AEROSPACE MATERIAL SPECIFICATION

AMS5900™	REV. D

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Superseding AMS5900C

Steel Bars, Wire, Forgings, Mechanical Tubing and Forging Stock, Corrosion Resistant 14Cr - 2.1Mo - 0.30Cb (Nb) - 1.0V (1.05 - 1.15C) Premium Aircraft Quality for Bearing Applications, Double Vacuum Melted, Annealed

(Composition similar to UNS S42800)

RATIONALE

AMS5900D is the result of a Five-Year Review and update of the specification. The revision updates the Title to include the condition and applicable forms, addresses composition reporting (see 3.1.1), clarifies macrostructure requirements (see 3.4.1 and 8.8), revises decarburization measurement methods (see 3.4.4.5), clarifies quality requirements for bar (see 3.5.2 and 8.6), updates bar from plate reporting (see 4.4.2), permits additional forging stock properties to be specified (see 4.4.4 and 8.8), and updates the prohibition of exceptions requirements (see 8.7).

1. SCOPE

1.1 Form

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

1.2 Application

These products have been used typically for critical bearing components requiring a through-hardening, corrosion-resistant steel operating under heavy loads and high speeds at moderate temperatures and subject to very rigid inspection standards, 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)
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Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS5900D/

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

AMS2243 Tolerances, Corrosion and Heat-Resistant Steel Tubing

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

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

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 E45 Determining the Inclusion Content of Steels

ASTM E112 Determining the 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 E1077 Estimating the Depth of Decarburization of Steel Specimens

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	1.05	1.15
Manganese	0.25	0.50
Silicon	0.20	0.40
Phosphorus	--	0.015
Sulfur	--	0.010
Chromium	13.75	14.75
Molybdenum	1.90	2.25
Columbium (Niobium)	0.25	0.35
Vanadium	0.90	1.15
Nickel	--	0.35
Copper	--	0.35

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.

3.2 Melting Practice

Product shall be multiple melted using vacuum induction melting practice followed by vacuum consumable electrode remelting.

3.3 Condition

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

3.3.1 Bars

Bars shall be annealed having hardness not higher than 255 HB, or equivalent (see 8.2).

3.3.1.1 All hexagons and other bars 2.75 inches (69.8 mm) and under in nominal diameter or distance between parallel sides shall be cold finished.

3.3.1.2 Bars, other than hexagons, over 2.75 inches (69.8 mm) in nominal diameter or distance between parallel sides shall be hot finished.

3.3.1.3 Bars shall not be cut from plate (see 4.4.2).

3.3.2 Wire

Wire shall be cold finished and annealed having a tensile strength not higher than 130 ksi (896 MPa), except that for wire 0.062 inch (1.57 mm) and under in nominal diameter tensile strength shall be as agreed upon by the purchaser and producer.

3.3.3 Forgings

Forgings shall be supplied as ordered.

3.3.4 Mechanical Tubing

Mechanical tubing shall be annealed and cold finished having hardness not higher than 293 HB, or equivalent (see 8.2).

3.3.5 Forging Stock

Forging stock shall be as ordered by the forging manufacturer.

3.4 Properties

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

3.4.1 Macrostructure

Visual examination of transverse full cross sections from bars, forgings, tube rounds, and forging stock, etched in hot hydrochloric acid in accordance with ASTM A604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections for product 225 square inches (1452 cm^2) and under in nominal cross-sectional area shall be no worse than the macrographs of ASTM A604 shown in Table 2.

3.4.1.1 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 8.8).

3.4.1.2 If mechanical tubing is produced directly from ingots or large blooms, transverse sections may be taken from the tubing. Macrostructure standards for such tubes shall be as agreed upon by the purchaser and producer (see 8.8).

Table 2 - Macrostructure limits

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

3.4.2 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 limits

	A Thin	A Heavy	B Thin	B Heavy	C Thin	C Heavy	D Thin	D Heavy
Worst Field Severity	1.5	1.0	1.0	1.0	1.0	1.0	1.5	1.0
Worst Field Frequency, max	x	1	x	1	x	1	3	1
Total Ratable Fields, Frequency, max	y	1	y	1	y	1	8	1

[x] Combined A+B+C; not more than 3 fields.
[y] Combined A+B+C; not more than 8 fields.

3.4.2.1 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 in accordance with ASTM E45.

3.4.3 Response to Heat Treatment

Specimens (see 4.3.3) shall have hardness not lower than 60 HRC, or equivalent (see 8.2), after being treated as follows in a neutral atmosphere or neutral salt to minimize scale and prevent either carburization or decarburization:

a. Preheat at 1500 °F ± 10 °F (816 °C ± 6 °C) for not less than 15 minutes.

b. Heat to 2100 °F ± 25 °F (1149 °C ± 14 °C) and hold at heat for 7 to 10 minutes. Oil quench to room temperature or, preferably, quench into salt maintained at 1050 to 1150 °F (566 to 621 °C), hold at temperature for 2 minutes ± 0.2 minute, and cool in air to room temperature.

c. Stress relieve by heating to 300 °F ± 15 °F (149 °C ± 8 °C), hold at temperature for 60 minutes ± 5 minutes, and cool in air to room temperature.

d. Subzero cool to -100 °F ± 10 °F (-73 °C ± 6 °C), hold at temperature for not less than 15 minutes, and allow to return to room temperature in air.

e. Temper within 4 hours after the subzero cool by heating to 975 °F ± 15 °F (524 °C ± 8 °C), holding at heat for 2 hours ± 0.25 hour, and cooling in air to room temperature.

3.4.4 Decarburization

3.4.4.1 Bars, wire, and mechanical tubing ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces.

3.4.4.2 Allowable decarburization of bars, wire, forging stock, and tubing ordered for redrawing or forging or to specified microstructural requirements shall be as agreed upon by the purchaser and producer.

