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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4937

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Submitted for recognition as an American National Standard

TITANIUM ALLOY EXTRUSIONS AND FLASH WELDED RINGS
6Al - 6V - 2Sn
Beta Extruded Plus Annealed, Heat Treatable

UNS R56620

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 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 following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2245 Tolerances, Titanium and Titanium Alloy Extruded Bars, Rods, and Shapes
MAM 2245 Tolerances, Metric, Titanium and Titanium Alloy Extruded Bars, Rods, and Shapes
AMS 2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2750 Pyrometry
AMS 2809 Identification, Titanium and Titanium Alloy Wrought Products
AMS 7498 Rings, Flash Welded, Titanium and Titanium Alloys
ARP982 Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

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

2.3 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 120, 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 applicable requirements of AMS 2249. No variation over maximum will be permitted for yttrium.

3.2 Melting Practice:

Alloy shall be multiple melted; at least one of the melting cycles shall be under vacuum. The first melt shall be made by consumable electrode, nonconsumable electrode, electron beam, or plasma arc melting practice. 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 (R) 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 shall 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 AMS 7498 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 AMS 2750.

3.4.1 Annealing: Extruded shapes and flash welded rings shall be annealed by heating in a suitable atmosphere 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 two 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 in a suitable atmosphere 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 two to four 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 4.0 inches (102 mm) and under in nominal diameter or distance between parallel sides shall have the following properties; properties for product over 4.0 inches (102 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor:

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 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

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength ksi, min	Yield Strength at 0.2% Offset ksi	Elongation in 4D %, min		Reduction of Area %, min	
			L	LT	L	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 Distance Between Parallel Sides Millimeters	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa	Elongation in 4D %, min		Reduction of Area %, min	
			L	LT	L	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 from which a transverse tensile specimen not less than 2.50 inches (63.5 mm) in length can be obtained.

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 100X 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 one 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 four 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 Distance Between Parallel Sides Inches	Tensile Strength ksi, min	Yield Strength at 0.2% Offset ksi	Elongation in 4D %, min		Reduction of Area %, min	
			L	T	L	T
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	15	15

TABLE 3B - Tensile Properties, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa	Elongation in 4D %, min		Reduction of Area %, min	
			L	T	L	T
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	15	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 AMS 2245 or MAM 2245.

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 performing 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 requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for 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.

4.2.2 Periodic Tests: Tests for tensile properties (3.5.1.2.1) after solution and precipitation heat treatment and of stock for flash welded rings to demonstrate ability to develop specified properties (3.5.2) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

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.

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 Tensile Properties: At least one sample from each lot.

4.3.1.2.1 Tensile specimens shall be taken from the center of the cross-section of the predominant or thickest portion of product 1.50 inches (38.1 mm) and under in nominal diameter or distance between parallel sides. Tensile specimens shall be taken midway between center and surface of product over 1.50 inches (38.1 mm) in nominal diameter or distance between parallel sides.