AEROSPACE MATERIAL SPECIFICATION

AMS4933™	REV. G

Issued 1978-10
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Superseding AMS4933F

Titanium Alloy Extrusions and Flash Welded Rings
8Al - 1Mo - 1V
Solution Heat Treated and Stabilized
(Composition similar to UNS R54810)

RATIONALE

AMS4933G results from a Five-Year Review and update of this specification. Changes have been made to prohibit unauthorized exceptions (3.5.1.1.4, 3.9, 4.4.2, 5.1.1, 8.6,), update applicable documents (Section 2, 8.3) and ordering information (8.8), and allow the use of the immediate prior specification revision (8.5).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of extruded bars, tubes, and shapes, and flash welded rings up through 4.000 in^2 (25.81 cm^2) cross-section and stock for flash welded rings.

1.2 Application

This alloy has been used typically for parts that require high mechanical properties and are machined from product in the heat-treated condition, but usage is not limited to such applications. This alloy exhibits high strength-to-weight ratios up to 800 °F (427 °C), 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 issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2245 Tolerances Titanium and Titanium Alloy Extruded Bars, Rods, and Shapes

AMS2249 Chemical Check Analysis Limits Titanium and Titanium Alloys

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS4933G/

AMS2368 Sampling and Testing of Wrought Titanium Raw Material Except Forgings and Forging Stock

AMS2750 Pyrometry

AMS2809 Identification Titanium and Titanium Alloy Wrought Products

AMS7498 Rings, Flash Welded Titanium and Titanium Alloys

ARP982 Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

AS1814 Terminology for Titanium Microstructures

AS6279 Standard Practice for Production, Distribution, and Procurement of Metal Stock

AS7766 Terms Used in Aerospace Metals Specifications

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E8/E8M Tension Testing of Metallic Materials

ASTM E21 Elevated Temperature Tension Tests of Metallic Materials

ASTM E1409 Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion

ASTM E1447 Determination of Hydrogen in Titanium and Titanium Alloys by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

ASTM E1941 Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis

ASTM E2371 Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission Spectrometry (Performance-Based Test Methodology)

ASTM E2994 Analysis of Titanium and Titanium Alloys by Spark Atomic Emission Spectrometry and Glow Discharge Atomic Emission Spectrometry (Performance-Based Method)

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1; carbon shall be determined in accordance with ASTM E1941, hydrogen in accordance with ASTM E1447, oxygen and nitrogen in accordance with ASTM E1409, and other elements in accordance with ASTM E2371 or ASTM E2994. Other analytical methods may be used if acceptable to the purchaser.

Table 1 - Composition

Element	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)
Other Elements, each (3.1.1)	--	0.10	
Other 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 AMS2249.

3.2 Melting Practice

Alloy shall be multiple melted. The first melt shall be made by vacuum consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The subsequent melt or melts shall be made under vacuum using vacuum arc remelting (VAR) practice. Alloy additions are not permitted in the final (VAR) melt.

3.2.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be inert gas at a 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, solution heat treated, stabilized, and descaled.

3.3.2 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 AMS7498.

3.3.3 Stock for Flash Welded Rings

As ordered by the flash welded ring manufacturer.

3.4 Heat Treatment

Bars, tubes, shapes, and flash welded rings shall be heat treated as follows; pyrometry shall be in accordance with AMS2750:

3.4.1 Solution Heat Treatment

Heat to a temperature within the range 1800 to 1850 °F (982 to 1010 °C), hold at the selected temperature within ±25 °F (±14 °C) for 1 hour ± 0.1 hour, and cool at a rate equivalent to an air cool or faster.

3.4.2 Stabilization Heat Treatment

Heat to a temperature within the range 1050 to 1150 °F (566 to 621 °C), hold at the selected temperature within ±15 °F (±8 °C) for not less than 8 hours, and cool in air.

3.5 Properties

The product shall conform to the following requirements:

3.5.1 Bars, Tubes, Shapes, and Flash Welded Rings

3.5.1.1 Tensile Properties

Shall be as follows for product 4.000 in^2 (25.81 cm^2) and under in cross-sectional area.

