AEROSPACE MATERIAL SPECIFICATION

AMS6539™	REV. B
Issued 2013-02 Revised 2024-01 Superseding AMS6539A	

Steel Bars, Forgings, Mechanical Tubing and Forging Stock
1.7Cr - 3.8Ni - 0.3Mo (0.32 - 0.38C)
Aircraft-Quality
(Composition similar to UNS K54532)

RATIONALE

AMS6539B is the result of a Five-Year Review and update of the specification. The revision updates the Title to match the Scope, clarifies composition reporting (see 3.1.2), modifies macrostructure requirements (see 3.3.1), revises testing specifications (see 3.2.1 and 3.3.3), adds tables to clarify heat treatment (see 3.3.3, Table 3, and Table 4), temper temperature conversion corrected (see Table 3 and Table 5), updates product exceptions (see Table 2 and 8.5), adds reduced testing per AMS2301 (see 4.2.1 and 4.4), updates prohibition of bar from plate (see 4.4.2), and adds information on ordering bar and tubing (see 8.4).

1. SCOPE

1.1 Form

This specification covers an aircraft-quality, low-alloy steel in the form of bars, forgings, mechanical tubing, and forging stock.

1.2 Application

These products have been used typically for carburized parts requiring high minimum core hardness with a narrow range, reduced distortion and subject to magnetic particle 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.

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.

AMS2251 Tolerances, Low-Alloy Steel Bars

AMS2253 Tolerances, Carbon and Alloy Steel Tubing

AMS2259 Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels

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/AMS6539B

AMS2301 Steel Cleanliness, Aircraft Quality, Magnetic Particle Inspection Procedure

AMS2370 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock

AMS2372 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel 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 A255 Determining Hardenability of Steel

ASTM A751 Chemical Analysis of Steel Products

ASTM E8/E8M Tension Testing of Metallic Materials

ASTM E10 Brinell Hardness of Metallic Materials

ASTM E23 Notched Bar Impact Testing of Metallic Materials

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 E381 Macroetch Testing Steel Bars, Billets, Blooms and Forgings

2.3 Definitions

Terms used in AMS are defined in AS7766.

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the following 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	0.32	0.40
Manganese	0.30	0.60
Silicon	0.15	0.40
Phosphorus	--	0.025
Sulfur	--	0.015
Chromium	1.60	2.00
Nickel	3.60	4.10
Molybdenum	0.25	0.60
Copper	--	0.20

3.1.1 Aluminum, vanadium, and columbium (niobium) are optional grain refining elements and need not be determined or reported unless used to satisfy the average grain size requirements of 3.3.2.2.

3.1.2 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.

3.1.3 Check Analysis

Composition variations shall meet the applicable requirements of AMS2259.

3.2 Condition

3.2.1 The product shall be supplied in the following condition. Tensile properties shall be in accordance with ASTM E8/E8M. Hardness shall be determined in accordance with ASTM E10.

3.2.2 Bars

Bar shall not be cut from plate (see 4.4.2).

3.2.2.1 Bars 0.500 Inch (12.70 mm) and Under in Nominal Diameter or Least Distance Between Parallel Sides

Cold finished having tensile strength not higher than 142 ksi (980 MPa) or hardness not higher than 295 HBW, or equivalent (see 8.2).

3.2.2.2 Bars Over 0.500 Inch (12.70 mm) in Nominal Diameter or Least Distance between Parallel Sides

Hot finished and annealed, unless otherwise ordered, having hardness not higher than 295 HBW, or equivalent (see 8.2). Bars ordered cold finished may have hardness as high as 310 HBW, or equivalent (see 8.2).

3.2.3 Forgings

As ordered.

3.2.4 Mechanical Tubing

Cold finished, unless otherwise ordered, having hardness not higher than 295 HBW, or equivalent (see 8.2). Tubing ordered hot finished and annealed or tempered shall have hardness not higher than 295 HBW, or equivalent (see 8.2).

3.2.5 Forging Stock

As ordered by the forging manufacturer.

