AEROSPACE MATERIAL SPECIFICATION

AMS4937	REV. D

Issued 1992-07
Revised 2014-10

Superseding AMS4937C

Titanium Alloy, Extrusions and Flash Welded Rings
6Al - 6V - 2Sn
Beta Extruded Plus Annealed, Heat Treatable
(Composition similar to UNS R56620)

RATIONALE

AMS4937D results from a Five Year Review and update of this specification to agreement of testing material outside the sizes of 1.1 (3.5.1.1.1.2), revise melting to restrct subsequent melting to VAR (3.2), add AMS2368 to sampling, the addition of AS6279 (3.8) and revise reporting (4.4).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of extruded bars, tubes, and shapes, and of flash welded rings up through 4.00 inches (101.6 mm) in diameter or least distance between parallel sides and stock for flash welded rings.

1.2 Application

These products have been used typically for parts requiring high strength up to 750 °F (399 °C), particularly those parts machined and/or flash-butt welded in the annealed condition with the option of subsequent solution and precipitation heat treatment, 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 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 724-776-4970 (outside USA), www.sae.org.

AMS2245 Tolerances, Titanium and Titanium Alloy Extruded Bars, Rods, and Shapes

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**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS4937D

AMS2368 Sampling and Testing of Wrought Titanium Raw Material, Except Forgings and Forging Stock

AMS2750 Pyrometry

AMS2809 Identification, Titanium and Titanium Alloy Wrought Products

AMS7498 Rings, Flash Welded, Titanium and Titanium Alloys

ARP982 Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

AS6279 Industry Standard Practices for Production, Distribution, and Procurement of Metal Stock

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 E 8 / E 8MTension Testing of Metallic Materials

ASTM E 1409 Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion

ASTM E 1447 Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion/Thermal Conductivity/Infrared Detection Method

ASTM E 1941 Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis

ASTM E 2371 Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission Spectrometry

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 E 1941, hydrogen in accordance with ASTM E 1447, oxygen and nitrogen in accordance with ASTM E 1409, and other elements in accordance with ASTM E 2371. Other analytical methods may be used if acceptable to the 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 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 under vacuum using vacuum arc remelting (VAR) practice. Alloy additions are not permitted in the final melt cycle.

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

The product shall be supplied in the following condition:

3.3.1 Bars, Tubes, and Shapes

Extruded, annealed, straightened and detwisted as required, and descaled.

3.3.1.1 Extrusions may be descaled by wet or dry abrasive blasting, by chemical procedures, or by other methods acceptable to purchaser.

3.3.2 Flash Welded Rings

Fabricated in accordance with AMS7498 and annealed.

3.3.3 Stock for Flash Welded Rings

As ordered by the flash welded ring manufacturer.

3.4 Heat Treating

At the option of the extrusion manufacturer, straightening and detwisting operations may be performed in conjunction with annealing. Pyrometry shall be in accordance with AMS2750.

3.4.1 Annealing

Extruded shapes and flash welded rings shall be annealed by heating to a temperature within the range 1300 to 1500 °F (704 to 816 °C), holding at the selected temperature within ±25 °F (±14 °C) for 2 hours ± 0.25, and cooling to room temperature.

3.4.2 Stress-Relieving

When specified by purchaser, extruded shapes and flash welded rings shall be stress-relieved after any forming operation performed below 1050 °F (566 °C) for dimensional control, sizing, or proof testing. Product shall be stress-relieved by heating to a temperature within the range 900 to 1100 °F (482 to 593 °C), holding at the selected temperature within ±25 °F (±14 °C) for 2 to 4 hours, and cooling in air.

3.5 Properties

The product shall conform to the following requirements:

3.5.1 Bars, Tubes, Shapes, and Flash Welded Rings

Product 4.00 inches (101.6 mm) and under in nominal diameter or least distance between parallel sides shall have the following properties:

3.5.1.1 As Annealed, Formed, or Formed and Stress-Relieved

3.5.1.1.1 Tensile Properties

Shall be as shown in Table 2, determined in accordance with ASTM E 8 / E 8M with the rate of strain set at 0.005 inch/inch/minute (0.005 mm/mm/minute) and maintained within a tolerance of ±0.002 inch/inch/minute (0.002 mm/mm/minute) through the 0.2% offset yield strain.

