Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 4933

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Revised

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

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 (425° C). Certain processing procedures and service conditions may cause this alloy to be subject to stress-corrosion cracking; ARP 982 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 Aerospace Material Specifications (AMS) and Aerospace Recommended Practices (ARP) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2245 - Tolerances, Titanium and Titanium-Base Alloy Extruded Bars, Rods, and Shapes
AMS 2249 - Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2350 - Standards and Test Methods
AMS 7498 - Rings, Flash Welded, Titanium and Titanium Alloys

2.1.2 Aerospace Recommended Practices:

ARP 982 - Minimizing Stress Corrosion in Wrought Titanium Alloy Products

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 E21 - Elevated Temperature Tension Tests 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 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

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 spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other approved analytical methods:

	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	--	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: Fabricated in accordance with AMS 7498, solution heat treated, and stabilized.

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:

3.3.1 Solution Heat Treatment: Heat to a temperature within the range 1800° - 1850°F (980° - 1010°C), hold at the selected temperature within ±25°F (±15°C) for 1 hr ± 0.1, and cool at a rate equivalent to air cool or faster.

3.3.2 Stabilization Heat Treatment: Heat to a temperature within the range 1050° - 1150°F (565° - 595°C), hold at the selected temperature within ± 15°F (±8°C) for not less than 8 hr, 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:

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 E8 with the rate of strain maintained at 0.003 - 0.007 in. per in. per min. (0.003 - 0.007 mm/mm/min.) 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 in. per in. per min. (0.005 mm/mm/min.) through the yield strength and a minimum cross head speed of 0.10 in. (2.5 mm) per min. 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 E21 on specimens heated to 800° F ± 5 (427° C ± 3); held at heat for 30 min. 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 Tensile property requirements for product over 4.00 sq in. (25.81 cm^2) in nominal cross-sectional area shall be as agreed upon by purchaser and vendor.

3.4.1.1.4 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.

3.4.1.1.5 Transverse tensile property requirements shall be as agreed upon by purchaser and vendor and shall apply only to product from which a tensile test specimen not less than 2-1/2 in. (63.5 mm) long can be taken.

3.4.1.2 Room-Temperature Notched Stress-Rupture Properties: Specimens as in 4.3.2.1 machined to the dimensions shown in Fig. 1 and Table IV, 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 Tests shall be conducted in accordance with ASTM E292.

TABLE III

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

TABLE III (SI)

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

3.4.1.3 Surface Contamination: Except as specified in 3.4.1.3.1, the product shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination.

3.4.1.3.1 When permitted by purchaser, flash welded rings to be machined all over may have an oxygen-rich layer provided such layer is removable within the machining allowance for the part.

3.4.2 Stock for Flash Welded Rings: As agreed upon by purchaser and vendor.

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 either consumable or nonconsumable electrode practice. The subsequent melt or melts shall be made using consumable electrode practice.

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 either graphite or 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 internal and external imperfections detrimental to usage of the product.

3.6 Tolerances: Unless otherwise specified, tolerances for extrusions shall conform to all applicable requirements of AMS 2245.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product shall supply all samples 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 perform such confirmatory testing as he deems necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests of the product to determine conformance to requirements for composition (3.1) and of extrusions and flash welded rings to determine conformance to requirements for room-temperature tensile properties (3.4.1.1.1) and surface contamination (3.4.1.3) are classified as acceptance tests and shall be performed on each lot of product.

4.2.2 Periodic Tests: Tests of extrusions and flash welded rings to determine conformance to requirements for 800°F (427°C) tensile properties (3.4.1.1.2) and room-temperature notched stress-rupture (3.4.1.2) properties 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 Room-Temperature Tensile Properties and Surface Contamination: One sample from each lot.

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 extrusions when size and configuration permit and in the circumferential direction from flash welded rings.

4.4 Reports:

4.4.1 The vendor of the product shall furnish with each shipment three copies of a report showing the results of tests for chemical composition of each heat and for the hydrogen content and room-temperature tensile properties of each lot and stating that the product conforms to the other technical requirements of this specification. This report shall include the purchase order number, heat number, material specification number, size, specific heat treatment used, and quantity from each heat.

4.4.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of test to determine conformance.

4.5 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Identification: The product shall be identified as follows:

5.1.1 Bars, Tubes, and Shapes:

5.1.1.1 Each straight bar and tube over 0.500 in. (12.70 mm) in nominal OD or least width of flat surface and each straight shape with configuration allowing access to a flat surface at least 0.500 in. (12.70 mm) wide recessed not more than 1 in. (25 mm) below the outline of the shape shall be marked in a row of characters recurring at intervals not greater than 3 ft (914 mm) with AMS 4933, heat number, and manufacturer's identification. The characters shall be of such size as to be clearly legible, shall be applied using a suitable marking fluid whose residue shall contain not more than traces of halogen-bearing compounds, and shall be removable in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the product or its performance and shall be sufficiently stable to withstand normal handling.

5.1.1.2 All straight extrusions other than those of 5.1.1.1 shall be securely bundled and identified by a durable tag marked with the purchase order number, AMS 4933, heat number, nominal size, and manufactuer's identification and attached to each bundle or shall be boxed and the box marked with the same information.

5.1.2 Flash Welded Rings and Stock for Flash Welded Rings: As agreed upon by purchaser and vendor.

5.2 Packaging:

5.2.1 The product shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the product to ensure carrier acceptance and safe delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.2.2 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-163, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.2.1 will be acceptable if it meets the requirements of Level C.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Material not conforming to this specification or to authorized modifications will be subject to rejection.

8. NOTES:

8.1 For direct U.S. Military procurement, purchase documents should specify not less than the following:

Title, number, and date of this specification
Form and size or part number of product desired
Quantity of product desired
Applicable level of packaging (See 5.2.2).