3.3 Properties

The product shall conform to the following requirements:

3.3.1 Macrostructure

Visual examination of transverse full cross sections from bars, billets tube rounds (solid, not hollow), and forging stock, etched in hot hydrochloric acid in accordance with ASTM E381, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM E381 shown in Table 2.

Table 2 - Macrostructure limits

Cross-Sectional Area Square Inches	Cross-Sectional Area Square Centimeters	Macrographs
Up to 36, incl	Up to 232, incl	S2 – R1 – C2
Over 36 to 133, incl	Over 232 to 858, incl	S2 – R2 – C3
Over 133	Over 858	Note 1

Note 1: Limits for larger sizes shall be agreed upon by purchaser and producer.

3.3.1.1 Macrostructure examination is not required for bored/hollow forgings (including ring forgings) and mechanical tubing that are produced directly from ingots or large blooms unless otherwise agreed upon by the purchaser and producer (see 8.8).

3.3.1.2 If mechanical tubing is produced directly from ingots or large blooms, transverse sections may be taken from the tubes rather than tube rounds. Macroetch standards for such tubes shall be agreed upon by the purchaser and producer (see 8.8).

3.3.2 Average Grain Size of Bars, Forgings, and Tubing

Average grain size shall be determined by either 3.3.2.1 or 3.3.2.2.

3.3.2.1 Shall be ASTM No. 5 or finer determined in accordance with ASTM E112.

3.3.2.2 The product of a heat shall be considered to have an ASTM No. 5 or finer austenitic grain size if one or more of the following are determined by heat analysis (see 8.7):

3.3.2.2.1 A total aluminum content of 0.020 to 0.050%.

3.3.2.2.2 An acid soluble aluminum content of 0.015 to 0.050%.

3.3.2.2.3 A vanadium content of 0.02 to 0.08%.

3.3.2.2.4 A columbium (niobium) content of 0.02 to 0.05%.

3.3.3 Response to Heat Treatment of Bars, Forgings, Tubing, and Forging Stock

Specimens shall be heat treated using each of the two different tempering cycles shown in Tables 3 and Table 4. Specimens from the two different tempering cycles shall have the properties shown in Table 5. Tensile properties shall be determined in accordance with ASTM E8/E8M. Impact testing shall be in accordance with ASTM E23.

Table 3 - Response to temper #1 - 410 °F (210 °C) temper

Processing Step [1]		Temperature	Time at Temperature
1	Austenitized	1607 °F ± 25 °F (875 °C ± 14°C)	Time commensurate with section thickness, heating equipment, and procedure used
2	Air Quench to below 90 °F (32 °C)		
3	Subzero treatment	-100 °F or colder (-73 °C) or colder	2 hours minimum
4	Warm in air to Room Temperature		
5	Temper	410 °F± 10 °F (210 °C ± 6 °C)	2 hours minimum
[1] Note that all processing must be performed in the order noted.			

Table 4 - Response to temper #2 - 1040 °F (560 °C) temper

Processing Step [1]		Temperature	Time at Temperature
1	Austenitized	1607 °F ± 25 °F (875 °C ± 14 °C)	Time commensurate with section thickness, heating equipment, and procedure used
2	Air Quench to Below 90 °F (32 °C)		
3	Temper	1040 °F± 10 °F (560 °C ± 6 °C)	2 hours minimum
[1] Note that all processing must be performed in the order noted.			

Table 5 - Minimum longitudinal mechanical properties - response to heat treatment

Temper	Temperature	Property	Value
#1	410 °F (210 °C)	Tensile Strength	254 ksi (1750 MPa)
		Yield Strength 0.2%	203 ksi (1400 MPa)
		Elongation in 4D	8%
		Charpy V–Notch	14 ft-lbf (19 J)
#2	1040 °F (560 °C)	Tensile Strength	178 ksi (1230 MPa)
		Yield Strength 0.2%	152 ksi (1050 MPa)
		Elongation in 4D	12%
		Charpy V–Notch	26 ft-lbf (35 J)

3.3.3.1 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).