TABLE 2A - TENSILE PROPERTIES, INCH/POUND UNITS

Nominal Diameter or Least Distance Between Parallel Sides Inches	Tensile Strength ksi, min	Yield Strength At 0.2% Offset ksi	Elongation in 4D %, min L	Elongation in 4D %, min LT	Reduction of Area %, min L	Reduction of Area %, min LT
Up to 3.00, incl	145	135 to 160	10	8	20	15
Over 3.00 to 4.00, incl	140	130 to 155	10	8	20	15

TABLE 2B - TENSILE PROPERTIES, SI UNITS

Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa	Elongation in 4D %, min L	Elongation in 4D %, min LT	Reduction of Area %, min L	Reduction of Area %, min LT
Up to 76.2, incl	1000	931 to 1103	10	8	20	15
Over 76.2 to 101.6, incl	965	896 to 1069	10	8	20	15

3.5.1.1.1.1 Tensile properties requirements apply in both longitudinal and long-transverse directions but transverse properties need be determined only on product that a transverse tensile specimen not less than 2.50 inches (63.5 mm) in length can be obtained (See 8.3).

3.5.1.1.1.2 Mechanical property requirements for product outside the range covered by Table 2 shall be agreed upon between purchaser and producer (Also see 4.4.3).

3.5.1.1.2 Surface Contamination

Except as permitted by 3.5.1.1.2.1, extrusions shall be free of any oxygen-rich layer, such as alpha-case, or any other surface contamination, determined by microscopic examination at not lower than 400X magnification or other method agreed upon by purchaser and vendor.

3.5.1.1.2.1 When permitted by purchaser, extrusions to be machined all-over may have an oxygen-rich layer provided such layer is removable within the machining allowance on the extrusion.

3.5.1.1.3 Microstructure

Shall be essentially that resulting from beta processing. Microstructure shall not be cause for rejection unless standards have been agreed upon by purchaser and vendor.

3.5.1.2 After Solution and Precipitation Heat Treatment

Product shall have the following properties after being solution heat treated by heating to 1650 °F ± 25 (899 °C ± 14), holding at heat for 1 hour ± 0.1, and quenching in agitated oil or water, and precipitation heat treated by heating to 1050 °F ± 15 (566 °C ± 8), holding at heat for 4 hours ± 0.25, and cooling in air.

3.5.1.2.1 Tensile Properties

Shall be as shown in Table 3, determined as in 3.5.1.1.1 and 3.5.1.1.1.1.

TABLE 3A - TENSILE PROPERTIES, INCH/POUND UNITS

Nominal Diameter or Least Distance Between Parallel Sides Inches	Tensile Strength ksi, min	Yield Strength at 0.2% Offset ksi	Elongation in 4D %, min L	Elongation in 4D %, min LT	Reduction of Area %, min L	Reduction of Area %, min LT
Up to 2.00, incl	150	140 to 165	10	8	20	15
Over 2.00 to 4.00, incl	145	135 to 160	10	8	20	15

TABLE 3B - TENSILE PROPERTIES, SI UNITS

Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa	Elongation in 4D %, min L	Elongation in 4D %, min LT	Reduction of Area %, min L	Reduction of Area %, min LT
Up to 50.8, incl	1034	965 to 1138	10	8	20	15
Over 50.8 to 101.6, incl	1000	931 to 1103	10	8	20	15

3.5.2 Stock for Flash Welded Rings

Specimens taken from the stock after heat treatment as in 3.4 shall meet the requirements of 3.5.1.1.1 and, after further heat treatment as in 3.5.1.2, shall meet the requirements of 3.5.1.2.1.

3.6 Quality

The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

3.7 Tolerances

Extrusions shall conform to all applicable requirements of AMS2245.

3.8 Production, distribution, and procurement of metal stock shall comply with AS6279. This requirement becomes effective April 1, 2016.

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 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), tensile properties (3.5.1.1), surface contamination (3.5.1.1.2), microstructure (3.5.1.1.3), and quality (3.6) of each lot of bars, tubes, shapes, and flash welded rings in the annealed, formed, or formed and stress relieved condition.

4.2.1.3 Tolerances (3.7) of extrusions.