

AEROSPACE MATERIAL SPECIFICATION

SAE AMS4904

REV. B

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Superseding AMS4904A

Titanium Alloy Sheet, Strip, and Plate
6Al - 4V
Solution Heat Treated and Aged

(Composition similar to UNS R56400)

RATIONALE

AMS4904B 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

This material has been used typically requiring high strength-to-weight ratio and stability up to 550 °F (288 °C) in the precipitation heat treated condition in material thicknesses 2.000 inches (50.8 mm) and under, but usage is not limited to such applications.

1.3 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 supplied 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.

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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
ARP982	Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

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 112	Determining Average Grain Size
ASTM E 384	Knoop and Vickers Hardness of Materials
ASTM E 539	X-Ray Emission Spectrometric Analysis of 6Al-4V Titanium Alloy
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 Thermal Conductivity/Infrared Detection Method ASTM E 1941 Determination of Carbon in Refractory and Reactive Metals and Their Alloys
ASTM E 1941	Determination of Carbon in Refractory and Reactive Metals and Their Alloys
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 539 or ASTM E 2371. Other analytical methods may be used if acceptable to the purchaser.

TABLE 1 - COMPOSITION

Element	min	max
Aluminum	5.50	6.75
Vanadium	3.50	4.50
Iron	--	0.30
Oxygen	--	0.20
Carbon	--	0.08
Nitrogen	--	0.05 (500 ppm)
Hydrogen (3.1.3)	--	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.

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

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 non-consumable 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, solution heat treated, descaled, leveled, and precipitation hardened (aged), having a surface appearance comparable to a commercial corrosion-resistant steel sheet ASTM No. 2D finish (See 8.3).

3.3.2 Plate

Hot rolled, solution treated, flattened, and precipitation hardened (aged), having a surface appearance comparable to a commercial corrosion-resistant steel ASTM 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 substituted for plate.

3.4 Heat Treatment

The product shall be solution heat treated and aged by heating in a suitable atmosphere to a temperature within the range 1650 to 1775 °F (899 to 968 °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 equivalent to a water quench and then aged by heating to 900 to 1275 °F ± 15 (482 to 691 °C ± 8), holding at heat for 2 to 8 hours, and cooling in air. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

Product shall conform to the following requirements:

3.5.1 Tensile Properties

Shall be as specified 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 - TENSILE PROPERTIES, INCH/POUND UNITS (SEE 8.2)

Nominal Thickness Inch	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %
Up to 0.032, excl	160	145	3 (See 3.5.1.1)
0.032 to 0.049, excl	160	145	4
0.049 to 0.1875, excl	160	145	5
0.1875 to 0.750, excl	160	145	8
0.750 to 1.000, excl	150	140	6
1.000 to 2.000, incl	145	135	6

TABLE 2B - TENSILE PROPERTIES, SI UNITS (SEE 8.2)

Nominal Thickness mm	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %
Up to 0.81, excl	1103	1000	3 (See 3.5.1.1)
0.81 to 1.24, excl	1103	1000	4
1.24 to 4.76, excl	1103	1000	5
4.76 to 19.05, excl	1103	1000	8
19.05 to 25.40, excl	1034	965	6
25.40 to 50.80, incl	1000	931	6

3.5.1.1 For thickness under 0.025 inch (0.64 mm), elongation values shall be as agreed upon.

3.5.2 Microstructure

Shall be that structure resulting from processing within the alpha-beta phase field. Microstructure shall conform to 3.5.2.1 or 3.5.2.2 (See 8.5).

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

3.5.2.2 Primary alpha in an aged transformed beta matrix.

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

3.5.3 Surface Contamination

The product shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination, determined as in 3.5.3.1 or 3.5.3.2, or other method acceptable to purchaser.

3.5.3.1 Microscopic examination at 400X minimum.

3.5.3.2 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 using a 200-gram load, being 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 8.4) 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 4.000 inch (12.70 to 101.60 mm) inclusive in nominal thickness shall meet Class A1 requirements of AMS2631.

3.7 Tolerances

In accordance with AMS2242.

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

All technical requirements are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.1 When required, ultrasonic inspection (3.6.1) of each plate

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 in the same heat treatment 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, Microstructure and Surface Contamination

At least one sample from each lot.

4.3.2.1 Specimens for tensile tests of widths 9 inches (229 mm) and over shall be taken in both the longitudinal and transverse directions; for widths under 9 inches (229 mm), specimens shall be taken in the longitudinal direction.