laps, tears, and cracks after removal of the standard stock removal allowance in accordance with AS1182.

3.7 Tolerances

Bars and wire shall conform to all applicable requirements of AMS2241. Tolerances for extrusions shall be as specified on the extrusion drawing.

3.8 Production, distribution, and procurement of metal stock shall comply with AS6279. After production and certification to the specified requirements, cutting in a plane perpendicular to the short-transverse dimension is permitted.

3.9 Exceptions

Any exception shall be authorized by the purchaser and reported as in 4.4.4.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for the producer's tests and shall be responsible for the performance of all required tests. The 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 (see 3.1) and macrostructure (see 3.5.1.1) of each heat.

4.2.1.2 Hardness (see 3.5.2.1.2) as solution heat treated, microstructure (see 3.5.1.2), and average grain size (see 3.5.2.1.3 and 4.3.3) of each lot of bars, forgings, flash-welded rings, and extrusions.

4.2.1.3 Tensile strength (see 3.5.2.1.1) of each lot of wire as solution heat treated.

4.2.1.4 Tensile properties (see 3.5.2.2.2) of each lot of bars, wire, forgings, flash-welded rings, and extrusions after precipitation heat treatment to hardened condition (H1000 or as specified by the purchaser) (see 3.5.2.2).

4.2.1.5 Ability of forging stock (see 3.5.3) and stock for flash-welded rings or extrusions (see 3.5.4) to develop required properties of each heat.

4.2.1.6 Tolerances (see 3.7) of bars, wire, and extrusions.

4.2.2 Periodic Tests

Tensile properties (see 3.5.2.2.2) of all product forms in other than the specified precipitation-hardened condition, fracture toughness (see 3.5.2.2.3) of bars and forgings after precipitation heat treatment, and frequency-severity cleanliness rating (see 3.6.1) are periodic tests and shall be performed at a frequency selected by the producer unless frequency of testing is specified by the purchaser.

4.3 Sampling and Testing

4.3.1 Bars, Wire, Flash-Welded Rings, Extrusions, and Stock for Forging, Flash-Welded Rings, or Extrusion

In accordance with AMS2371.

4.3.2 Forgings

In accordance with AMS2374.

4.3.3 Samples for average grain size (see 3.5.2.1.3) may be hardened to any of the conditions of Table 3 to better define the grain boundaries.