

Titanium Alloy Sheet, Strip, and Plate
6Al-6V-2Sn
Solution Heat Treated

(Composition similar to UNS R56620)

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.

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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 112	Determining Average Grain Size
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 E120, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	min	max
Aluminum	5.00	6.00
Vanadium	5.00	6.00
Tin	1.50	2.50
Iron	0.35	1.00
Copper	0.35	1.00
Oxygen	--	0.20
Carbon	--	0.05
Nitrogen	--	0.04 (400 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.

3.1.3 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 8.3).

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).

3.3 Heat Treatment:

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

3.4 Properties:

Product shall conform to the following requirements:

3.4.1 As Solution Heat Treated:

3.4.1.1 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 - Tensile Properties, Inch/Pound Units (See 8.2)

Nominal Thickness Inch	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi, max	Elongation in 2 Inches or 4D %, min
Up to 0.1875, excl	(3.4.1.1.1)	160	10 (3.4.1.1.2)

TABLE 2B - Tensile Properties, SI Units (See 8.2)

Nominal Thickness Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa, max	Elongation in 50.8 mm or 4D %, min
Up to 4.76, excl	(3.4.1.1.1)	1103	6 (3.4.1.1.2)

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

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

3.4.1.2 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 25X magnification.

TABLE 3 - Bend Factor

Nominal Thickness Inch	Nominal Thickness Millimeters	Bend Factor
Up to 0.070, excl	Up to 1.78, excl	8
0.070 to 0.1875, incl	1.78 to 4.762, incl	9

- 3.4.1.3 Microstructure: Shall be that structure resulting from processing within the alpha-beta phase field. Microstructure shall conform to 3.4.1.3.1 or 3.4.1.3.2 (See 8.5).
- 3.4.1.3.1 Equiaxed and/or elongated primary alpha in a transformed beta matrix with no continuous network of alpha at prior beta grain boundaries.
- 3.4.1.3.2 Essentially complete field of equiaxed and/or elongated alpha with or without intergranular beta and with no continuous network of alpha at prior beta grain boundaries.
- 3.4.1.3.3 A microstructure showing a continuous network of alpha in prior beta grain boundaries is not acceptable,
- 3.4.1.4 Surface Contamination: The product shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination, determined as in any one of the following: 3.4.1.4.1, 3.4.1.4.2, 3.4.1.4.3, or other method acceptable to purchaser.
- 3.4.1.4.1 The bend test of 3.4.1.2.
- 3.4.1.4.2 Microscopic examination at 400X minimum.
- 3.4.1.4.3 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.
- 3.4.1.5 Average Grain Size: Shall be ASTM No. 6 or finer determined by comparison of a polished and etched specimen with the chart in ASTM E 112.
- 3.4.2 Response to Heat Treatment: Product shall conform to the following requirements after being precipitation heat treated in accordance with AMS-H-81200. Precipitation heat treatment shall precede final machining of specimens.
- 3.4.2.1 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 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 (See 8.2)

Nominal Thickness Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 in. or 4D %
Up to 0.1875, incl	170	160	8 (6) (See 3.4.2.1.1)
0.1875 to 1.500, excl	170	160	8
1.500 to 2.500, excl	160	150	6
2.500 to 4.000 excl	150	140	6

TABLE 4B - Minimum 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 %
Up to 4.76, incl	1172	1103	8 (6) (See 3.4.2.1.1)
4.76 to 38.10, excl	1172	1103	8
38.10 to 63.50, excl	1103	1034	6
63.50 to 101.60, excl	1034	965	6

3.4.2.1.1 Elongation value in parentheses is for transverse direction only.

3.5 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.

3.5.1 Ultrasonic Inspection: Plate 0.500 to 4.000 inch (12.70 to 101.60 mm) in nominal thickness shall meet Class A1 requirements of AMS 2631.

3.6 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:

Tests for 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, Average Grain Size, and Tensile Properties After Precipitation Hardening: At least one sample from each lot.

4.3.2.1 Specimens for tensile and notch-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 composition of each heat and for the hydrogen content, tensile and bending properties, average grain size, 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 4988, size, specific aging treatment used to develop precipitation hardened properties, and quantity.

4.5 Resampling and Retesting:

If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Identification:

Shall be in accordance with AMS 2809.