AEROSPACE MATERIAL SPECIFICATION

AMS6953™	REV. A
Issued 2018-02 Revised 2022-05 Superseding AMS6953	

Titanium Alloy Sheet
6Al - 4Sn - 3Nb - 0.5Mo - 0.3Si
Duplex Annealed
(Composition similar to UNS R56643)

RATIONALE

AMS6953A results from a Five-Year Review and update of this specification with changes to update general agreement language related to unauthorized exceptions (3.5.1.3, 3.9, 4.4.2, 8.6), relocate definitons (2.3), update applicable documents (Section 2, 2.3) and ordering information (8.7), and allow use of the immediate prior specification revision (8.5).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of sheet 0.020 to 0.1874 inch (0.51 to 4.760 mm), inclusive, in nominal thickness. (see 8.7)

1.2 Application

This sheet product has been used typically for parts requiring a combination of high strength, toughness, and oxidation resistance up to 1200 °F (649 °C), but usage is not limited to such applications.

1.2.1 Certain processing procedures and service conditions may cause this product 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 +1 724-776-4970 (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

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**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS6953A/

AMS2368	Sampling and Testing of Wrought Titanium Raw Materials, Except Forgings and Forging Stock
AMS2750	Pyrometry
AMS2809	Identification, Titanium and Titanium Alloy Wrought Products
ARP982	Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products
AS1814	Terminology for Titanium Microstructures
AS4194	Sheet and Strip Surface Finish Nomenclature
AS6279	Standard Practice for Production, Distribution, and Procurement of Metal Stock
AS7766	Terms Used in Aerospace Metals Specifications

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 A480/A480M	General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM E8/E8M	Tension Testing of Metallic Materials
ASTM E21	Elevated Temperature Tension Tests of Metallic Materials
ASTM E290	Bend Testing of Material for Ductility
ASTM E384	Microindentation Hardness of Materials
ASTM E539	Analysis of Titanium Alloys by Wavelength-Dispersive X-Ray Fluorescence Spectrometry
ASTM E1409	Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion
ASTM E1447	Determination of Hydrogen in Titanium and Titanium Alloys by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method
ASTM E1941	Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis
ASTM E2371	Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Atomic Emission Spectrometry (Performance-Based Test Methodology)
ASTM E2994	Analysis of Titanium and Titanium Alloys by Spark Atomic Emission Spectrometry and Glow Discharge Atomic Emission Spectrometry (Performance-Based Method)

2.3 Definitions

Terms used in AMS are defined in AS7766 and as follows:

2.3.1 OIL CAN

An excess of material in a localized area of a sheet that causes the sheet to buckle in that area. When the sheet is placed on a flat surface and hand pressure applied to the buckle, the buckle will spring through to the opposite surface or spring up in another area of the sheet.

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 E1941, hydrogen in accordance with ASTM E1447, oxygen and nitrogen in accordance with ASTM E1409, and other elements in accordance with ASTM E539, ASTM E2371, or ASTM E2994. Other analytical methods may be used if acceptable to the purchaser.

Table 1 - Composition

Element	Min	Max
Aluminum	5.50	6.50
Tin	3.75	4.25
Niobium	2.50	3.50
Molybdenum	0.40	0.80
Silicon	0.10	0.40
Iron	--	0.25
Oxygen	--	0.15
Carbon	--	0.10
Nitrogen	--	0.05 (500 ppm)
Hydrogen	--	0.0150 (150 ppm)
Yttrium (3.1.1)	--	0.005 (50 ppm)
Residual Elements, each (3.1.1)	--	0.10
Residual Elements, total (3.1.1)	--	0.30
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.

3.2 Melting Practice

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

3.2.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be inert gas at a pressure not higher than 1000 mm of mercury.

3.2.2 The electrode tip for nonconsumable electrode melting shall be water-cooled copper.

3.3 Condition

Hot rolled with or without subsequent cold reduction, duplex annealed, descaled, and leveled, having a surface appearance comparable to a commercial corrosion-resistant steel No. 2D finish (see 8.2).

3.4 Heat Treatment

The sheet shall be duplex annealed as follows. Pyrometry shall be in accordance with AMS2750.

3.4.1 Sheet shall be heated to 1650 °F ± 25 °F (899 °C ± 14 °C), held at heat for 30 minutes cooled in air to room temperature, reheated to 1450 °F ± 25 °F (788 °C ± 14 °C), held at heat for 15 minutes, and cooled in air to room temperature.

3.4.2 Heat treating time tolerances shall be commensurate with heating equipment and procedures used to produce sheet meeting the requirements of 3.5.

3.5 Properties

The sheet shall conform to the following requirements:

3.5.1 Tensile Properties

3.5.1.1 At Room Temperature

Shall be as specified in Table 2, determined in accordance with ASTM E8/E8M, with the rate of strain set at 0.005 in/in/min (0.005 mm/mm/min) and maintained within a tolerance of ±0.002 in/in/min (0.002 mm/mm/min) through the 0.2% offset yield strain.

