SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS4899 REV. C

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Superseding AMS4899B

Titanium Alloy, Sheet, Strip, and Plate
4.5Al - 3V - 2Fe - 2Mo
Annealed

(Composition similar to UNS R54700)

RATIONALE

AMS4899C results from a Five Year Review and update of this specification.

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of sheet, strip, and plate.

1.2 Application

These products have been used typically for parts requiring high fracture toughness, fatigue strength, formability, and strength up to 480 °F (249 °C), but usage is not limited to such applications. This alloy is superplastic between 1330 °F (721 °C) and 1520 °F (627 °C) and hot formable from 1200 to 1560 °F (649 to 849 °C).

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 724-776-4970 (outside USA), www.sae.org.

AMS2242 Tolerances, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Sheet, Strip, and Plate

AMS2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys

AMS2631 Ultrasonic Inspection, Titanium and Titanium Alloy Bar and Billet

AMS2750 Pyrometry

AMS2809 Identification, Titanium and Titanium Alloy Wrought Products

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

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS4899C

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 E 8 / E 8M Tension Testing of Metallic Materials

ASTM E 290 Bend Testing Material for Ductility

ASTM E 384 Knoop and Vickers Hardness of Materials

ASTM E 1409 Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique

ASTM E 1447 Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Conductivity/Infrared Detection Method

ASTM E 1941 Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis

ASTM E 2371 Analysis of Titanium and Titanium Alloys by Atomic Emission Plasma Spectrometry

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1; carbon shall be determined in accordance with ASTM E 1941, hydrogen in accordance with ASTM E 1447, oxygen and nitrogen in accordance with ASTM E 1409, and other elements in accordance with ASTM E 2371. Other analytical methods may be used if acceptable to the purchaser.

TABLE 1 - COMPOSITION

Element	min	max	
Aluminum	4.00	5.00	
Vanadium	2.50	3.50	
Molybdenum	1.80	2.20	
Iron	1.70	2.30	
Oxygen	--	0.15	
Carbon	--	0.08	
Nitrogen	--	0.05	(500 ppm)
Hydrogen (3.1.1)	--	0.015	(150 ppm)
Yttrium (3.1.2)	--	0.005	(50 ppm)
Other Elements, each (3.1.2)	--	0.10	
Other Elements, total (3.1.2)	--	0.40	
Titanium	remainder		

3.1.1 Sample size when using ASTM E 1447 may be as large as 0.35 gram.

3.1.2 Determination not required for routine acceptance.

3.1.3 Check Analysis

Composition variations shall meet the applicable requirements of AMS2249.

3.2 Melting Practice

3.2.1 Alloy shall be multiple melted. The first melt shall be made by consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The subsequent melt or melts shall be made under vacuum using vacuum arc remelting (VAR) practice. Alloy additions are not permitted in the final melt cycle.

3.2.1.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be argon and/or helium at an absolute pressure not higher than 1000 mm of mercury.

3.2.1.2 The electrode tip for nonconsumable electrode melting shall be water-cooled copper.

3.3 Condition

The product shall be supplied in the following condition:

3.3.1 Sheet and Strip

Hot rolled with or without subsequent cold reduction, annealed, descaled, and leveled, having a surface appearance comparable to the following commercial corrosion-resistant steel finishes as applicable (See 8.2).

3.3.1.1 Sheet

Shall be No. 2D finish.

3.3.1.2 Strip

Shall be No. 1 finish.

3.3.2 Plate

Hot rolled, annealed, descaled, and flattened, having a surface appearance comparable to a commercial corrosion-resistant steel No. 1 finish or No. 2D finish (See 8.2). Plate product shall be produced using standard industry practices designed strictly for the production of plate stock to the procured thickness. Bar, billet, forgings, or forging stock shall not be substituted for plate.

3.4 Annealing

The product shall be annealed by heating to a temperature within the range 1260 to 1400 °F (682 to 760 °C), holding at the selected temperature within ±25 °F (±14 °C) for a time commensurate with product thickness and the heating equipment and procedure used, and cooling at a rate which will produce product meeting the requirements of 3.5. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

The product shall conform to the following requirements and shall meet the requirements of 3.5.1 and 3.5.2 after being reheated to 1325 °F ± 25 (718 °C ± 14), held at heat for 20 minutes ± 5, and cooled at a rate equivalent to an air cool or slower.

