AEROSPACE MATERIAL SPECIFICATION

AMS5922™	REV. D

Issued 2008-01
Revised 2024-11

Superseding AMS5922C

(R) Steel, Corrosion-Resistant, Bars, Forgings and Forging Stock 10Cr - 5.5Ni - 14Co - 2Mo - 1W (0.19-0.23C), Premium Aircraft Quality, Vacuum Induction Melted, Vacuum Arc Remelted, Normalized and Annealed (Composition similar to UNS S10500)

RATIONALE

AMS5922D is the result of a Five-Year Review and update of the specification. The revision updates the Title to match the Scope, addresses composition reporting (see 3.1.1), prohibits bar cut from plate (see 3.3.1.1 and 4.4.3), updates heat treatment, including the addition of a second option for heat treatment (double temper), revises the aim temperatures and conversions (see 3.4 and 3.5.3), addresses macrostructure requirements for hollow product (see 3.5.1.1 and 8.7), clarifies tensile test requirements (see 3.5.3.1), updates fracture toughness requirements (see 3.5.3.3.1), adds macrostructure and microstructure reporting, updates reporting of hardness to a per heat basis (see 4.4.1), adds forging stock properties (see 4.4.4 and 8.7), adds bar quality information (see 8.5), and updates the exceptions requirements (see 8.6).

1. SCOPE

1.1 Form

This specification covers a corrosion-resistant, premium aircraft-quality alloy steel in the form of bars, forgings, and stock for forging.

1.2 Application

These products have been used typically for heat-treated parts requiring a combination of high strength, good toughness, weldability, and stress-corrosion resistance, but usage is not limited to such applications. Product after heat treatment should attain a minimum tensile strength of 280 ksi (1931 MPa).

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)
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For more information on this standard, visit
https://www.sae.org/standards/content/AMS5922D/

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

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

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 Test Methods and Definitions for 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 E45 Determining the Inclusion Content of Steel

ASTM E140 Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

ASTM E399 Linear Elastic Plane-Strain Fracture Toughness K_{Ic} of Metallic Materials

ASTM E1181 Characterizing Duplex Grain Sizes

2.3 Definitions

Terms used in AMS are defined in AS7766.

3. TECHNICAL REQUIREMENTS

3.1 Composition

Composition shall conform to the percentages by weight shown in Table 1, determined in accordance with ASTM A751 or by other analytical methods acceptable to the purchaser.

Table 1 - Composition

Element	Min	Max
Carbon	0.19	0.23
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.008
Sulfur	--	0.005
Chromium	9.50	10.50
Nickel	5.20	5.80
Cobalt	13.50	14.50
Molybdenum	1.80	2.20
Tungsten	0.80	1.20
Titanium	--	0.015
Aluminum	--	0.01
Vanadium	0.25	0.35
Oxygen	--	0.0020 (20 ppm)
Nitrogen	--	0.0015 (15 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. No variation is permitted for oxygen and nitrogen.

3.2 Melting Practice

Steel shall be multiple melted using vacuum induction melting followed by vacuum arc remelting.

3.3 Condition

The product shall be supplied in the following condition; hardness shall be determined in accordance with ASTM A370:

3.3.1 Bars and Forgings

Bars and forgings shall be normalized and annealed (see 3.4) with a resulting hardness not higher than 372 HBW, or equivalent (see 8.2), and descaled.

3.3.1.1 Bars shall not be cut from plate (see 4.4.3).

3.3.2 Stock for Forging

Stock for forging shall be as ordered by the forging manufacturer.

3.4 Heat Treatment

Bars and forgings shall be heat treated in accordance with 3.4.1 or 3.4.2. Pyrometry shall be in accordance with AMS2750.

3.4.1 Bars and forgings shall be:

a. Normalized by:

1. Heating to 1975 °F ± 25 °F (1079 °C ± 14°C) and holding at the selected temperature for a time commensurate with section thickness for a minimum of 60 minutes.

2. Cooling in air to room temperature, subzero cooling to -100 °F (-73 °C) or lower, and holding at temperature for a minimum of 60 minutes.

3. Air warming to room temperature.

b. Annealed by:

1. Heating to 1255 °F ± 25 °F (679 °C ± 14 °C) and holding at temperature for 8 hours (+2 hours, -0.5 hour).

2. Cooling in air to room temperature.

3.4.2 Bars and forgings shall be:

a. Normalized by:

1. Heating to 1975 °F ± 25 °F (1079 °C ± 14 °C) and holding at the selected temperature for a time commensurate with section thickness for a minimum of 60 minutes.

2. Cooling to 50 °F (10 °C) or lower and holding for a minimum of 4 hours.

b. Annealed by:

1. Heating to 1255 °F ± 25 °F (679 °C ± 14 °C) and holding at temperature for 8 hours (+2 hours, -0.5 hour).

2. Cooling in air to room temperature.

3. Cooling to 50 °F (10 °C) or lower and holding for a minimum of 4 hours.

c. Re-annealed by:

1. Heating to 1255 °F ± 25 °F (679 °C ± 14 °C) and holding at temperature for 8 hours (+2 hours, -0.5 hour).

2. Cooling in air to room temperature.

3.5 Properties

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

3.5.1 Macrostructure

Visual examination of transverse full cross sections from bars, billets, and stock for forging, 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.

