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400 COMMONWEALTH DRIVE WARRENDALE PA 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 4916E
Superseding AMS 4916D

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TITANIUM ALLOY SHEET, STRIP, AND PLATE
8Al - 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 (425°C). Certain processing procedures and service conditions may cause these products to become subject to stress-corrosion cracking; ARP 982 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 Aerospace Material Specifications (AMS) and Aerospace Recommended Practices (ARP) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

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

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 2350 - Standards and Test Methods
AMS 2631 - Ultrasonic Inspection of Titanium Alloys

2.1.2 Aerospace Recommended Practices:

ARP 982 - Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E8 - Tension Testing of Metallic Materials
ASTM E120 - Chemical Analysis of Titanium and Titanium Alloys
ASTM E290 - Semi-Guided Bend Test for Ductility of Metallic Materials

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

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 E120, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by 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	(50 ppm)
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 Annealing: The product shall be duplex annealed by heating to a temperature within the range 1400° - 1450°F (760° - 790°C), holding at the selected temperature within ±25°F (±15°C) for 1 - 8 hr. cooling at a rate not faster than 100 F (55 C) deg per hour to below 900°F (480°C), and cooling to room temperature, reheating to 1450°F ± 25 (790°C ± 15), holding at heat for not less than 15 min., and cooling in air to room temperature.

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 E8 with the rate of strain maintained at 0.003 - 0.007 in./in. per min. (0.003 - 0.007 mm/mm per min.) 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 in./in. per min. (0.005 mm/mm per min.) through the yield strength and a minimum cross head speed of 0.10 in. (2.5 mm) per min. above the yield strength.

TABLE I

Nominal Thickness Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 2 in. 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 mm or 4D %, min
0.20 to 0.35, incl	930	825	6
Over 0.35 to 0.60, incl	930	825	8
Over 0.60 to 4.75, incl	930	825	10
Over 4.75 to 25.00, incl	895	825	10
Over 25.00 to 50.00, incl	860	795	10
Over 50.00 to 100.00, incl	825	760	8

3.4.2 Bending: Product under 0.1875 in. (4.75 mm) in nominal thickness shall withstand, without evidence of cracking when examined at 20X magnification, bending in accordance with ASTM E290 through an angle of 105 deg 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		
Inch	Millimetres	Bend Factor
Up to 0.070, incl	Up to 1.75, incl	8
Over 0.070 to 0.1875, excl	Over 1.75 to 4.75, excl	9

3.4.2.1 Bending requirements for product 0.1875 in. (4.75 mm) and over in nominal thickness shall be as agreed upon by purchaser and vendor.

3.4.3 Microstructure: Shall be essentially that resulting from alpha-beta processing. Microstructure shall not be cause for rejection unless standards for acceptance have been agreed upon by purchaser and vendor.

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

3.4.4.1 The bend test of 3.4.2.
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3.4.4.2 Microscopic examination at 100X magnification.
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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, ø nonconsumable eletrode, electron beam, or plasma arc melting practice. The subsequent melt or melts shall be made using consumable electrode practice.

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 ø 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) of depth in excess of flatness tolerances, ripples, and foreign materials and from internal and external imperfections detrimental to usage of the product.

3.5.2.1 Plate 0.500 to 4.000 in. (12.50 to 100.00 mm), incl, in nominal thickness, ultrasonically inspected in accordance with AMS 2631, shall meet Class A1 requirements of AMS 2631.

3.6 Tolerances: Unless otherwise specified, 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 in. (900 mm) and under in width shall be 5% if nominal thickness is less than 0.025 in. (0.65 mm) and 3% if nominal thickness is 0.025 to 0.1875 in. (0.65 to 4.75 mm), exclusive. Flatness tolerance for product under 0.1875 in. (4.75 mm) in nominal thickness and over 36 in. (900 mm) in nominal width and for product 0.1875 in. (4.75 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 samples for vendor's tests and shall be responsible for performing all Ø required tests. Results of such tests shall be reported to the purchaser as required by 4.4. 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 to determine conformance to all technical Ø requirements of this specification are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.3 Sampling: Shall be in accordance with the following; a lot shall be all Ø product of the same nominal size from the same heat processed at the same time and annealed in the same heat treat batch.

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

4.3.2 Tensile Properties, Bending, Microstructure, and Surface Contamination: Not less than one sample from each lot.

4.3.2.1 Specimens for tensile tests of widths 9 in. (225 mm) and over shall be taken with the axis of the specimen perpendicular to the direction of rolling; for widths less than 9 in. (225 mm), specimens shall be taken with the axis parallel to the direction of rolling.

4.3.2.2 For V-block or U-channel bend tests, specimen width shall be not less than 10 times the nominal thickness but not less than 1 in. (25 mm). For free bend tests, minmum specimen width shall, when possible, be not less than 10 times the nominal thickness; maximum width need not be greater than 1 in. (25 mm).

4.3.3 Other Requirements: As agreed upon by purchaser and vendor.

4.4 Reports:

4.4.1 The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and of tests to determine conformance to the hydrogen, tensile, bending, and surface contamination requirements of each lot, and stating that the product conforms to the other technical requirements of this specification. This report shall include the purchase order number, heat number, AMS 4916E, size, and quantity from each heat.

4.4.2 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 4916E, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification and shall include in the report either a statement that the material conforms or copies of laboratory reports showing the results of tests to determine conformance.

4.5 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY: