SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4899A

Issued APR 1996
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Superseded by AMS 4899

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

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, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2242	Tolerances, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Sheet, Strip, and Plate
MAM 2242	Tolerances, Metric, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Sheet, Strip, and Plate
AMS 2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys

TO PLACE A DOCUMENT ORDER:
Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: http://www.sae.org

2.1 (Continued):

AMS 2631	Ultrasonic Inspection, Titanium and Titanium Alloy Bar and Billet
AMS 2750	Pyrometry
AMS 2809	Identification, Titanium and Titanium Alloy Wrought Products

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 120	Chemical Analysis of Titanium and Titanium Alloys
ASTM E 290	Bend Testing Material for Ductility
ASTM E 384	Microhardeness of Materials
ASTM E 1409	Determination of Oxygen 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 Method

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1; oxygen shall be determined in accordance with ASTM E 1409, hydrogen in accordance with ASTM E 1447, and other elements by wet chemical methods in accordance with ASTM E 120, by spectrochemical methods, or by other analytical methods acceptable to 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)
Residual Elements, each (3.1.2)	--	0.10
Residual 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 AMS 2249.

3.2 Melting Practice:

3.2.1 Alloy shall be multiple melted. Melting cycle(s) prior to the final melting cycle shall be made using consumable electrode, nonconsumable electrode, electron beam, or plasma arc melting practice(s). The final melting cycle shall be made under vacuum using consumable electrode practice with no alloy additions permitted.

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).

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 AMS 2750.

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 or ASTM E 8M with the rate of strain maintained at 0.003 to 0.007 inch/inch/minute (0.003 to 0.007 mm/mm/minute) through the yield strength and then increased so as to produce failure in approximately one additional minute. When a dispute occurs between purchaser and vendor over the yield strength values, a referee test shall be performed on a machine having a strain rate pacer using a rate of 0.005 inch/inch/minute (0.005 mm/mm/minute) through the yield strength and a minimum cross head speed of 0.10 inch per minute (0.04 mm/s) after the yield strength.

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 excl	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 excl	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 from which 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 diameter equal to the bend factor shown in Table 3 times the nominal thickness. Examination of the bent sample shall show no 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	9
Over 0.070 to 0.1875, excl	Over 1.78 to 4.762, excl	10

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 by microscopic examination of a polished and etched transverse specimen, at 400 to 500X magnification. Other methods, such as bend test (3.5.4.1) or hardness differential (3.5.4.2), may be used if acceptable to purchaser.

3.5.4.1 The bend test of 3.5.2.

3.5.4.2 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) 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 AMS 2631 and shall meet Class A1 requirements of AMS 2631.

3.7 Tolerances:

Shall conform to all applicable requirements of AMS 2242 or MAM 2242.

3.7.1 Special flatness may be specified for plate; in such case, the special flatness tolerances of AMS 2242 or MAM 2242 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.

4.2.2 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.

4.3 Sampling and Testing:

Shall be in accordance with the following; a lot shall be all product of the same nominal size from the same heat processed at the same time.

4.3.1 For Acceptance Tests:

4.3.1.1 Composition: One sample from each heat, except that for hydrogen determinations one sample from each lot obtained after thermal and chemical processing is completed.

4.3.1.2 Tensile Properties, Bending, Microstructure, and Surface Contamination: One or more samples from each lot for each requirement.

4.3.1.2.1 Specimens for tensile tests of widths 9 inches (229 mm) and over shall be taken with the axis of the specimen perpendicular to the direction of rolling; for widths between 2 and 8.9 inches (51 and 226 mm), specimens shall be taken with the axis parallel to the direction of rolling. Length requirements of 3.5.1.1 apply in all cases.

4.4 Reports:

The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and for the hydrogen content, tensile properties, bending, microstructure, surface contamination, and ultrasonic inspection 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, AMS 4899A, size, specific annealing treatment used, and quantity.