

AEROSPACE MATERIAL SPECIFICATION



AMS-4916

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Superseding AMS-4916E

An American National Standard

TITANIUM ALLOY SHEET, STRIP, AND PLATE
8A1 - 1Mo - 1V
Duplex Annealed

UNS R54810

1. SCOPE:

- 1.1 Form: This specification covers a titanium alloy in the form of sheet, strip, and plate.
- 1.2 Application: Primarily for parts requiring strength and fracture toughness up to 800°F (427°C). Certain processing procedures and service conditions may cause these products to become subject to stress-corrosion cracking; ARP982 recommends practices to minimize such conditions.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

- 2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

2.1.1 Aerospace Material Specifications:

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
AMS-2631 - Ultrasonic Inspection of Titanium Alloys
AMS-2809 - Identification, Titanium and Titanium Alloy Wrought Products

2.1.2 Aerospace Recommended Practices:

ARP982 - Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

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2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

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 - Semi-Guided Bend Test for Ductility of Metallic Materials
 ASTM E 384 - Microhardness of Materials

2.3 U.S. Government Publications: Available from Naval Publications and Forms Center, Attn: NPODS, 5801 Tabor Avenue, Philadelphia, PA 19120-5099.

2.3.1 Military Specifications:

MIL-H-81200 - Heat Treatment of Titanium and Titanium Alloys

2.3.2 Military Standards:

MIL-STD-163 - Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E 120, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	min	max
Aluminum	7.35	- 8.35
Molybdenum	0.75	- 1.25
Vanadium	0.75	- 1.25
Iron	--	0.30
Oxygen	--	0.12
Carbon	--	0.08
Nitrogen	--	0.05 (500 ppm)
Hydrogen	--	0.015 (150 ppm)
Yttrium (3.1.1)	--	0.005 (50ppm)
Residual Elements, each (3.1.1)	--	0.10
Residual Elements, total (3.1.1)	--	0.40
Titanium	remainder	

3.1.1 Determination not required for routine acceptance.

3.1.2 Check Analysis: Composition variations shall meet the requirements of AMS-2249.

3.2 Condition: The product shall be supplied in the following condition:

3.2.1 Sheet and Strip: Hot rolled with or without subsequent cold reduction, duplex annealed, descaled, and leveled, having a surface appearance comparable to a commercial corrosion-resistant steel No. 2D finish.

3.2.2 Plate: Hot rolled, duplex annealed, descaled, and flattened, having a surface appearance comparable to a commercial corrosion-resistant steel No. 1 finish.

3.3 Arinealing: The product shall be duplex annealed by heating to a temperature within the range 1400° - 1450°F (760° - 788°C), holding at the selected temperature within $\pm 25^\circ\text{F}$ ($\pm 14^\circ\text{C}$) for 1 - 8 hours, cooling at a rate not faster than 100 F (56 °C) degrees per hour to below 900°F (482 °C), cooling to room temperature, reheating to 1450°F ± 25 (788°C ± 14), holding at heat for not less than 15 minutes, and cooling in air to room temperature. Furnace surveys and calibration of temperature controllers and recorders shall be in accordance with MIL-H-81200.

3.4 Properties: The product shall conform to the following requirements:

3.4.1 Tensile Properties: Shall be as specified in Table I, determined in accordance with ASTM E 8 or ASTM E 8M with the rate of strain maintained at 0.003 - 0.007 inch/inch/minute (0.003 - 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 (2.5 mm) per minute above the yield strength.

TABLE I

Nominal Thickness Inches	Tensile Strength psi, min	Yield Strength At 0.2% Offset psi, min	Elongation in Inches or 4D %, min
0.008 to 0.014, incl	135,000	120,000	6
Over 0.014 to 0.025, incl	135,000	120,000	8
Over 0.025 to 0.187, incl	135,000	120,000	10
Over 0.187 to 1.000, incl	130,000	120,000	10
Over 1.000 to 2.000, incl	125,000	115,000	10
Over 2.000 to 4.000, incl	120,000	110,000	8

TABLE I (SI)

Nominal Thickness Millimetres	Tensile Strength MPa, min	Yield Strength At 0.2% Offset MPa, min	Elongation in 50.8 mm or Q %, min
0.20 to 0.36, incl	931	827	6
Over 0.36 to 0.64, incl	931	827	8
Over 0.64 to 4.75, incl	931	827	10
Over 4.75 to 25.40, incl	896	827	10
Over 25.40 to 50.80, incl	862	793	10
Over 50.80 to 101.60, incl	827	758	8

