



AEROSPACE MATERIAL SPECIFICATION

AMS6294™

REV. L

Issued 1939-12
Reaffirmed 2006-02
Revised 2023-10

Superseding AMS6294K

Steel Bars and Forgings and Forging Stock, Carburizing,
Aircraft-Quality
1.8Ni - 0.25Mo (0.17 - 0.22C) (4620)
(Composition similar to UNS G46200)

RATIONALE

AMS6294L is the result of a Five-Year Review and update of the specification. The revision includes update of the Title to match the Scope and product quality, addition to composition reporting (see 3.1.2), clarification of macrostructure for hollow forgings (see 3.3.1 and 8.9), revision of hardenability requirements (see 3.3.3), incorporation of requirements for periodic testing per AMS2301 (see 4.2.1 and 4.4.5), additional ordering information on forging stock (see 4.4.3 and 8.9), notes on grain size testing (see 8.6) and bar stock quality (see 8.7), and updates to the requirements for product exceptions (see 8.8).

1. SCOPE

1.1 Form

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

1.2 Application

These products have been used typically for carburized parts that require high minimum core hardness and allow wide hardness range in sections 0.375 inch (9.5 mm) and under in nominal thickness, but usage is not limited to such applications. The core may or may not be machinable after hardening.

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

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

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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 A370	Mechanical Testing of Steel Products
ASTM A751	Standard Test Methods, Practices, and Terminology for 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 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 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	0.17	0.22
Manganese	0.45	0.65
Silicon	0.15	0.35
Phosphorus	--	0.025
Sulfur	--	0.025
Nickel	1.65	2.00
Molybdenum	0.20	0.30
Chromium	--	0.20
Copper	--	0.35

- 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.
- 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

The product shall be supplied in the following condition unless another condition is authorized by the purchaser; hardness and tensile strength shall be determined in accordance with ASTM A370:

3.2.1 Bars

- 3.2.1.1 Bars 0.500 inch (12.70 mm) and under in nominal diameter or least distance between parallel sides shall be cold finished having tensile strength not higher than 130 ksi (895 MPa) or equivalent hardness (see 8.2).
- 3.2.1.2 Bars over 0.500 inch (12.70 mm) in nominal diameter or least distance between parallel sides hot finished, unless otherwise ordered, having hardness not higher than 229 HBW, or equivalent (see 8.3). Bars ordered cold finished may have hardness as high as 241 HBW, or equivalent (see 8.3).
- 3.2.1.3 Bar shall not be cut from plate (see 4.4.2).

3.2.2 Forgings

Forgings shall be as ordered.

3.2.3 Forging Stock

Forging stock shall be as ordered by the forging manufacturer.

3.3 Properties

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

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 macrograph ratings of ASTM E381 shown in Table 2.

Table 2 - Macrostructure limits

Section Size Square Inches	Section Size Square Centimeters	Macrographs
Up to 36, incl	Up to 230, incl	S2 - R1 - C2
Over 36 to 133, incl	Over 230 to 858, incl	S2 - R2 - C3
Over 133	Over 858	Note 1

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

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

3.3.2 Average Grain Size of Bars and Forgings

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

3.3.2.1 Average grain size shall be ASTM 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 8.6):

- A total aluminum content of 0.020 to 0.050%.
- An acid soluble aluminum content of 0.015 to 0.050%.
- A vanadium content of 0.02 to 0.08%.
- A columbium (niobium) content of 0.02 to 0.05%.

3.3.3 Hardenability of Each Heat

Hardenability of each heat shall be J 1/16 inch (1.6 mm) = 48 HRC maximum and J 3/16 inch (4.8 mm) = 27 HRC minimum, determined on the standard end-quench test specimen in accordance with ASTM A255, except that the steel shall be normalized at 1700 °F ± 10 °F (925 °C ± 6 °C) and the test specimen austenitized at 1700 °F ± 10 °F (925 °C ± 6 °C). Cast specimens do not need to be normalized.

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 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 flow.

3.5 Tolerances

3.5.1 Bars

Tolerances for bars shall be in accordance with AMS2251.

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 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), hardenability (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 and Forging Stock

Bars and forging stock shall be sampled and tested in accordance with AMS2370.

4.3.2 Forgings

Forgings shall be sampled and tested in accordance with AMS2372.

4.4 Reports

4.4.1 The producer of bars and forgings shall furnish with each shipment a report showing the producer's identity, country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations), results of tests for composition, macrostructure, hardenability, and frequency-severity cleanliness rating of each heat (see 4.4.5) of condition, and, if measured, average grain size 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, AMS6294L, product form and size or part number, 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 3.3.1.2 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 cross-sectional size and the cut size, if different (see 3.2.1.3).

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 (e.g., final melt in the case of metal processed by multiple melting operations), the results of tests for composition, macrostructure, hardenability, and frequency-severity cleanliness rating of each heat (see 4.4.5), and the results of additional property requirements imposed by the purchase order (see 8.9). This report shall include the purchase order number, heat number, AMS6294L, 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 AMS6294L(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."