3.5.1 Tensile Properties

Shall be as shown in Table 2, determined in accordance with ASTM E 8 / E 8M with the rate of strain set at 0.005 inch/inch/minute (0.005 mm/mm/minute) and maintained within a tolerance of ±0.002 inch/inch/minute (0.002 mm/mm/minute) through the 0.2% offset yield strain.

TABLE 2A - MINIMUM TENSILE PROPERTIES, INCH/POUND UNITS

Nominal Thickness Inch	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 inches or 4D %
Up to 0.008, excl	134	126	--
Over 0.008 to 0.025, excl	134	126	6
Over 0.025 to 0.063, excl	134	126	8
Over 0.063 to 0.187, excl	134	126	10
Over 0.187 to 4.000, incl	130	120	10

TABLE 2B - MINIMUM TENSILE PROPERTIES, SI UNITS

Nominal Thickness Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %
Up to 0.20, excl	924	869	--
Over 0.20 to 0.64, excl	924	869	6
Over 0.64 to 1.60, excl	924	869	8
Over 1.60 to 4.75, excl	924	869	10
Over 4.75 to 101.60, incl	896	827	10

3.5.1.1 Tensile property requirements apply in both the longitudinal and transverse directions but tests in the transverse direction need be made only on product that a specimen not less than 8 inches (203 mm) in length for sheet and strip and 2.5 inches (63.5 mm) in length for plate can be taken. Tests in the transverse direction are not required on product tested in the longitudinal direction.

3.5.2 Bending

Product under 0.1875 inch (4.762 mm) in nominal thickness shall have a test sample prepared nominally 0.750 inch (19.06 mm) in width, with its axis of bending parallel to the direction of rolling. The sample shall be bend tested in conformance with the guided bend test defined in ASTM E 290 through an angle of 105 degrees. The test fixture supports shall have a contact radius 0.010 minimum, and the plunger shall have a radius equal to the bend factor shown in Table 3 times the nominal thickness. Examination of the bent sample shall not show evidence of cracking when examined at 15 to 25X magnification.

TABLE 3 - BENDING FACTOR

Nominal Thickness Inch	Nominal Thickness Millimeters	Bend Factor
Up to 0.070, incl	Up to 1.78, incl	4.5
Over 0.070 to 0.1875, excl	Over 1.78 to 4.762, excl	5

3.5.3 Microstructure

Shall be that structure resulting from alpha-beta processing. Microstructure shall conform to 3.5.3.1, 3.5.3.2, 3.5.3.3, 3.5.3.4. A microstructure showing a continuous network of alpha in prior beta grain boundaries is not acceptable.

3.5.3.1 Lamellar alpha with some equiaxed alpha in a transformed beta matrix.

3.5.3.2 Equiaxed alpha in a transformed beta matrix.

3.5.3.3 Equiaxed alpha and/or elongated alpha in a transformed beta matrix.

3.5.3.4 Partially broken and distorted grain boundary alpha with plate-like alpha.

3.5.4 Surface Contamination

The product shall be free of any oxygen-rich layer, such as alpha case or other surface contamination, determined as in 3.5.4.1 or 3.5.4.2 or 3.5.4.3, or other method acceptable to purchaser

3.5.4.1 The bend test of 3.5.2.

3.5.4.2 Microscopic examination at 400X minimum.

3.5.4.3 Hardness difference; a surface hardness more than 40 points higher than the subsurface hardness, determined in accordance with ASTM E 384 on the Knoop scale or the Vickers scale using a 200-gram load, shall be evidence of unacceptable surface contamination.

3.6 Quality

The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from “oil cans” (See 8.3.1) of depth in excess of the flatness tolerances, ripples, and foreign materials and from imperfections detrimental to usage of the product.

3.6.1 Ultrasonic Inspection

Plate, 0.500 to 4.00 inches (12.70 to 101.60 mm), inclusive, in nominal thickness, shall be subjected to ultrasonic inspection in accordance with AMS2631 and shall meet Class A1 requirements of AMS2631.

3.7 Tolerances

Shall conform to all applicable requirements of AMS2242.

3.7.1 Special flatness may be specified for plate; in such case, the special flatness tolerances of AMS2242 shall apply.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of the product shall supply all samples for vendor'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

Composition (3.1), condition (3.3), tensile properties (3.5.1), bending (3.5.2), microstructure (3.5.3), surface contamination (3.5.4), quality (3.6), and tolerances (3.7) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.1.1 Ultrasonic inspection of each plate when required by 3.6.1.

4.2.2 Periodic Tests

Tests of the product after reheating as in 3.5 for tensile properties (3.5.1) and bending (3.5.2) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.