3.4.4.3 Decarburization of bars to which 3.4.4.1 or 3.4.4.2 is not applicable shall be not greater than shown in Table 4.

Table 4A - Maximum decarburization, inch/pound units

Nominal Diameter or Distance Between Parallel Sides Inches	Total Depth of Decarburization Inch
Up to 0.500, incl	0.015
Over 0.500 to 1.000, incl	0.030
Over 1.000 to 2.000, incl	0.040
Over 2.000 to 3.000, incl	0.050
Over 3.000 to 4.000, incl	0.065
Over 4.000 to 5.000, incl	0.095

Table 4B - Maximum decarburization, SI units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Total Depth of Decarburization Millimeters
Up to 12.70, incl	0.38
Over 12.70 to 25.40, incl	0.76
Over 25.40 to 50.80, incl	1.02
Over 50.80 to 76.20, incl	1.27
Over 76.20 to 101.60, incl	1.65
Over 101.60 to 127.00, incl	2.41

3.4.4.4 Decarburization of tubing to which 3.4.4.1 or 3.4.4.2 is not applicable shall be not greater than shown in Table 5.

Table 5A - Maximum decarburization, inch/pound units

Nominal Outside Diameter Inches	Total Depth of Decarburization Inch
Up to 1.000, incl	0.025
Over 1.000 to 2.000, incl	0.035
Over 2.000 to 3.000, incl	0.045
Over 3.000 to 4.000, incl	0.055
Over 4.000 to 5.000, incl	0.080

Table 5B - Maximum decarburization, SI units

Nominal Outside Diameter Millimeters	Total Depth of Decarburization Millimeters
Up to 25.40, incl	0.64
Over 25.40 to 50.80, incl	0.89
Over 50.80 to 76.20, incl	1.14
Over 76.20 to 101.60, incl	1.40
Over 101.60 to 127.00, incl	2.03

3.4.4.5 Decarburization shall be measured by one of the two methods of 3.4.4.5.1 or 3.4.4.5.2.

3.4.4.5.1 Metallographic (Microscopic) Method

A cross section taken perpendicular to the surface shall be etched and examined metallographically at a magnification not to exceed 200X in accordance with ASTM E1077. The sample shall not show a layer of complete (ferrite) or partial decarburization exceeding the limits of Table 4 or Table 5.

3.4.4.5.2 Hardness Traverse (Microindentation) Method

The total depth of decarburization shall be determined by a traverse method using microindentation hardness testing in accordance with ASTM E1077. Samples shall be hardened and protected during heat treatment to prevent changes in surface carbon content. Samples may be tempered at the option of the producer. Measurements shall be far enough away from any adjacent surface to be uninfluenced by any decarburization on the adjacent surface. Acceptance shall be as listed in Table 5 or Table 6.

3.4.4.5.3 When determining the depth of decarburization, it is permissible to disregard local areas provided the decarburization of such areas does not exceed the above limits by more than 0.005 inch (0.13 mm) and the width is 0.065 inch (1.65 mm) or less.

3.4.4.5.4 In case of dispute, the depth of decarburization determined using the hardness traverse method shall govern.

3.4.5 Average Grain Size

The average grain size shall be ASTM 7 or finer determined in accordance with ASTM E112 (see 8.3).

3.5 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.

3.5.1 Steel shall be premium aircraft-quality conforming to AMS2300.

3.5.2 Bars and mechanical tubing shall be free from seams, laps, tears, and cracks open to the ground, turned, or polished surface after removal of the standard machining allowance in accordance with AS1182.

3.5.3 Forgings shall have substantially uniform macrostructure. Standards for acceptance shall be as agreed upon by the purchaser and producer.

3.5.4 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.

3.6 Tolerances

3.6.1 Bars and Wire

Tolerances for bar and wire shall conform to all applicable requirements of AMS2241.

3.6.2 Mechanical Tubing

Tolerances for mechanical tubing shall conform to all applicable requirements of AMS2243.

3.7 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 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 are acceptance tests and shall be performed on each heat or lot as applicable: composition (see 3.1), condition (see 3.3), macrostructure rating (see 3.4.1), micro-inclusion rating (see 3.4.2), response to heat treatment (see 3.4.3), decarburization (see 3.4.4), average grain size (see 3.4.5), quality (see 3.5.2), and tolerances (see 3.6).

4.2.2 Periodic Tests

Frequency-severity cleanliness rating (see 3.5.1) and grain flow of die forgings (see 3.5.4) 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, Mechanical Tubing, and Forging Stock

Sampling and testing of bars, wire, mechanical tubing, and forging stock shall be in accordance with AMS2371.

4.3.2 Forgings

Sampling and testing of forgings shall be in accordance with AMS2374.

4.3.3 Samples for response to heat treatment (see 3.4.3) of bars, forgings, and forging stock shall be the full cross section of the product ground on both faces normal to the axis so that the length is 0.375 to 0.500 inch (9.52 to 12.70 mm). Specimens from mechanical tubing shall be full sections of the tubing, shall have wall thickness of 0.625 inch (15.88 mm) or less with wall thicknesses over 0.625 inch (15.88 mm) being turned to 0.625 inch ± 0.010 inch (15.88 mm ± 0.25 mm), and shall be ground on both faces normal to the axis so that length is 0.375 to 0.500 inch (9.52 to 12.70 mm).

4.4 Reports

4.4.1 The producer of the product shall furnish with each shipment a report showing the producer's name, country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations), and the results of the following tests. The report shall state that the product conforms to the other technical requirements.

For each heat:

Chemical composition
Macrostructure
Micro-inclusion rating

For each lot:

Condition
Response to heat treatment
Average grain size