3.5.1.1 Macrostructure examination is not required for bored/hollow forgings that are produced directly from ingots or large blooms, unless otherwise agreed upon by the purchaser and producer (see 8.7).

Table 2 - Macrostructure limits

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

3.5.2 Micro-Inclusion Rating

No specimen shall exceed the limits shown in Table 3, determined in accordance with ASTM E45, Method D.

Table 3 - Micro-inclusion rating limits

	A Thin	A Heavy	B Thin	B Heavy	C Thin	C Heavy	D Thin	D Heavy
Worst Field Severity	1.5	1.0	1.5	1.0	1.5	1.0	1.5	1.0
Worst Field Frequency, maximum	(a)	1	(a)	1	(a)	1	3	1
Total Ratable Fields, Frequency, maximum	(b)	1	(b)	1	(b)	1	8	1

(a) Combined A+B+C; not more than 3 fields.
(b) Combined A+B+C; not more than 8 fields.

3.5.2.1.1 A ratable field is defined as one that has a type A, B, C, or D inclusion rating of at least No. 1.0 thin or heavy.

3.5.3 Response to Heat Treatment

Test specimens extracted from product shall conform to the following requirements after being heat treated as follows:

a. Harden

1. Heating to 1985 °F ± 25 °F (1085 °C ± 14 °C) and holding at heat for 60 minutes (+10 minutes, -0 minutes).
2. Quenching in oil (or equivalent).
3. Subzero cooling to -100 °F (-73 °C) or lower and holding at temperature for 1 hour (+2 hours, -0 hours).
4. Warming in air to room temperature.

b. Double Temper

1. Heating to 935 °F ± 15 °F (501 °C ± 8 °C) and holding at heat for 3 hours ± 0.5 hour.
2. Quenching in oil (or equivalent), cooling to -100 °F (-73 °C) or lower, and holding at temperature for 1 hour (+2 hours, -0 hours).
3. Warming in air to room temperature.
4. Reheating to 900 °F ± 20 °F (482 °C ± 11 °C) and holding at heat for 12 hours (+2 hours, -1 hour).
5. Cooling in air (or equivalent).

3.5.3.1 Tensile Properties

Tensile properties shall be as shown in Table 4.

Table 4 - Minimum tensile properties - response to heat treatment

Property	Value
Tensile Strength	280 ksi (1931 MPa)
Yield Strength at 0.2% Offset	213 ksi (1468 MPa)
Elongation in 4D	11%
Reduction of Area	44%

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

3.5.3.1.2 If the product cross section does not allow a 2.5-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.

3.5.3.1.3 If the product cross section does not allow a 2.5-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.

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

3.5.3.2 Hardness

Hardness shall be not lower than 53 HRC, or equivalent (see 8.2).

3.5.3.3 Fracture Toughness

Material fracture toughness shall be not lower than 50 ksi $\sqrt{\text{inch}}$ (55 MPa $\sqrt{\text{m}}$) K_{IC}, determined in accordance with ASTM E399 on specimens in the longitudinal LS or LR orientation from product over 3.00 inches (76.2 mm) and over in nominal section thickness. If product size precludes use of specimens that will provide valid K_{IC} results, a K_Q value not lower than 50 ksi $\sqrt{\text{inch}}$ (55 MPa $\sqrt{\text{m}}$) will be acceptable.

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

a. $W-a < 2.5 (KQ/\sigma YS)^2$

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

3.5.3.4 Average Grain Size

Average grain size shall be ASTM No. 4 or finer, range ASTM No. 12 to ASTM No. 1, for product 50 square inches (232 cm^2) and under in cross-sectional area, determined in accordance with ASTM E1181. The sample shall have been heat treated in accordance with 3.5.3.

3.5.4 Forging Stock

When a sample of stock is forged to a test coupon acceptable to the purchaser and heat treated as in 3.4 and 3.5.3, specimens taken from the heat-treated coupon shall conform to the requirements of 3.5.3.1, 3.5.3.2, 3.5.3.3, and 3.5.3.4. If specimens taken from the stock after heat treatment as in 3.4 and 3.5 conform to the requirements of 3.5.3.1, 3.5.3.2, 3.5.3.3, and 3.5.3.4, the tests shall be accepted as equivalent to tests of a forged coupon.

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.

3.6.3 Grain flow of die forgings, except in areas that 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 AMS2241.

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 4.4.2.

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:

Composition (see 3.1), macrostructure rating (see 3.5.1), and micro-inclusion rating (see 3.5.2) of each heat; tensile properties (see 3.5.3.1) and hardness (see 3.5.3.2) of each lot of bars and forgings - response to heat treatment; and tolerances (see 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:

Average grain size (see 3.5.3.4) of bars and forgings - response to heat treatment; fracture toughness (see 3.5.3.3) of bars and forgings - response to heat treatment; ability of forging stock (see 3.5.4) to develop required properties; frequency-severity cleanliness rating (see 3.6.1); and grain flow of die forgings (see 3.6.3).

4.3 Sampling and Testing

4.3.1 Bars and stock for forging shall be sampled and tested in accordance with AMS2371.

4.3.2 Forgings shall be sampled and tested in accordance with AMS2374.