

TITANIUM ALLOY EXTRUSIONS AND FLASH WELDED RINGS
6Al - 4V
Solution Heat Treated and Aged

UNS R56400

1. SCOPE:

1.1 Form: This specification covers a titanium alloy in the form of extruded bars, tubes, and shapes, flash welded rings, and stock for flash welded rings.

1.2 Application: Primarily for parts that require high mechanical properties and are machined from product in the heat treated condition. This alloy exhibits high strength-to-weight ratios up to 750°F (399°C).

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

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 2350 - Standards and Test Methods

AMS 2809 - Identification, Titanium and Titanium Alloy Wrought Products

AMS 7498 - Rings, Flash Welded, Titanium and Titanium Alloys

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2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E8 - Tension Testing of Metallic Materials

ASTM E120 - Chemical Analysis of Titanium and Titanium Alloys

ASTM E292 - Conducting Time-for-Rupture Notch Tension Tests of Materials

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Specifications:

MIL-H-81200 - Heat Treatment of Titanium and Titanium Alloys

2.3.2 Military Standards:

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

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E120, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	min	max
Aluminum	5.50	6.75
Vanadium	3.50	4.50
Iron	--	0.30
Oxygen	--	0.20
Carbon	--	0.10
Nitrogen	--	0.05 (500 ppm)
Hydrogen	--	0.0125 (125 ppm)
Yttrium	--	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.

3.2 Condition: The product shall be supplied in the following condition:

3.2.1 Bars, Tubes, and Shapes: Extruded, solution heat treated, aged, and descaled.

3.2.2 Flash Welded Rings: Fabricated in accordance with AMS 7498, solution heat treated, and aged.

3.2.3 Stock for Flash Welded Rings: As ordered by the flash welded ring manufacturer.

3.3 Heat Treatment: Bars, tubes, shapes, and flash welded rings shall be solution treated by heating in a suitable atmosphere to a temperature within the range 1700° - 1750°F (927 - 954°C), holding at the selected temperature within $\pm 25^{\circ}\text{F}$ ($\pm 14^{\circ}\text{C}$) for a time commensurate with section thickness, and quenching in water and aged by heating to a temperature within the range 950° - 1050°F (510° - 566°C), holding at the selected temperature within $\pm 15^{\circ}\text{F}$ ($\pm 8^{\circ}\text{C}$) for a suitable time, and cooling as required. Extrusions shall be descaled by wet or dry abrasive blasting, by chemical procedures, or by other methods approved by purchaser. Extrusions may be straightened cold prior to aging or at 950° - 1050°F (510° - 566°C) after aging. Furnace surveys and calibration of temperature controllers and recorders shall be in accordance with MIL-H-81200.

3.4 Properties: Extrusions and flash welded rings shall conform to the following requirements:

3.4.1 Tensile Properties: Shall be as specified in Table I for product 3.000 inches (76.20 mm) and under, in nominal diameter or distance between parallel sides, determined in accordance with ASTM E8 on specimens selected in either the long-transverse or the longitudinal direction with the rate of strain maintained at 0.003 - 0.007 inch/inch/minute (0.003 - 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 I

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, minimum	Elongation in 2 Inches or 4D %, minimum	Reduction of Area %, minimum
Up to 0.500, incl	160,000	150,000	6	12
Over 0.500 to 0.750, incl	155,000	145,000	6	12
Over 0.750 to 1.000, incl	150,000	140,000	6	12
Over 1.000 to 2.000, incl	140,000	130,000	6	12
Over 2.000 to 3.000, incl	130,000	120,000	6	12

TABLE I (SI)

Nominal Diameter or Distance Between Parallel Sides Millimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, minimum	Elongation in 50.8 mm or 4D %, minimum	Reduction of Area %, minimum
Up to 12.70, incl	1103	1034	6	12
Over 12.70 to 19.05, incl	1069	1000	6	12
Over 19.05 to 25.40, incl	1034	965	6	12
Over 25.40 to 50.80, incl	965	896	6	12
Over 50.80 to 76.20, incl	896	827	6	12

- 3.4.1.1 Tensile property requirements for extrusions over 3.000 inches (76.20 mm) in nominal diameter or distance between parallel sides and for flash welded rings over 3.000 inches (76.20 mm) in nominal radial thickness shall be as agreed upon by purchaser and vendor.
- 3.4.1.2 Tensile properties shall be determined in the long-transverse direction on product from which tensile specimens 2.50 inches (63.5 mm) or greater in length can be obtained.
- 3.4.1.3 Tests in the longitudinal direction are not required on product tested in the transverse direction.
- 3.4.2 Compressive Properties: Extrusions shall show a longitudinal compressive yield strength equal to or greater than the specified yield strength in tension.
- 3.4.3 Room-Temperature Notched Stress-Rupture Properties: Notched cylindrical specimens as in 4.3.2.1 machined to the dimensions shown in ASTM E292, maintained at room temperature while an initial axial stress of 185,000 psi (1276 MPa) is applied continuously, shall not rupture in less than 5 hours. The initial load may be lower than required to produce a stress of 185,000 psi (1276 MPa) and increased to 185,000 psi (1276 MPa), based on the initial diameter at root of notch, in increments of 10,000 psi (69 MPa) at intervals of not less than 5 hours. Tests shall be conducted in accordance with ASTM E292.
- 3.4.4 Surface Contamination: The product shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination.
- 3.5 Quality:
- 3.5.1 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 practice. The subsequent melt or melts shall be made using consumable electrode practice with no alloy additions permitted in the last consumable electrode melt.
- 3.5.1.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be inert gas at a pressure not higher than 250 mm of mercury.
- 3.5.1.2 The electrode tip for nonconsumable electrode melting shall be water-cooled copper.
- 3.5.2 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.
- 3.6 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. Results of such tests shall be reported to the purchaser as required by 4.4. 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 to determine conformance to the following requirements are classified as 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 Tensile properties (3.4.1) and surface contamination (3.4.4) of each lot of extrusions and flash welded rings.

4.2.2 Periodic Tests: Tests of extrusions and flash welded rings to determine conformance to requirements for compressive properties (3.4.2) and room-temperature notched stress-rupture properties (3.4.3) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling: Shall be as follows; a lot shall be all product of the same nominal size from the same heat processed at the same time:

4.3.1 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 and Surface Contamination: 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 1.500 inches (38.10 mm) and under in nominal diameter or distance between parallel sides. Tensile specimens shall be taken midway between center and surface of product over 1.500 inches (38.10 mm) in nominal diameter or distance between parallel sides.

4.3.2 Periodic Tests: As agreed upon by purchaser and vendor.

4.3.2.1 Specimens for room-temperature notched stress-rupture tests shall be taken in the longitudinal direction from bars, tubes, and shapes when size and configuration permit and in the circumferential direction from flash welded rings.