AEROSPACE MATERIAL SPECIFICATION

AMS4898™	REV. F
Issued 1996-09 Revised 2022-11 Superseding AMS4898E	

Titanium Alloy, Sheet
6Al - 2Sn - 2Zr - 2Mo - 2Cr - 0.15Si
Annealed
(Composition similar to UNS R56222)

RATIONALE

AMS4898F results from a Five-Year Review and update of this specification with changes to update wording to prohibit unauthorized exceptions (3.4.1.1.1, 8.7), relocate definitions (2.3), update applicable documents (Section 2), and ordering information (8.8).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of sheet in nominal thicknesses 0.016 through 0.1874 inch (0.41 through 4.760 mm).

1.2 Application

This sheet has been used typically for parts requiring high strength, toughness, and fatigue strength up to 750 °F (399 °C), but usage is not limited to such applications. The product can be superplastically formed above 1500 °F (816 °C) and it can be aged after air cooling from the solution treatment or super-plastic forming temperature to increase the strength.

1.2.1 Certain processing procedures and service conditions may cause this sheet 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/AMS4898F/

AMS2368 Sampling and Testing of Wrought Titanium Raw Material, 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

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 A480/480M General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

ASTM E8/E8M Tension Testing of Metallic Materials

ASTM E290 Bend Testing Material for Ductility

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 the 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 Plasma 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 CANNING

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.

2.3.2 Commercial corrosion-resistant steel finishes are defined in ASTM A480/A480M and AS4194.

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	5.25	6.25	
Tin	1.75	2.25	
Zirconium	1.75	2.25	
Molybdenum	1.75	2.25	
Chromium	1.75	2.25	
Silicon	0.10	0.20	
Iron	--	0.15	
Oxygen	--	0.15	
Carbon	--	0.08	
Nitrogen	--	0.05	(500 ppm)
Hydrogen	--	0.015	(150 ppm)
Other Elements, each (3.1.1)		0.10	
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 applicable requirements of AMS2249.

3.2 Melting Practice

Alloy shall be multiple melted. The first melt shall be made by vacuum consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The subsequent melt or melts shall be made using vacuum arc remelting (VAR) practice. Alloy additions are not permitted in the final vacuum arc remelting (VAR) melt.

3.2.1 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.

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

3.3 Condition

Hot rolled, annealed, ground, and pickled. Surface appearance shall be comparable to a commercial corrosion-resistant steel No. 2D finish (see 2.3.2).

3.3.1 Annealing

The product shall be annealed as follows, pyrometry shall be in accordance with AMS2750.

3.3.1.1 Heat to a temperature within the range 1300 to 1650 °F (704 to 899 °C), hold at the selected temperature within ±25 °F (±14 °C) for a time commensurate with product thickness and the heating equipment and procedure used, and cool to room temperature at a rate equivalent to an air cool or faster.

3.3.1.2 Continuous Anneal of Sheet and Strip

When continuous annealing is used, process parameters (e.g., furnace temperature set points, heat input, travel rate, etc.) for continuous heat treating lines shall be established by the material producer and validated by testing of product to requirements of 3.4.

3.4 Properties

The product shall conform to the following requirements, determined in accordance with AMS2368, except tensile testing shall be determined in accordance with 3.4.1.1 and bending shall be determined in accordance with 3.4.1.2.

3.4.1 As Annealed

3.4.1.1 Tensile Properties

Shall be as shown 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. Tensile property requirements apply in both the longitudinal and transverse directions.

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

Nominal Thickness Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %
0.016 to 0.025, incl	155	150	5
Over 0.025 to 0.032, incl	155	150	6
Over 0.032 to 0.080, incl	155	150	7
Over 0.080 to 0.1874, incl	155	150	8

Table 2B - Minimum tensile properties, SI units

Nominal Thickness Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %
0.41 to 0.64, incl	1069	1034	5
Over 0.64 to 0.81, incl	1069	1034	6
Over 0.81 to 2.03, incl	1069	1034	7
Over 2.03 to 4.760, incl	1069	1034	8

3.4.1.1.1 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 (see 8.8).