Table 2A - Minimum tensile properties, inch/pound units

Nominal Thickness Inches	Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %
0.020 to 0.1874, incl	Longitudinal	135	125	8
0.020 to 0.1874, incl	Long-transverse	135	125	8

Table 2B - Minimum tensile properties, SI units

Nominal Thickness Millimeters	Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %
0.51 to 4.760, incl	Longitudinal	931	862	8
0.51 to 4.760, incl	Long-transverse	931	862	8

3.5.1.2 At 900 °F (482 °C)

Shall be as specified in Table 3, determined in accordance with ASTM E21 on specimens tested at 900 °F ± 10 °F (482 °C ± 6 °C).

Table 3A - Minimum tensile properties, inch/pound units

Nominal Thickness Inches	Specimen Orientation	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %
0.020 to 0.1874, incl	Longitudinal	90	75	7
0.020 to 0.1874, incl	Long-transverse	90	75	7

Table 3B - Minimum tensile properties, SI units

Nominal Thickness Millimeters	Specimen Orientation	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %
0.51 to 4.760, incl	Longitudinal	621	517	7
0.51 to 4.760, incl	Long-transverse	621	517	7

3.5.1.3 Mechanical property requirements for product outside the range covered by 1.1 shall be agreed upon between purchaser and producer and reported per 4.4.2.

3.5.2 Bending

Shall be as specified in Table 4. Samples shall be bend tested at room temperature in conformance with the guided bend test defined in ASTM E290 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 4 times the nominal thickness. Examination of the bent sample shall not show evidence of cracking when examined at 20X magnification.

Table 4 - Bend factor

Nominal Thickness Inches	Nominal Thickness Millimeters	Specimen Orientation	Bend Factor
0.020 to 0.070, incl	0.51 to 1.78, incl	L and LT	4.5
Over 0.070 to 0.1874, incl	Over 1.78 to 4.760, incl	L and LT	5

3.5.3 Microstructure

Shall be that structure resulting from processing in the alpha-beta phase field. Microstructure shall conform to 3.5.3.1, 3.5.3.2, or 3.5.3.3. A microstructure showing a continuous network of alpha in prior beta grain boundaries is not acceptable.

3.5.3.1 Equiaxed and/or elongated primary alpha in a transformed beta matrix with no continuous network of alpha at prior beta grain boundaries.

3.5.3.2 Essentially complete field of equiaxed and/or elongated alpha with no continuous network of alpha at prior beta grain boundaries.

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

3.5.4 Surface Contamination

Freedom from surface contamination, such as alpha case, shall be determined in accordance with 3.5.4.1 or 3.5.4.2, or other method agreed upon by purchaser and producer. (see 8.7)

3.5.4.1 If the sheet complies with the bend test requirements in 3.5.2, the sheet is acceptable.

3.5.4.2 If the hardness between the surface and the subsurface, when measured in accordance with ASTM E384 on the Knoop scale using a 200 g load, differs by 40 points or less, the sheet is acceptable.

3.6 Quality

The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from oil cans (see 2.3.1) of depth in excess of the flatness tolerances, ripples, foreign materials, and from imperfections detrimental to usage of the product.

3.7 Tolerances

Shall conform to the following:

3.7.1 Thickness, Width, Length, and Straightness

All applicable requirements of AMS2242.

3.7.2 Flatness

Flatness tolerance for product 36 inches (914 mm) and under in width shall be 3%. Flatness tolerance for product over 36 inches (914 mm) wide shall be as agreed upon by purchaser and producer. (see 8.7)

3.7.2.1 Flatness shall be determined from the expression 100H/L, where “H” is the distance from the straight edge to the product at the point of greatest separation and “L” is the distance between contact points of a straight edge laid in any direction on the product.

3.8 Production, distribution, and procurement of metal stock shall comply with AS6279.

3.9 Exceptions

Any exceptions shall be authorized by purchaser and reported as in 4.4.2.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for producer'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

4.2.1 Acceptance Tests

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

4.2.1.1 Composition (3.1) of each heat.

4.2.1.2 Hydrogen content (3.1), longitudinal and long-transverse room-temperature tensile properties (3.5.1.1), longitudinal and long-transverse bending (3.5.2), microstructure (3.5.3), surface contamination (3.5.4), and tolerances (3.7) of each lot.

4.2.2 Periodic Tests

Longitudinal and long-transverse 900 °F (482 °C) tensile properties (3.5.1.2) are a periodic test and shall be performed at a frequency selected by the producer unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing

Shall be in accordance with AMS2368 and the following:

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.

4.3.1.2 Room Temperature Tensile Properties

At least one sample for each testing direction specified in Table 2 from each lot.

4.3.1.3 Bending

At least one sample for each testing direction specified in Table 4 from each lot.

Bend test samples shall be 0.750 inch (19.05 mm) in width. Longitudinal specimens shall have their long dimension parallel to the direction of rolling. Transverse specimens shall have their long dimension perpendicular to the direction of rolling.

4.3.1.4 Microstructure and Surface Contamination Requirements

At least one sample from each lot.