3.5.1.1.1 At Room Temperature

Shall be as specified in Table 2 and 3.5.1.1.3, determined in accordance with ASTM E8/E8M with the rate of strain set at 0.005 in/in/min (0.005 mm/mm/min) and maintained within a tolerance of ±0.002 in/in/min (0.002 mm/mm/min) through the 0.2% offset yield strain.

Table 2A - Minimum tensile properties, inch/pound units

Nominal Cross-Sectional Area Square Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %	Reduction of Area %
Up to 2.500, excl	130	120	10	20
2.500 to 4.000, incl	125	115	10	20

Table 2B - Minimum tensile properties, SI units

Nominal Cross-Sectional Area Square Centimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %	Reduction of Area %
Up to 16.13, excl	896	827	10	20
16.13 to 25.81, incl	862	793	10	20

3.5.1.1.2 At 800 °F (427 °C)

Shall be as specified in Table 3 and 3.5.1.1.3, determined in accordance with ASTM E21 on specimens heated to 800 °F ± 5 °F (427 °C ± 3 °C), held at heat for 20 to 30 minutes before testing, and tested at 800 °F ± 5 °F (427 °C ± 3 °C).

Table 3A - Minimum tensile properties, inch/pound units

Nominal Cross-Sectional Area Square Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %	Reduction of Area %
Up to 2.500, excl	90	70	10	25
2.500 to 4.000, incl	80	60	10	25

Table 3B - Minimum tensile properties, SI units

Nominal Cross-Sectional Area Square Centimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %	Reduction of Area %
Up to 16.13, excl	621	483	10	25
16.13 to 25.81, incl	552	414	10	25

3.5.1.1.3 The requirements of Tables 2 and 3 apply to bars, rods, and shapes tested in the longitudinal direction and to flash welded rings tested in the circumferential direction.

3.5.1.1.4 Mechanical property requirements for product outside the size range covered by 1.1 shall be agreed upon between purchaser and producer and reported per 4.4.2.

3.5.1.2 Microstructure

Shall be that structure resulting from processing within the alpha-beta phase field. Microstructure shall conform to 3.5.1.2.1.

3.5.1.2.1 Equiaxed and/or elongated primary alpha in a transformed beta matrix with no continuous network of alpha at prior beta grain boundaries.

3.5.1.3 Surface Contamination

Except as specified in 3.5.1.3.1, 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 400X magnification or other method agreed upon by purchaser and producer (see 8.8).

3.5.1.3.1 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.

3.5.2 Stock for Flash Welded Rings

A sample of stock heat treated as in 3.4 shall conform to the requirements of 3.5.1.1.

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 AMS2245.

3.8 Production, distribution, and procurement of metal stock shall comply with AS6279.

3.9 Exceptions

Any exceptions shall be authorized by purchaser and reported as in 4.4.2.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for producer's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

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 (3.5.1.1.1) and surface contamination (3.5.1.3) of each lot of extrusions and flash welded rings.

4.2.1.3 Tolerance (3.7) of extrusions.

4.2.2 Periodic Tests

The following requirements are periodic tests and shall be performed at a frequency selected by the producer unless frequency of testing is specified by purchaser:

4.2.2.1 Tensile properties at 800 °F (427 °C) (3.5.1.1.2).

4.2.2.2 Ability of stock for flash welded rings (3.5.2) to develop required properties.

4.3 Sampling and Testing

Shall be in accordance with AMS2368 and as follows; a lot shall be all product of the same nominal size from the same heat, processed at the same time, and solution and stabilization heat treated in the same heat treat batch.

4.3.1 For Acceptance Tests

4.3.1.1 Composition

One sample from each heat, except 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

At least one sample from each lot.

4.4 Reports

4.4.1 The producer shall furnish a report showing the producer name, country where the metal was melted (i.e., final melt in the case of metal processed by multiple melting operations), results of tests for 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 and lot numbers, AMS4933G, product form, size, part number (if applicable), specific heat treatment used, and quantity.

4.4.2 When material produced to this specification is beyond the sizes allowed in the scope or tables, or other exceptions are taken to the technical requirements listed in Section 3 (see 5.1.1), the report shall contain a statement "This material is certified as AMS4933G(EXC) because of the following exceptions:" and the specific exceptions shall be listed.

4.5 Resampling and Retesting

Shall be in accordance with AMS2368.