

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 4933B

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Superseding AMS 4933A

TITANIUM ALLOY EXTRUSIONS AND FLASH WELDED RINGS 8A1 - 1M - 1V Solution Heat Treated and Stabilized

UNS R54810

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 800°F (427°C). 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 as specified in AMS 2350.

2.1 **SAE Publications:** Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

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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2.1.2 Aerospace Recommended Practices:

ARP982 - Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

2.2 ASTM Publications: Available from ASTM 1916 Race Street, Philadelphia, PA 19103.

ASTM E 8 - Tension Testing of Metallic Materials
ASTM E 8M - Tension Testing of Metallic Materials (Metric)
ASTM E 21 - Elevated Temperature Tension Tests of Metallic Materials
ASTM E 120 - Chemical Analysis of Titanium and Titanium Alloys
ASTM E 292 - 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:**

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

2.3.2 Military Standards:

ML-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 E 120, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	min	max
Aluminum	7.35	8.35
Molybdenum	0.75	1.25
Vanadium	0.75	1.25
Iron	--	0.30
Oxygen	--	0.12
Carbon	--	0.08
Nitrogen	--	0.05 (500 ppm)
Hydrogen	--	0.0150 (150 ppm)
Yttrium (3.1.1)	--	0.0050 (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, stabilized, and descaled.
- 3.2.2 Flash Welded Rings:** Solution heat treated, and stabilized. Flash welded rings shall not be supplied unless specified or permitted on purchaser's part drawing. When supplied, rings shall be manufactured in accordance with AMS 7498.
- 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 heat treated as follows; furnace surveys and calibration of temperature controllers and recorders shall be in accordance with ML-H-81200:
- 3.3.1 Solution Heat Treatment:** Heat to a temperature within the range 1800° - 1850°F (982° - 1010°C), hold at the selected temperature within ±25°F (±14°C) for 1 hour ± 0.1, and cool at a rate equivalent to an air cool or faster.
- 3.3.2 Stabilization Heat Treatment:** Heat to a temperature within the range 1050° - 1150°F (566° - 621°C), hold at the selected temperature within ±15°F (±8°C) for not less than 8 hours, and cool in air.
- 3.4 Properties:** The product shall conform to the following requirements:
- 3.4.1 Bars, Tubes, Shapes, and Flash Welded Rings:**
- 3.4.1.1 Tensile Properties:** Shall be as follows for product 4.000 square inches (25.81 cm²) and under in cross-sectional area. Requirements for product over 4.000 square inches (25.81 cm²) in cross-sectional area shall be as agreed upon by purchaser and vendor.
- 3.4.1.1.1 At Room Temperature:** Shall be as specified in Table I and 3.4.1.1.3, determined in accordance with ASTM E 8 or ASTM E 8M on specimens as in 4.3.1.2 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 Cross-Sectional Area Square Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 4D %, min	Reduction of Area %, min
Up to 2.500, excl	130,000	120,000	10	20
2.500 to 4.000, incl	125,000	115,000	10	20

TABLE I (SI)

Nominal Cross-Sectional Area Square Centimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min	Reduction of Area %, min
Up to 16.13, excl	896	827	10	20
16.13 to 25.81, incl	862	793	10	20

- 3.4.1.1.2 **At 800°F (427°C):** Shall be as specified in Table II and 3.4.1.1.3, determined in accordance with ASTM E 21 on specimens heated to 800°F ± 5 (427°C ± 3), held at heat for 20 - 30 minutes before testing, and tested at 800°F ± 5 (427°C ± 3).

TABLE II

Nominal Cross-Sectional Area Square Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 4D %, min	Reduction of Area %, min
Up to 2.500, excl	90,000	70,000	10	25
2.500 to 4.000, incl	80,000	60,000	10	25

TABLE II (SI)

Nominal Cross-Sectional Area Square Centimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min	Reduction of Area %, min
Up to 16.13, excl	621	483	10	25
16.13 to 25.81, incl	552	414	10	25

- 3.4.1.1.3 The requirements of Table I and Table II apply to bars, rods, and shapes tested in the longitudinal direction and to flash welded rings tested in the circumferential direction.
- 3.4.1.1.4 Transverse tensile property requirements shall be as agreed upon by purchaser and vendor and shall apply only to product from which a tensile specimen not less than 2.50 inches (63.5 mm) in length can be obtained.

- 3.4.1.2 **Room Temperature Notched Stress-Rupture Properties:** Notched cylindrical specimens as in 4.3.2.1, machined to the dimensions shown in ASTM E 292, maintained at room temperature while a load sufficient to produce the initial axial stress shown in Table III is applied continuously, shall not rupture in less than 5 hours. The initial load may be lower than required to produce the stress specified in Table III and increased to the specified stress, 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 E 292.

TABLE III

Noninal Cross-Sectional Area Square Inches	Stress psi
Up to 4.000, incl	150,000
Over 4.000	130,000

TABLE III (SI)

Noninal Cross-Sectional Area Square Centimetres	Stress MPa
Up to 25.81, incl	1034
Over 25.81	896

- 3.4.1.3 **Microstructure:** Shall be that structure resulting from alpha-beta processing. Microstructure shall conform to 3.4.1.3.1, 3.4.1.3.2, or 3.4.1.3.3.
- 3.4.1.3.1 Equiaxed alpha in a transformed beta matrix.
- 3.4.1.3.2 Equiaxed alpha and elongated alpha in a transformed beta matrix.
- 3.4.1.3.3 Partially broken and distorted grain boundary alpha with plate-like alpha.
- 3.4.1.3.4 A microstructure showing a continuous network of alpha in prior beta grain boundaries is not acceptable.
- 3.4.1.4 **Surface Contamination:** Except as specified in 3.4.1.4.1, the product shall be free of any oxygen-rich layer (See 8.2), such as alpha case, or other surface contamination, determined by microscopic examination at not lower than 100X magnification or other method agreed upon by purchaser and vendor.
- 3.4.1.4.1 When permitted by purchaser, flash welded rings to be machined all over may have an oxygen-rich layer (See 8.2) provided such layer is removable within the machining allowance for the part.

3.4.2 Stock for Flash Welded Rings: A sample of stock heat treated as in 3.3 shall conform to the requirements of 3.4.1.1.

3.5 Quality:

3.5.1 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. 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 Test: 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 and hydrogen content of each lot.

4.2.1.2 Room temperature tensile properties (3.4.1.1.1) and surface contamination (3.4.1.3) of each lot of extrusions and flash welded rings.

4.2.1.3 Tolerance (3.6) of extrusions.

4.2.2 Periodic Tests: Tests for the following requirements are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser:

4.2.2.1 Tensile properties at 800°F (427°C) (3.4.1.1.2) and room temperature notched stress-rupture properties of extrusions and flash welded rings.