AEROSPACE MATERIAL SPECIFICATION

AMS5933™	REV. B

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Superseding AMS5933A

Steel, Corrosion Resistant Bars and Forgings
12.5Cr - 1.0Ni - 15.5Co - 2.0Mo
Vacuum Induction Plus
Vacuum Consumable Electrode Remelted

RATIONALE

AMS5933B has been declared "STABILIZED" by AMS Committee F. This document will no longer be updated and may no longer represent standard industry practice. This document was stabilized because Committee F can find no users for this document and thus no further revisions are anticipated. Previously this document was revised. The last technical update of this document occurred in November 2018. Users of this document should refer to the cognizant engineering organization for disposition of any issues with reports/certifications to this specification; including exceptions listed on the certification.

NOTE: In many cases, the purchaser may represent a sub tier supplier and not the cognizant engineering organization.

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1. SCOPE

1.1 Form

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

1.2 Application

These products have been used typically for aircraft landing gear parts requiring tensile strength levels of 255 ksi (1758 MPa) and higher with good fracture toughness and corrosion resistance, 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.

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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

AMS2806 Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat-Resistant Steels and Alloys

AMS2808 Identification, Forgings

ARP1917 Clarification of Terms Used in Aerospace Metals Specifications

AS1182 Standard Stock Removal Allowance, Aircraft-Quality and Premium Aircraft-Quality Steel Bars and Mechanical Tubing

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 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

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

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 A751, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

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Table 1 - Composition

Element	Min	Max
Carbon	0.18	0.25
Manganese	0.40	1.00
Silicon	0.40	1.00
Phosphorus	--	0.03
Sulfur	--	0.03
Chromium	12.00	13.50
Nickel	0.80	1.20
Molybdenum	1.75	2.25
Cobalt	14.50	16.50
Columbium	--	0.10

3.1.1 Check Analysis

Composition variations shall meet the requirements of AMS2248.

3.2 Melting Practice

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

3.3 Condition

3.3.1 Bars

Annealed with hardness not higher than BHN 363, or equivalent (see 8.1), determined in accordance with ASTM A370.

3.3.1.1 Bars shall not be cut from plate (also see 4.4.1).

3.3.2 Forgings

As ordered.

3.3.3 Forging Stock

As ordered by the forging manufacturer.

3.4 Properties

The product shall conform to the following requirements:

3.4.1 Average Grain Size

Shall be ASTM No. 4 or finer, determined in accordance with ASTM E112.

3.4.2 Macrostructure

Visual examination of transverse full cross-sections of bars, forgings, 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 shall be no worse than the macrographs of ASTM A604 shown in Table 2.

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Table 2 - Macrostructure limits

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

3.4.3 Response to Heat Treatment

Product 6.00 inches (15.2 mm) and under in nominal diameter or maximum cross-sectional dimension, shall conform to the following requirements after austenitizing by heating to 1985 °F ± 25 °F (1085 °C ± 14 °C), holding at heat for not less than 1 hour, quenching in oil not hotter than 140 °F (60 °C), cooling to -100 °F ± 20 °F (-73 °C ± 11 °C) for not less than 2 hours, tempering twice at 725 °F ± 10 °F (385 °C ± 6 °C) for 2 hours, and cooling to room temperature.

3.4.3.1 Longitudinal Tensile Properties

Shall be as shown in Table 3, determined in accordance with ASTM A370.

Table 3

Table 3A - Minimum tensile properties, inch/pound units

Property	Value
Tensile Strength	255 ksi
Yield Strength at 0.2% Offset	185 ksi
Elongation	15%
Reduction of Area	40%

Table 3B - Minimum tensile properties, SI units

Property	Value
Tensile Strength	1758 MPa
Yield Strength at 0.2% Offset	1276 MPa
Elongation	15%
Reduction of Area	40%

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3.4.3.2 Fracture Toughness

Shall not be lower than 100 ksi $\sqrt{\text{inch}}$ K_{IC} (110 MPa $\sqrt{\text{m}}$), determined in accordance with ASTM E399. Fracture toughness specimens shall be taken in the longitudinal LS or LR orientation. If standard 1 inch thick specimens are not capable, due to section size, of yielding a K_{IC} value, the K_Q value will be acceptable.

3.4.3.3 Hardness

Shall be a minimum of 50 HRC, or equivalent (see 8.2).

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 internal and external imperfections detrimental to usage of the product.

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

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

3.5.3 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 re-entrant grain flow.

3.6 Tolerances

Bars shall conform to all applicable requirements of AMS2241.

3.7 Any exceptions shall be authorized by 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 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), macrostructure (3.4.2), and frequency-severity cleanliness rating (3.5.1) of each heat.

4.2.1.2 Condition (3.3.), average grain size (3.4.1), and response to heat treatment (3.4.3.1, 3.4.3.2, and 3.4.3.3) of each lot.

4.2.1.3 Tolerances (3.6) of bars.

4.2.2 Periodic Test

Grain flow of die forgings (3.5.3) 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 and Forging Stock

In accordance with AMS2371.

4.3.2 Forgings

In accordance with AMS2374.

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