SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4939

Issued APR 2003

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

(Composition similar to UNS R58640)

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 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 canceled 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)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2242	Tolerances, 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 of Titanium Alloys
AMS 2809	Identification, Titanium and Titanium Alloy Wrought Products
AMS-H-81200	Heat Treatment of Titanium and Titanium Alloys
ARP982	Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials, Metric
ASTM E 120	Chemical Analysis of Titanium and Titanium Alloys
ASTM E 290	Bend Testing of Material for Ductility
ASTM E 384	Microindentation Hardness 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

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, oxygen shall be determined in accordance with ASTM E 1409, hydrogen in accordance with ASTM E 1447, and other elements by wet chemical methods in accordance with ASTM E 120, by spectrochemical methods, or by other analytical methods acceptable to 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)
Residual Elements, each (3.1.1)	--	0.15
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 applicable requirements of AMS 2249.

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 final melting cycle shall be under vacuum. The first melt shall be made by consumable electrode, nonconsumable electrode, electron beam, or plasma arc melting practice. The subsequent melt or melts shall be made using consumable electrode practice with no alloy additions permitted in the last consumable electrode 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).

3.4 Heat Treatment:

The product shall be solution heat treated in accordance with AMS-H-81200.

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 or ASTM E 8M with the rate of strain maintained at 0.003 to 0.007 inch/inch/minute (0.003 to 0.007 mm/mm/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 inch/inch/minute (0.005 mm/mm/minute) through the yield strength and a minimum cross head speed of 0.10 inch (2.5 mm) per minute above the yield strength.

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 0.1875, incl	125	120 (3.5.1.1.1)	8
Over 0.1875 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 diameter equal to the bend factor shown in Table 3 times the nominal thickness. Examination of the bent sample shall show no 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, excl	6
Over 0.070 to 0.1875, incl	Over 1.75 to 4.762, incl	7

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 in accordance with AMS-H-81200 except that aging time may be adjusted to meet the listed tensile properties. 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 ASTM E 8 or ASTM E 8M with the rate of strain maintained at 0.003 to 0.007 inch/inch/minute (0.003 to 0.007 mm/mm/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 test machine having a strain rate pacer using a rate of 0.005 inch/inch/minute (0.005 mm/mm/minute) through the yield strength and a minimum cross head speed of 0.10 inch (2.5 mm) per minute above the yield strength.

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 0.1875, incl	180	170	6
Over 0.1875 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 to 4.000 inches (12.70 to 101.60 mm), inclusive, in nominal thickness, shall be ultrasonically inspected in accordance with AMS 2631 and shall meet the quality standards agreed upon between the purchaser and supplier.

3.7 Tolerances:

Shall conform to all applicable requirements of AMS 2242.

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 the specified requirements.

4.2 Classification of Tests:

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

4.3 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 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.

4.4 Reports:

The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and for the hydrogen content, tensile and bending properties, and surface contamination of each lot, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS 4939, size, specific aging treatment used to develop precipitation hardened properties, and quantity.