- 3.4.2 Bending: Product under 0.1875 inch (4.762 mm) in nominal thickness shall withstand, without evidence of cracking when examined at 20X magnification, bending in accordance with ASTM E 290 through an angle of 105 degrees around a diameter equal to the bend factor times the nominal thickness of the product, using either V-block, U-channel, or free bend procedure, with axis of bend parallel to the direction of rolling. Only one of these tests will be required for routine inspection. In case of dispute, results of bend tests using the V-block procedure shall govern:

Nominal Thickness		Bend Factor
Inch	Millimetres	
Up to 0.070, incl	Up to 1.78, incl	8
Over 0.070 to 0.1875, excl	Over 1.78 to 4.762, excl	9

- 3.4.2.1 Bending requirements for product 0.1875 inch (4.762 mm) and over in nominal thickness shall be as agreed upon by purchaser and vendor.

- 3.4.3 Microstructure: Shall be that structure resulting from alpha-beta processing. Microstructure shall conform to 3.4.3.1, 3.4.3.2, or 3.4.3.3.

- 3.4.3.1 Equiaxed alpha in a transformed beta matrix.

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- 3.4.3.2 Equiaxed alpha and elongated alpha in transformed beta matrix.

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- 3.4.3.3 Primary broken and distorted grain boundary alpha with plate-like alpha.

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- 3.4.3.4 A microstructure showing a continuous network of alpha in prior beta grain boundaries is not acceptable.

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- 3.4.4 Surface Contamination: The product shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination, determined as in 3.4.4.1, 3.4.4.2, or by other method agreed upon by purchaser and vendor.

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- 3.4.4.1 The bend test of 3.4.2.

- 3.4.4.2 Hardness differential; a surface hardness more than 40 points higher than the subsurface hardness, determined in accordance with ASTM E 384 on the Knoop scale using a 200-gram load, being evidence of unacceptable surface contamination.

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3.5 Quality:

- 3.5.1 Alloy shall be multiple melted; at least one of the melting cycles shall be under vacuum. The first melt shall be made by consumable electrode, nonconsumable electrode, electron beam, or plasma arc melting practice. The subsequent melt or melts shall be made using consumable electrode practice with no alloy additions permitted in the last consumable electrode melt.

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- 3.5.1.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be inert gas at a pressure not higher than 250 mm of mercury.
- 3.5.1.2 The electrode tip for nonconsumable electrode melting shall be water-cooled copper.
- 3.5.2 The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from "oil cans" (See 8.2) with depth in excess of flatness tolerances, ripples, and foreign materials and from imperfections detrimental to usage of the product.
- 3.5.2.1 Plate 0.500 to 4.000 inches (12.70 to 101.60 mm), incl, in nominal thickness, ultrasonically inspected in accordance with AMS-2631, shall meet Class A1 of that specification.
- 3.6 Tolerances: Shall conform to the following:
- 3.6.1 Thickness, Width, Length, and Straightness: All applicable requirements of AMS-2242 or MAM-2242.
- 3.6.2 Flatness: Flatness tolerance for product 36 inches (914 mm) and under in width shall be 5% if nominal thickness is under 0.025 inch (0.64 mm) and 3% if nominal thickness is 0.025 to 0.1875 inch (0.64 to 4.762 mm), exclusive. Flatness tolerance for product under 0.1875 inch (4.762 mm) in nominal thickness and over 36 inches (914 mm) in nominal width and for product 0.1875 inch (4.762 mm) and over in nominal thickness in all widths shall be as agreed upon by purchaser and vendor.
- 3.6.2.1 Flatness shall be determined from the expression $100H/L$ where "H" is the distance from the straight edge to the product at the point of greatest separation and "L" is the distance between contact points of a straight edge laid in any direction on the product.
- 3.6.2.2 Flatness tolerances do not apply to coiled products.
4. QUALITY ASSURANCE PROVISIONS:
- 4.1 Responsibility for Inspection: The vendor of the product shall supply all 0 samples for vendor's tests and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.
- 4.2 Classification of Tests: Tests for all technical requirements are acceptance tests and shall be performed on each heat or lot as applicable.
- 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 and duplex annealed in the same heat treat batch.