



# AEROSPACE MATERIAL

## Society of Automotive Engineers, Inc. SPECIFICATION

400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

# AMS 4934A

Superseding AMS 4934

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### TITANIUM ALLOY EXTRUSIONS AND FLASH WELDED RINGS

6Al - 4V

Solution Heat Treated and Aged

#### 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 (400° 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 (AMS) 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

- 2.2 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-Base Alloys
- ASTM E292 - Conducting Time-for-Rupture Notched 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:

SAE Technical Board rules provide that: "All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against any infringement of patents."

	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 (925° - 955°C), holding at the selected temperature within +25°F (+15°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° - 565°C), holding at the selected temperature within +15°F (+8°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° - 565°C) after aging.

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 sizes 3.000 in. (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 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 Diameter or Distance Between Parallel Sides Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 2 in. or 4D %, min	Reduction of Area %, min
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, min	Elongation in 50.8 mm or 4D %, min	Reduction of Area %, min
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 in. (76.20 mm) in nominal diameter or distance between parallel sides and for flash welded rings over 3.000 in. (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 in. (63.5 mm) or greater in length can be obtained.
- 3.4.1.3 Tests in the longitudinal direction are not required if tests in the transverse direction are made.
- 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 Test: Specimens as in 4.3.2.1 machined to the dimensions shown in Fig. 1 and Table II, 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; 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 the 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.

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 composition (3.1) requirements and of extrusions and flash welded rings to determine conformance to tensile property (3.4.1) and surface contamination (3.4.4) requirements are classified as acceptance tests.
- 4.2.2 Periodic Tests: Tests of extrusions and flash welded rings to determine conformance to compressive property (3.4.2) and room temperature notched stress-rupture (3.4.3) requirements are classified as periodic tests.
- 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.
- 4.3.2 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.
- 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 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 and its revision letter, 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 and its revision letter, 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 4934A, 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 4934A, heat number, nominal size, and manufacturer'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 to ensure carrier acceptance and safe transportation to the point of 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 and its revision letter 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 Marginal Indicia: The phi ( $\phi$ ) symbol is used to indicate technical changes from the previous issue of this specification.

8.2 For direct U.S. Military procurement, purchase documents should specify 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).