



AEROSPACE MATERIAL SPECIFICATION

AMS4916™**REV. M**

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Superseding AMS4916L

Titanium Alloy Sheet, Strip, and Plate

8Al - 1Mo - 1V

Duplex Annealed

(Composition similar to UNS R54810)

RATIONALE

AMS4916M has been declared "STABILIZED" by AMS Committee G Titanium and Refractory Metals Committee. This document will no longer be updated and may no longer represent standard industry practice.

NOTE: This document was stabilized because AMS Committee G can find no producers for this material. Previously, this document was revised. The last technical update of this document occurred in November, 2017. Users of this document should refer to the cognizant engineering organization for disposition of any issues with reports/certifications to the specification; including exceptions listed on the certification. In many cases, the purchaser may represent a sub-tier supplier and not the cognizant engineering organization.

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AMS4916 has been declared "STABILIZED" by SAE AMS Committee G Titanium and Refractory Metals Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of sheet, strip, and plate up through 4.000 inches (101.60 mm) inclusive in thickness (see 8.6).

1.2 Application

These products have been used typically for parts requiring strength and fracture toughness up to 800 °F (427 °C), but usage is not limited to such applications.

1.2.1 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 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 +1 724-776-4970 (outside USA), or 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

AMS2368	Sampling and Testing of Wrought Titanium Raw Material Except Forgings and Forging Stock
AMS2631	Ultrasonic Inspection Titanium and Titanium Alloy Bar, Billet and Plate
AMS2750	Pyrometry
AMS2809	Identification, Titanium and Titanium Alloy Wrought Products
ARP982	Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products
ARP1917	Clarification of Terms Used in Aerospace Metals Specifications
AS1814	Terminology for Titanium Microstructures
AS4194	Sheet and Strip Surface Finish Nomenclature
AS6279	Industry Standard Practices for Production, Distribution, and Procurement of Metal Stock

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, or www.astm.org.

ASTM A480/A480M	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM E8/E8M	Tension Testing of Metallic Materials
ASTM E290	Bend Testing Material for Ductility
ASTM E384	Microindentation Hardness of Materials
ASTM E539	Analysis of Titanium Alloys by X-Ray Fluorescence Spectrometry
ASTM E1409	Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion
ASTM E1447	Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity/Infrared Detection Method
ASTM E1941	Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis
ASTM E2371	Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission Spectrometry
ASTM E2994	Analysis of Titanium and Titanium Alloys by Spark Atomic Emission Spectrometry and Glow Discharge Atomic Emission 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 E1941, hydrogen in accordance with ASTM E1447, oxygen and nitrogen in accordance with ASTM E1409, and other elements in accordance with ASTM E539, ASTM E2371 or ASTM E2994. Other analytical methods may be used if acceptable to the purchaser.

Table 1 - Composition

Element	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)
Other Elements, each (3.1.1)	--	0.10
Other 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 applicable requirements of AMS2249.

3.2 Melting Practice

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

3.2.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be inert gas at a pressure not higher than 1000 mm of mercury.

3.2.2 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, duplex annealed, descaled, and leveled, having a surface appearance comparable to a commercial corrosion-resistant steel No. 2D finish (see 8.3).

3.3.2 Plate

Hot rolled, duplex annealed, descaled, and flattened, having a surface appearance comparable to a commercial corrosion-resistant steel No. 1 finish (see 8.3). 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 supplied in lieu of plate.

3.4 Annealing

The product shall be duplex annealed by heating to a temperature within the range 1400 to 1450 °F (760 to 788 °C), holding at the selected temperature within ± 25 °F (± 14 °C) for 1 to 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 °F (788 °C ± 14 °C), holding at heat for not less than 15 minutes, and cooling in air to room temperature. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

The product shall conform to the following requirements:

3.5.1 Tensile Properties

Shall be as specified in Table 2, determined in accordance with ASTM E8/E8M 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 2

Table 2A - Minimum tensile properties, inch/pound units

Nominal Thickness Inches				Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 inches or 4D %
	0.008 to	0.014, incl		135	120	6
Over	0.014 to	0.025, incl		135	120	8
Over	0.025 to	0.187, incl		135	120	10
Over	0.187 to	1.000, incl		130	120	10
Over	1.000 to	2.000, incl		125	115	10
Over	2.000 to	4.000, incl		120	110	8

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 %
	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

3.5.1.1 Mechanical property requirements for product outside the range covered by 1.1 shall be agreed upon between purchaser and producer.

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 E290 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 - Bend factors

Nominal Thickness Inch			Nominal Thickness Millimeters		Bend Factor
	Up to	0.070, incl		Up to 1.78, incl	4
Over	0.070 to	0.1875, excl	Over	1.78 to 4.762, excl	4.5

3.5.3 Microstructure

Shall be that structure resulting from processing within the alpha-beta phase field. Microstructure shall conform to 3.5.3.1 or 3.5.3.2 (see 8.2).

3.5.3.1 Equiaxed and/or elongated primary alpha in a transformed beta matrix with no continuous network of alpha at prior beta grain boundaries.

3.5.3.2 Essentially complete field of equiaxed and/or elongated alpha with or without intergranular beta with no continuous network of alpha at prior beta grain boundaries.

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, 3.5.4.2, 3.5.4.3, or by other method acceptable to purchaser.

3.5.4.1 The bend test of 3.5.2.

3.5.4.2 Examination of a metallographic cross section at 400X minimum magnification.

3.5.4.3 Hardness differential; a surface hardness more than 40 points higher than the subsurface hardness, determined in accordance with ASTM E384 on the Knoop scale using a 200-gram load, being evidence of unacceptable surface contamination.

3.6 Quality

3.6.1 The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from "oil cans" (see 8.4.1) with depth in excess of flatness tolerances, ripples, and foreign materials and from imperfections detrimental to usage of the product.

3.6.2 Plate 0.500 to 4.000 inches (12.70 to 101.60 mm), incl, in nominal thickness, ultrasonically inspected in accordance with AMS2631, shall meet Class A1 of that specification.

3.7 Tolerances

Shall conform to the following:

3.7.1 Thickness, Width, Length, and Straightness

All applicable requirements of AMS2242.

3.7.2 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 producer.

3.7.2.1 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.

3.7.2.2 Flatness tolerances do not apply to coiled products.

3.8 Production, distribution, and procurement of metal stock shall comply with AS6279. This requirement becomes effective June 1, 2019.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

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

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

4.2.1 Ultrasonic quality (3.6.2) of each plate, when required.

4.3 Sampling and Testing

Shall be in accordance with AMS2368 and 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.

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

One or more samples from each lot.

4.3.2.1 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 under 9 inches (229 mm), specimens shall be taken with the axis parallel to the direction of rolling.

4.3.2.2 Bend Specimens

Whenever possible, the specimen shall be long enough to permit two separate bends so that each surface is tested in tension.

4.3.3 Other Requirements

As agreed upon by purchaser and producer.

4.4 Reports

4.4.1 The producer shall furnish with each shipment a report showing producer identity, country where the metal was melted (i.e., final melt in the case of metal processed by multiple melting operations), the results of tests for composition of each heat and for hydrogen content, tensile and bending properties, and surface contamination of each lot, ultrasonic quality when required, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, lot number, AMS4916M, product form, size, and quantity.

4.4.2 When material produced to this specification is beyond the sizes allowed in the scope or tables, or other exceptions are taken to the technical requirements listed in Section 3 (see 5.1.1), the report shall contain a statement "This material is certified as AMS4916M(EXC) because of the following exceptions:" and the specific exceptions shall be listed.