AEROSPACE MATERIAL SPECIFICATION

AMS6499™	REV. C
Issued 2010-07 Revised 2024-04 Superseding AMS6499B	

Steel, Bars, Forgings, Mechanical Tubing and Forging Stock,
2.7Si - 0.85Cr - 1.8Ni - 0.4Mo - 0.2V - (0.37 - 0.44C)
Premium Aircraft Quality, Double Vacuum Melted
(Composition similar to UNS K54015 and 40SiNiCrMoV10)

RATIONALE

AMS6499C is the result of a Five-Year Review and update of the specification. The revision updates the Title to match the Scope, quality, and adds a standard identifier for the material, adds composition reporting requirements (see 3.1.1), updates exception requirements (see 4.4.4 and 8.7), revises macrostructure requirements (see 3.4.3 and 8.8) and decarburization requirements (see 3.4.3.5), updates the heat-treatment requirements to industry standards for this material, and adds pyrometry (see 3.4.4), stock removal (see 8.5), and ordering options for forging stock (see 4.4.3 and 8.8).

1. SCOPE

1.1 Form

This specification covers a premium 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 parts requiring a through-hardening steel capable of developing a minimum hardness of 53 HRC in nominal cross-sectional thickness 3.5 inches (89 mm) and under, and being capable of producing finished parts that may be required to pass stringent inspection standards, but usage is not limited to such applications.

1.2.1 Certain design, processing procedures, or environmental conditions may cause these products to become susceptible to stress-corrosion cracking; ARP1110 recommends practices to minimize such conditions.

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)
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/AMS6499C/

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

AMS2300 Steel Cleanliness, Premium Aircraft-Quality, Magnetic Particle Inspection Procedure

AMS2310 Qualification Sampling and Testing of Steels for Transverse Tensile Properties

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

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

ARP1110 Minimizing Stress Corrosion Cracking in Wrought Forms of Steels and Corrosion Resistant Steels and Alloys

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 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 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 by in accordance with ASTM A751 or by other analytical methods acceptable to the purchaser.

Table 1 - Composition

Element	Min	Max
Carbon	0.37	0.44
Manganese	0.50	0.95
Silicon	2.60	2.85
Phosphorus	--	0.015
Sulfur	--	0.010
Chromium	0.65	1.05
Nickel	1.50	2.10
Molybdenum	0.30	0.55
Vanadium	0.10	0.30

3.1.1 The producer may test for any element not listed in Table 1 and include this analysis in the report of 4.5. 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 AMS2259, except that check analysis limits carbon shall apply over maximum only.

3.2 Melting Practice

The product shall be double vacuum melted, using vacuum induction melting (VIM) followed by vacuum arc consumable electrode remelting (VAR).

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

3.3.1.1 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 149 ksi (1027 MPa) or equivalent hardness (see 8.2).

3.3.1.2 Bars over 0.500 inch (12.70 mm) in nominal diameter or least distance between parallel sides shall be hot finished, annealed, or normalized and tempered having hardness not higher than 311 HBW, or equivalent (see 8.3).

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

3.3.2 Forgings

Forgings shall be normalized and tempered having hardness not higher than 311 HBW, or equivalent (see 8.3).

3.3.3 Mechanical Tubing

Mechanical tubing shall be annealed, normalized, and tempered or cold finished having hardness not higher than 33 HRC, or equivalent (see 8.3).

3.3.4 Forging Stock

Forging stock shall be as ordered by the forging manufacturer.

3.4 Properties

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

3.4.1 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 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.

Table 2 - Macrostructure limits

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

3.4.1.1 Macrostructure examination is not required for bored/hollow forgings (including ring forgings) and mechanical tubing that is produced directly from ingots or 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. Macroetch standards for such tubes shall be as agreed upon by the purchaser and producer (see 8.8).

3.4.2 Average Grain Size of Bars, Forgings, and Mechanical Tubing

The average grain size of bars, forgings, and mechanical tubing shall be ASTM No. 6 or finer, determined in accordance with ASTM E112.

3.4.3 Decarburization

3.4.3.1 Bars and tubing ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces. Decarburization on tubing ID shall not exceed the maximum depth specified in Table 4.

3.4.3.2 Allowable decarburization of bars, billets, and tube rounds ordered for redrawing or forging or to be specified microstructural requirements shall be agreed upon by the producer and purchaser.

3.4.3.3 Where 3.4.3.1 or 3.4.3.2 are not applicable, decarburization of bars shall be not greater than shown in Table 3.

Table 3A - Maximum total depth of decarburization, bars, inch/pound units

Nominal Diameter or Distance Between Parallel Sides Inches	Total Depth of Decarburization Inches
Up to 0.375, incl	0.015
Over 0.375 to 0.500, incl	0.017
Over 0.500 to 0.675, incl	0.019
Over 0.675 to 1.000, incl	0.022
Over 1.000 to 1.500, incl	0.025
Over 1.500 to 2.000, incl	0.030
Over 2.000 to 2.500, incl	0.035
Over 2.500 to 3.000, incl	0.040
Over 3.000 to 5.000, incl	0.045

Table 3B - Maximum total depth of decarburization, bars, SI units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Total Depth of Decarburization Millimeters
Up to 9.52, incl	0.38
Over 9.52 to 12.70, incl	0.43
Over 12.70 to 15.88, incl	0.48
Over 15.88 to 25.40, incl	0.56
Over 25.40 to 38.10, incl	0.64
Over 38.10 to 50.80, incl	0.76
Over 50.80 to 63.50, incl	0.89
Over 63.50 to 76.20, incl	1.02
Over 76.20 to 127.00, incl	1.14

3.4.3.4 Where 3.4.3.1 or 3.4.3.2 are not applicable, decarburization of tubing shall be not greater than shown in Table 4.

Table 4A - Maximum total depth of decarburization, tubing, inch/pound units

Nominal Diameter or Distance Between Parallel Sides Inches	Total Depth of Decarburization Inches ID	Total Depth of Decarburization Inches OD
Up to 0.109, incl	0.008	0.015
Over 0.109 to 0.203, incl	0.010	0.020
Over 0.203 to 0.400, incl	0.012	0.025
Over 0.400 to 0.600, incl	0.015	0.030
Over 0.600 to 1.000, incl	0.017	0.035
Over 1.000	0.020	0.040

Table 4B - Maximum total depth of depth of decarburization, tubing, SI units

Nominal Wall Thickness Millimeters	Total Depth of Decarburization Millimeters ID	Total Depth of Decarburization Millimeters OD
Up to 2.77, incl	0.20	0.38
Over 2.77 to 5.16, incl	0.25	0.51
Over 5.16 to 10.16, incl	0.30	0.64
Over 10.16 to 15.24, incl	0.38	0.76
Over 15.24 to 25.40, incl	0.43	0.89
Over 25.40	0.51	1.02

3.4.3.5 Decarburization shall be evaluated by one of the two methods of 3.4.3.5.1 or 3.4.3.5.2.

3.4.3.5.1 Metallographic Method

A cross section of the surface shall be prepared in accordance with ASTM E1077 and examined metallographically at a magnification not to exceed 200X. The sample shall not show a layer of complete (ferrite) or partial decarburization over the limits of Table 3 or Table 4.

3.4.3.5.2 Hardness Traverse Method

The total depth of decarburization shall be determined by a traverse method using microhardness 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 3 or Table 4.

3.4.3.5.3 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.

3.4.3.5.4 In case of dispute, the total depth of decarburization determined using the microindentation traverse method shall govern.

3.4.4 Response to Heat Treatment of Bars, Forgings, and Mechanical Tubing

Specimens shall have the properties of Table 5 and Table 6 after heat treatment as follows. Pyrometry shall be in accordance with AMS2750.

- Anneal by heating to 1750 °F ± 25 °F (955 °C ± 14 °C), holding at heat for 60 minutes - 0 minutes, + 5 minutes, and transfer to a furnace at 1290 °F ± 25 °F (700 °C ± 14 °C), holding at heat for 24 hours ± 1 hour, and cooling to room temperature at a rate equivalent to air cooling.
- Harden by heating to 1720 °F ± 25 °F (940 °C ± 14 °C), holding at heat for 60 minutes - 0 minutes, + 5 minutes, and quenching in oil.
- Within 4 hours ± 0.4 hour after quenching, subzero treat at -100 °F or colder (-73 °C), holding at temperature for 4 hours ± 0.4 hour.
- Air warm to room temperature.
- Temper by heating to 575 °F ± 10 °F (302 °C ± 6 °C), holding at heat for 2 hours ± 0.2 hour, cooling in air to room temperature, then temper a second time by reheating to 575 °F ± 10 °F (302 °C ± 6 °C), holding at heat for 2 hours ± 0.2 hour, and cooling in air.

3.4.4.1 Longitudinal Tensile Properties

Longitudinal tensile properties shall be as shown in Table 5; testing in the longitudinal direction need not be performed on product tested in the transverse direction.

Table 5A - Minimum longitudinal tensile properties - response to heat treatment, inch/pound units

Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %	Reduction of Area %
Longitudinal	305	250	7	30

Table 5B - Minimum longitudinal tensile properties, SI units

Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50 mm or 4D %	Reduction of Area %
Longitudinal	2100	1725	7	30

3.4.4.2 Transverse Tensile Properties

Transverse tensile properties shall be as shown in Table 6, determined on specimens selected and prepared in accordance with AMS2310; transverse tensile property requirements of Table 6 apply only to product that tensile specimens not less than 2.50 inches (63.5 mm) in length can be taken.

Table 6A - Minimum transverse tensile properties - response to heat treatment, inch/pound units

Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %	Reduction of Area %
Transverse	305	250	7	25

Table 6B - Minimum transverse tensile properties, SI units

Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50 mm or 4D %	Reduction of Area %
Transverse	2100	1725	7	25

3.4.4.3 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).

3.5 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 after removal of the standard stock removal allowance in accordance with AS1182.

3.5.3 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.

3.6 Tolerances

3.6.1 Bar

Bar tolerances shall be in accordance with AMS2251.

3.6.2 Mechanical Tubing

Mechanical tubing tolerances shall be in accordance with AMS2253.

3.7 Exceptions

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 3.3), macrostructure (see 3.4.1), average grain size (see 3.4.2), decarburization (see 3.4.3), response to heat treatment (see 3.4.4), and tolerances (see 3.6) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests

Frequency-severity cleanliness rating (see 3.5.1) and grain flow of die forgings (see 3.5.3) 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, Mechanical Tubing, and Forging Stock

Bars, mechanical tubing, 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, forgings, and mechanical tubing 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 and macrostructure of each heat and for condition, average grain size, and response to heat treatment 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, AMS6499C, melt practice, product form and size or part number, and quantity. If forgings are supplied, the size and melt source of the stock used to make the forgings shall also be included.

4.4.2 Report the nominal metallurgically worked cross-sectional size and the cut size, if different (see 3.3.1.3).