AEROSPACE MATERIAL SPECIFICATION

AMS4903	REV. C

Issued 2003-04
Revised 2015-03

Superseding AMS4903B

Titanium Alloy Sheet, Strip, and Plate
6Al - 4V
Solution Heat Treated
(Composition similar to UNS R56400)

RATIONALE

AMS4903C is a Five Year Review and update of this specification that includes the removal of sample size allowance for hydrogen of Table 1 (covered by ASTM E1447), requires agreement on mechanical property values for material outside specification ranges (3.5.2.1.2), removes the upper limit on ultrasonic quality, adds AS6279 (3.8), adds AMS2368 in sampling and resampling (4.3 and 4.5) and revises the report paragraph (4.4).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of sheet strip, and plate up through 2.000 inches (50.80 mm), inclusive.

1.2 Application

This material has been used typically for parts to be formed or machined in the solution heat treated condition and subsequently precipitation heat treated requiring high strength-to-weight ratio and stability up to 550 °F (288 °C) in the precipitation heat treated condition, 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 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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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http://www.sae.org/technical/standards/AMS4903C

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), 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 Materials, Except Forging and Forging Stock

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

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, www.astm.org.

ASTM E8 / E8M Tension Testing of Metallic Materials

ASTM E112 Determining Average Grain Size

ASTM E290 Bend Testing of Material for Ductility

ASTM E384 Knoop and Vickers 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 the Inert Gas Fusion Technique

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

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 or ASTM E2371. 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	--	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 requirements of AMS2249.

3.2 Melting Practice

Alloy shall be multiple melted. The first melt shall be made by vacuum 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 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.

3.2.2 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, 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, solution treated, 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 substituted for plate.

3.4 Solution Heat Treatment

The product shall be solution heat treated by heating 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 that will produce product meeting the requirements of 3.5. When vacuum furnace equipment is used, inert gas cooling may be applied. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

Product shall conform to the following requirements:

3.5.1 As Solution Heat Treated

3.5.1.1 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 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 %, min
Up to 0.032, excl	(See 3.5.1.1.1)	150 (max)	6 (See 3.5.1.1.2)
0.032 to 0.1875, excl	(See 3.5.1.1.1)	150 (max)	8

Table 2B - Tensile properties, SI units (See 8.2)

Nominal Thickness Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %, min
Up to 0.81, excl	(See 3.5.1.1.1)	1034 (max)	6 (See 3.5.1.1.2)
0.81 to 4.76, excl	(See 3.5.1.1.1)	1034 (max)	8

3.5.1.1.1 Spread between tensile strength and yield strength shall be 15 ksi (103 MPa) minimum.

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

3.5.1.2 Bending

Product under 0.1875 inch (4.76 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 inch (0.25 mm) 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 not show evidence of cracking when examined at 15 to 25X magnification.

Table 3 - Bend factor

Nominal OD Inches	Nominal OD Millimeters	Bend Factor
Up to 0.070, incl	Up to 1.78, incl	9
Over 0.70 to 0.1875, excl	Over 1.78 to 4.762, excl	10

3.5.1.3 Microstructure

Shall be that structure resulting from processing within the alpha-beta phase field. Microstructure shall conform to 3.5.1.3.1 or 3.5.1.3.2 (See 8.5).

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

3.5.1.3.2 Primary alpha in a matrix of equiaxed alpha prime.

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

3.5.1.4 Surface Contamination

The product shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination, determined as in 3.5.1.4.1 or 3.5.1.4.2 or 3.5.1.4.3, or other method acceptable to purchaser.

3.5.1.4.1 The bend test of 3.5.1.2.

3.5.1.4.2 Microscopic examination at 400X minimum.

3.5.1.4.3 Hardness difference; 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.

3.5.2 Response to Heat Treatment

Product shall conform to the following requirements after being precipitation heat treated at 900 to 1275 °F ± 15 (482 to 691 °C ± 8), holding at heat for 2 to 8 hours, and cooling in air. Precipitation heat treatment shall precede final machining of specimens. Pyrometry shall be in accordance with AMS2750.

3.5.2.1 Tensile Properties

Shall be as shown in Table 4, 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 4A - Minimum tensile properties, inch/pound units (See 8.2)

Nominal Thickness Inches	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 3.5.2.1.1)
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 4B - Minimum 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 3.5.2.1.1)
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

3.5.2.1.1 For thickness under 0.025 inch (0.635 mm), elongation values shall be as agreed.

3.5.2.1.2 Mechanical property requirements for product outside the size range covered by Table 4 shall be agreed upon between purchaser and producer.

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 inch (12.70 mm) and over in nominal thickness shall meet Class A1 requirements of AMS2631.

3.7 Tolerances

In accordance with AMS2242.

3.8 Production, distribution, and procurement of metal stock shall comply with AS6279. This requirement becomes effective October 1, 2016.

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

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

4.2.1 Ultrasonic inspection of each plate when required by 3.6.1.

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 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, Bending, Microstructure, Surface Contamination, Average Grain Size, and Tensile Properties after Precipitation Hardening

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.

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 Ultrasonic Quality

Each plate, when required (3.6.1).