3.4 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.

3.4.1 Steel shall be aircraft-quality conforming to AMS2301.

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

3.4.3 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.

3.5 Tolerances

3.5.1 Bars

In accordance with AMS2251.

3.5.2 Mechanical Tubing

In accordance with AMS2253.

3.6 Any exceptions 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

Composition (see 3.1), condition (see 3.2), macrostructure (see 3.3.1), average grain size (see 3.3.2), response to heat treatment for both tempering temperatures (see 3.3.3), frequency-severity cleanliness rating (see 3.4.1), and tolerances (see 3.5) are acceptance tests and shall be performed on each heat or lot as applicable. If grain refining elements (see 3.3.2.2) are not present, the ASTM E112 grain size test (see 3.3.2.1) shall be conducted on each lot. If process qualification in accordance with AMS2301 has been met, the frequency-severity cleanliness rating shall be conducted on a periodic basis as defined in AMS2301.

4.2.2 Periodic Tests

If grain refining elements (see 3.3.2.2) are present, the ASTM E112 grain size test (see 3.3.2.1) shall be conducted on a periodic basis and shall be performed at a frequency selected by the producer (not to exceed 1 year) unless frequency of testing is specified by the purchaser. Grain flow of die forgings (see 3.4.3) is a periodic test 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, Mechanical Tubing, and Forging Stock

In accordance with AMS2370.

4.3.2 Forgings

In accordance with AMS2372.

4.4 Reports

4.4.1 The producer of the bars, forgings and tubing shall furnish with each shipment a report showing the producer's identity, country where the metal was melted (i.e., final melt in the case of metal processed by multiple melting operations), results of tests for composition macrostructure, response to heat treatment and frequency-severity cleanliness rating of each heat (see 4.4.5), for condition, average grain size (if measured) 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, AMS6539B, product form and size (and/or part number, if applicable), and quantity. If forgings are supplied, the size and melt source of stock used to make the forgings shall also be included. If the grain size requirement of 3.3.2 is met by the aluminum, vanadium, and/or columbium (niobium) content, the aluminum, vanadium, and/or columbium (niobium) content shall be reported and a statement that the chemistry satisfies the grain size requirement shall be included.

4.4.2 Report the nominal metallurgically worked size and the cut size if different (see 3.2.1).

4.4.3 The producer of forging stock shall furnish with each shipment a report showing the producer's identity, country where the metal was melted (i.e., final melt in the case of metal processed by multiple melting operations), results of tests for composition, macrostructure, response to heat treatment and frequency-severity cleanliness rating (see 4.4.5) of each heat, and the results of additional property requirements imposed by the purchase order (see 8.8). This report shall include the purchase order number, heat number, AMS6539B, size, and quantity.

4.4.4 When material produced to this specification has exceptions authorized by the purchaser taken to the technical requirements listed in Section 3, the report shall contain a statement "This material is certified as AMS6539B(EXC) because of the following exceptions:" and the specific exceptions shall be listed (see 5.2.1).

4.4.5 Reduced Testing

If the producer has qualified for periodic testing for frequency-severity cleanliness rating in accordance with AMS2301, then the frequency severity cleanliness rating is not required to be reported for each shipment. In this circumstance the report shall read, "Process qualification in accordance with AMS2301 has been completed."

4.5 Resampling and Retesting

4.5.1 Bars, Mechanical Tubing, and Forging Stock

In accordance with AMS2370.

4.5.2 Forgings

In accordance with AMS2372.

5. PREPARATION FOR DELIVERY

5.1 Sizes

Except when exact lengths or multiples of exact lengths are ordered, straight bars and tubing will be acceptable in mill lengths of 6 to 20 feet (1.8 to 6.1 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 feet (3 m).

5.2 Identification

5.2.1 Bars and Mechanical Tubing

In accordance with AMS2806. When technical exceptions are taken (see 4.4.4), the material shall be marked with AMS6539B(EXC).

5.2.2 Forgings

In accordance with AMS2808.