3.4.1.2 Bending

Product 0.016 to 0.1874 inch (0.41 to 4.76 mm) and under 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 E290 through an angle of 105 degrees. The test fixture supports shall have a contact radius 0.010 inches (0.254 mm) 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 25X magnification.

Table 3 - Bending parameters

Nominal Thickness Inches	Nominal Thickness Millimeters	Bend Factor
0.016 to 0.070, incl	0.41 to 1.78, incl	4.5
Over 0.070 to 0.1874, incl	Over 1.78 to 4.760, incl	5

3.4.1.3 Average Grain Size

Sheet 0.016 to 0.125 inch (0.41 to 3.18 mm) and under in nominal thickness, shall have an average grain size of ASTM No. 10 or finer (see 8.4).

3.4.1.4 Microstructure

Shall be that structure resulting from processing within the alpha-beta phase field. Microstructure shall conform to 3.4.1.4.1 or 3.4.1.4.2.

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

3.4.1.4.2 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.

3.4.1.5 Surface Contamination

Sheet shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination.

3.4.2 Response to Heat Treatment

When specified by purchaser, specimens from sheet, 0.016 to 0.1874 inch (0.41 to 4.760 mm), inclusive, in nominal thickness, shall meet the requirements shown in Table 4 after being solution heat treated by heating to a temperature within the range 1600 to 1700 °F (871 to 927 °C), holding at the selected temperature within ±25 °F (±14 °C) for 15 to 60 minutes, cooling to room temperature at a rate equivalent to an air cool or faster, followed by aging within the range of 900 to 1000 °F (482 to 538 °C), holding at the selected temperature within ±15 °F (±8 °C) for 8 to 12 hours (see 8.2 and 8.3), and cooling to room temperature.

Table 4 - Minimum tensile properties

Property	Value
Tensile Strength	180 ksi (1241 MPa)
Yield Strength at 0.2% Offset	160 ksi (1103 MPa)
Elongation in 2 Inches (50.8 mm)	5% (3.4.2.1)

3.4.2.1 Elongation requirement applies only to sheet 0.032 inch (0.81 mm) and over in nominal thickness.

3.5 Quality

Sheet, as received by purchaser, shall be uniform in quality and condition, sound, and free from “oil canning” (see 2.3.1) of depth in excess of one-half of the flatness tolerances, ripples, foreign materials, and from imperfections detrimental to usage of the sheet.

3.6 Tolerances

Shall conform to all applicable requirements of AMS2242 except the variation in flatness, unless otherwise specified, shall not exceed 1/2 of the standard flatness tolerance.

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

3.8 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 sheet 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

Composition (3.1), surface appearance (3.3), tensile properties as annealed (3.4.1.1), bending (3.4.1.2), average grain size (3.4.1.3), microstructure (3.4.1.4), and tolerances (3.6) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests

Surface contamination (3.4.1.5) and tensile properties after solution heat treatment and aging (3.4.2) are periodic tests and shall be performed at a frequency selected by the producer unless frequency of testing is specified by the purchaser.

4.3 Sampling and Testing

In accordance with AMS2368 except for the following:

4.3.1 For Acceptance Tests

4.3.1.1 Tensile Tests

Specimens from sheet 9 inches (228 mm) and over in width shall be taken with the axis of the specimens both perpendicular and parallel to the direction of rolling.

4.3.2 For Periodic Tests

As selected by the producer, unless otherwise specified.

4.4 Reports

4.4.1 The producer shall furnish with each shipment a report showing the producer identity, country where the metal was melted (i.e., final melt in the case of metal processed by multiple melting operations), results of tests for composition of each heat and for the hydrogen content, tensile properties as annealed, bending, average grain size, and, when specified, tensile properties after solution and aging heat treatment for each lot and stating that the sheet conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS4898F, specific annealing treatment used, product form, size, and quantity.

4.4.2 When material produced to this specification is beyond the sizes allowed in the scope or tables, or exceptions authorized by purchaser are taken to the technical requirements listed in Section 3, the report shall contain a statement, "This material is certified as AMS4898F(EXC) because of the following exceptions:" and the specific exceptions shall be listed (also see 5.1).

4.5 Resampling and Retesting

In accordance with AMS2368.