SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE MAM 4911B

Issued APR 1998
Revised JUN 1994
Cancelled MAR 2003

Superseding MAM 4911A

Titanium Alloy Sheet, Strip, and Plate
6Al - 4V
Annealed

UNS R56400

CANCELLATION NOTICE

This specification has been declared “CANCELLED” by the Aerospace Materials Division, SAE, as of March, 2003. By this action, this document will remain listed in the Numerical Section of the Index of Aerospace Material Specifications.

AMS 4911 covers the same material.

“CANCELLED” specifications are available from SAE.

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

1. SCOPE:

1.1 Form:

This specification covers a titanium alloy in the form of sheet, strip, and plate procured in metric units.

1.1.1 AMS 4911 is the inch/pound version of this MAM.

1.2 Application:

These products have been used typically for parts requiring strength up to 400 °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 following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

MAM 2242 Tolerances, Metric, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Sheet, Strip, and Plate
AMS 2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2631 Ultrasonic Inspection, Titanium and Titanium Alloy Bar and Billet
AMS 2750 Pyrometry
AMS 2809 Titanium and Titanium Alloy Wrought Products

ARP982 Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM E 8M Tension Testing of Metallic Materials (Metric)
ASTM E 120 Chemical Analysis of Titanium and Titanium Alloys
ASTM E 290 Semi-Guided Bend Test for Ductility of Metallic Materials
ASTM E 384 Microhardness of Materials
ASTM E 1409 Determination of Oxygen 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 Method

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

(R)

Shall conform to the percentages by weight shown in Table 1, determined by analytical methods in accordance with ASTM E 120, ASTM E 1409, and ASTM E 1447, by spectrochemical methods, or by other analytical methods acceptable to 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)
Residual Elements, each (3.1.1)	- -	0.10
Residual 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 AMS 2249.

3.2 Melting Practice:

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

3.2.1.1 (R) The atmosphere for nonconsumable 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 (R) Sheet and Strip: Hot rolled with or without subsequent cold reduction, annealed, descaled, and leveled, having a surface appearance comparable to a commercial corrosion-resistant steel No. 2D finish (See 8.2).

3.3.2 (R) Plate: Hot rolled, annealed, descaled, and flattened, having a surface appearance comparable to a commercial corrosion-resistant steel No. 1 finish (See 8.2).

3.4 Annealing:

(R) The product shall be annealed by heating to a temperature within the range 705 to 900 °C, holding at the selected temperature within ±15 °C for a time commensurate with product thickness and the heating equipment and procedure used, and cooling at a rate which will produce product meeting the requirements of 3.5. Pyrometry shall be in accordance with AMS 2750.

3.5 Properties:

The product shall conform to the following requirements and shall meet the requirements of 3.5.1 and 3.5.2 after being heated in air to 720 °C ± 15, held at heat for 20 minutes ± 2, cooled at a rate equivalent to an air cool or slower, and descaled.

3.5.1 Tensile Properties: Shall be as specified in Table 2 determined in accordance with ASTM E 8M with the rate of strain maintained at 0.003 to 0.007 mm/mm per minute through the yield strength and then increased so as to produce failure in approximately one additional minute. When a dispute occurs between purchaser and vendor over the yield strength values, a referee test shall be performed on a machine having a strain rate pacer using a rate of 0.005 mm/mm/per minute through the yield strength.

TABLE 2 - Minimum Tensile Properties

Nominal Thickness Millimeters	Tensile Strength MPa	Yield Strength At 0.2% Offset MPa	Elongation in 50 Millimeters or 4D %
Upto 0.20, excl	925	870	--
0.20 to 0.62, excl	925	870	6
0.62 to 1.60, excl	925	870	8
1.60 to 4.75, excl	925	870	10
4.75 to 100.00, incl	895	825	10

3.5.1.1 (R) Tensile property requirements apply in both the longitudinal and transverse directions but tests in the transverse direction need be made only on product from which a specimen not less than 200 mm in length for sheet and strip and 63.5 mm in length for plate can be taken. Tests in the transverse direction are not required on product tested in the longitudinal direction.

3.5.2 Bending: Product shall withstand, without evidence of cracking when examined at 20X magnification, bending at room temperature in accordance with ASTM E 290 through an angle of 105 degrees around a diameter equal to the bend factor shown in Table 3 times the nominal thickness of the product, using either V-block, U-channel, or free bend procedure. The axis of bend shall be parallel to the direction of rolling. Only one of these tests will be required in routine inspection. In case of dispute, results of bend tests using the V-block procedure shall govern.

TABLE 3 - Bending Parameters

Nominal Thickness Millimeters	Bend Factor
Up to 1.75, incl	9
Over 1.75 to 4.75, excl	10

3.5.3 (R) Microstructure: Shall be that structure resulting from alpha-beta processing. Microstructure shall conform to 3.5.3.1, 3.5.3.2, or 3.5.3.3.

3.5.3.1 (R) Equiaxed alpha in a transformed beta matrix.

3.5.3.2 (R) Equiaxed alpha and elongated alpha in a transformed beta matrix.

3.5.3.3 (R) Partially broken and distorted grain boundary alpha with plate-like alpha.

3.5.3.4 (R) A microstructure showing a continuous network of alpha in prior beta grain boundaries is not acceptable.

3.5.4 (R) 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 other method agreed upon by purchaser and vendor.

3.5.4.1 The bend test of 3.5.2.

3.5.4.2 (R) Microstructural Hardness Differential: 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.

3.5.4.3 Microscopic examination at 100X magnification.

3.6 Quality:

The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from "oil cans" (See 8.2) of depth in excess of the flatness tolerances, ripples, and foreign materials and from imperfections detrimental to usage of the product.

3.6.1 Plate 12.50 to 100.00 mm, inclusive, in nominal thickness, ultrasonically inspection in accordance with AMS 2631, shall meet Class Al requirements of AMS 2631.

3.7 Tolerances:

Shall conform to all applicable requirements of MAM 2242.

3.7.1 Special flatness may be specified for plate, in such case the special flatness tolerances of MAM 2242 apply.

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 performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 (R) Acceptance Tests: Tests of the product as received for composition (3.1), condition (3.3), annealed tensile properties (3.5.1), bending (3.5.2), microstructure (3.5.3), surface contamination (3.5.4), ultrasonic quality (3.6.1), and tolerances (3.7) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Tests of the product after reheating as in 3.5 for tensile properties (3.5.1) and bending (3.5.2) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

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:

4.3.1 For Acceptance Tests:

4.3.1.1 Composition: One sample from each heat, except that for hydrogen determinations one sample from each lot obtained after thermal and chemical processing is completed.