

# AEROSPACE MATERIAL SPECIFICATION

**SAE AMS4903**

**REV. B**

Issued 2003-04  
Revised 2011-06

Superseding AMS4903A

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

(Composition similar to UNS R56400)

## RATIONALE

AMS4903B is 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 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 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](http://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](http://www.astm.org).

|                 |                                                                                                                                  |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------|
| ASTM E 8 / E 8M | Tension Testing of Metallic Materials                                                                                            |
| ASTM E 112      | Determining Average Grain Size                                                                                                   |
| ASTM E 290      | Bend Testing of Material for Ductility                                                                                           |
| 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 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 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, 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  $\pm 25$  °F ( $\pm 14$  °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 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  $\pm 0.002$  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<br>Inch | Tensile Strength<br>ksi | Yield Strength<br>at 0.2% Offset<br>ksi | Elongation in<br>2 inches or 4D<br>%, 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<br>Millimeters | Tensile Strength<br>MPa | Yield Strength<br>at 0.2% Offset<br>MPa | Elongation in<br>50.8 mm or 4D<br>%, 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 (4.762 mm), elongation values shall be as agreed upon.

#### 3.5.1.2 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 E 290 through an angle of 105 degrees. The test fixture supports shall have a contact radius 0.010 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 E 384 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 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 4A - MINIMUM TENSILE PROPERTIES, INCH/POUND UNITS (SEE 8.2)

| Nominal Thickness<br>Inches | Tensile Strength<br>ksi | Yield Strength<br>at 0.2% Offset<br>ksi | Elongation<br>in 2 inches or 4D<br>% |
|-----------------------------|-------------------------|-----------------------------------------|--------------------------------------|
| 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<br>mm |             | Tensile Strength<br>MPa | Yield Strength<br>at 0.2% Offset<br>MPa | Elongation<br>in 50.8 mm or 4D<br>% |
|-------------------------|-------------|-------------------------|-----------------------------------------|-------------------------------------|
| 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, elongation values shall be as agreed upon.

### 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

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 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.