SAE Aerospace
An SAE International Group

# AEROSPACE MATERIAL SPECIFICATION

SAE AMS4939 | REV. B

Issued 2003-04
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Superseding AMS4939A

## Titanium Alloy Sheet, Strip, and Plate
## 3Al - 8V - 6Cr - 4Mo - 4Zr
## Solution Heat Treated

(Composition similar to UNS R58640)

RATIONALE

AMS4939B 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 through 4.000 inches (101.60 mm).

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.

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 of Titanium Alloys





**TO PLACE A DOCUMENT ORDER:** Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
**SAE WEB ADDRESS:** http://www.sae.org

**SAE values your input. To provide feedback on this Technical Report, please visit**
**http://www.sae.org/technical/standards/AMS4939B**

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 290 Bend Testing of Material for Ductility

ASTM E 384 Knoop and Vickers Hardness of Materials

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 2371. Other analytical methods may be used if acceptable to the purchaser.

TABLE 1 - COMPOSITION

| | min | max |
|---|---|---|
| Vanadium | 7.50 | 8.50 |
| Chromium | 5.50 | 6.50 |
| Molybdenum | 3.50 | 4.50 |
| Zirconium | 3.50 | 4.50 |
| Aluminum | 3.00 | 4.00 |
| Iron | -- | 0.30 |
| Oxygen | -- | 0.12 |
| Carbon | -- | 0.05 |
| Nitrogen | -- | 0.03 |
| Hydrogen (3.1.3) | -- | 0.020 (200 ppm) |
| Yttrium (3.1.1) | -- | 0.005 ( 50 ppm) |
| Other Elements, each (3.1.1) | -- | 0.15 |
| 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

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 VAR melt.

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 8.2).

3.3.2 Plate

Hot rolled, solution heated, and flattened, having a surface appearance comparable to a commercial corrosion-resistant steel No. 1 finish (See 8.2). 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 Heat Treatment

The product shall be solution heat treated by heating to a temperature within the range 1450 to 1700 °F (788 to 927 °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. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

The 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 ±0.002 inch/inch/minute (0.002 mm/mm/minute) through the 0.2% offset yield strain.

TABLE 2A - MINIMUM TENSILE PROPERTIES, INCH/POUND UNITS (SEE 8.3)

| Nominal Thickness Inches | Tensile Strength ksi | Yield Strength at 0.2% Offset ksi | Elongation in 2 Inches or 4D % |
|---|---|---|---|
| Up to 0.029, incl | 125 | 120 (3.5.1.1.1) | 6 |
| Over 0.029 to 0.1874, incl | 125 | 120 (3.5.1.1.1) | 8 |
| Over 0.1874 to 1.999, incl | 125 | 120 | 10 (8) (3.5.1.1.2) |
| Over 1.999 to 4.000, incl | 120 | 115 | 8 (6) (3.5.1.1.2) |

TABLE 2B - MINIMUM TENSILE PROPERTIES, SI UNITS (SEE 8.3)

| Nominal Thickness Millimeters | Tensile Strength MPa | Yield Strength at 0.2% Offset MPa | Elongation in 50.8 mm or 4D % |
|---|---|---|---|
| Up to 0.74, incl | 862 | 827 (3.5.1.1.1) | 6 |
| Over 0.74 to 4.76, incl | 862 | 827 (3.5.1.1.1) | 8 |
| Over 4.76 to 50.77, incl | 862 | 827 | 10 (8) (3.5.1.1.2) |
| Over 50.77 to 101.60, incl | 827 | 793 | 8 (6) (3.5.1.1.2) |

3.5.1.1.1 Yield strength value is a maximum for this size in the Solution Treated Condition.

3.5.1.1.2 Elongation value in parentheses applies in the transverse direction only.

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 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 25 X magnification.

TABLE 3 - BEND FACTOR

| Nominal Thickness Inch | Nominal Thickness Millimeters | Bend Factor |
|---|---|---|
| Up to 0.070, incl | Up to 1.78, incl | 3 |
| Over 0.070 to 0.1875, excl | Over 1.78 to 4.762, excl | 3.5 |

3.5.1.3 Surface Contamination

The product shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination, determined as in 3.5.1.3.1, or 3.5.1.3.2, or 3.5.1.3.3, or other method acceptable to purchaser.

3.5.1.3.1 The bend test of 3.5.1.2.

3.5.1.3.2 Microscopic examination at 400X minimum.

3.5.1.3.3 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 by heating within the range 875 to 1150 °F (468 to 621 °C), holding at the selected temperature within ±15 °F (±8 °C) for 2 to 30 hours. Precipitation heat treatment shall precede final machining of specimens.

3.5.2.1 Tensile Properties

Shall be as shown in Table 4, determined in accordance with 3.5.1.1.

TABLE 4A - MINIMUM TENSILE PROPERTIES, INCH/POUND UNITS (SEE 8.3)

| Nominal Thickness Inches | Tensile Strength ksi | Yield Strength at 0.2% Offset ksi | Elongation in 2 Inches or 4D% |
|---|---|---|---|
| Up to 0.1874, incl | 180 | 170 | 6 |
| Over 0.1874 to 1.999, incl | 180 | 170 | 8 |
| Over 1.999 to 4.000, incl | 170 | 160 | 6 (4) (3.5.2.1.1) |

TABLE 4B - MINIMUM TENSILE PROPERTIES, SI UNITS (SEE 8.3)

| Nominal Thickness Millimeters | Tensile Strength MPa | Yield Strength at 0.2% Offset MPa | Elongation in 50.8 mm or 4D % |
|---|---|---|---|
| Up to 4.76, incl | 1241 | 1172 | 6 |
| Over 4.76 to 50.77, incl | 1241 | 1172 | 8 |
| Over 50.77 to 101.60, incl | 1172 | 1103 | 6 (4) (3.5.2.1.1) |

3.5.2.1.1 Elongation value in parentheses applies in the transverse direction only.

3.6 Quality

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

3.6.1 When specified, plate 0.500 inches (12.70 mm) and over in nominal thickness shall be ultrasonically inspected in accordance with AMS2631 and shall meet the quality standards agreed upon between the purchaser and supplier.

3.7 Tolerances

Shall conform to all applicable requirements of 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.