SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4933D

Issued 1978-10
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Superseding AMS 4933C

Titanium Alloy Extrusions and Flash Welded Rings
8Al - 1Mo - 1V
Solution Heat Treated and Stabilized

(Composition similar to UNS R54810)

RATIONALE

AMS 4933D results from a Five Year Review and update of this specification.

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

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.

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

2.1 SAE Publications

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

AMS 2245	Tolerances, Titanium and Titanium Extruded Bars, Rods, and Shapes
AMS 2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2368	Sampling and Testing of Wrought Titanium Raw Material Except Forgings and Forging Stock
AMS 2750	Pyrometry
AMS 2809	Identification, Titanium and Titanium Alloy Wrought Products
AMS 7498	Rings, Flash Welded, Titanium and Titanium Alloys
ARP982	Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

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 E 8	Tension Testing of Metallic Materials
ASTM E 21	Elevated Temperature Tension Tests of Metallic Materials
ASTM E 292	Conducting Time-for-Rupture Notch Tension Tests of Materials
ASTM E 1409	Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique
ASTM E 1447	Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity/Infrared Detection Method
ASTM E 1941	Determination of Carbon in Refractory and Reactive Metals and Their Alloys
ASTM E 2371	Analysis of Titanium and Titanium Alloys by Atomic Emission Plasma Spectrometry

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 E 1941, hydrogen in accordance with ASTM E 1447, oxygen and nitrogen in accordance with ASTM E 1409, and other elements in accordance with ASTM E 2371. 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 (3.1.3)	--	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 AMS 2249.

3.1.3 Sample size when using ASTM E 1447 for hydrogen may be as large as 0.35 gram.

3.2 Melting Practice

3.2.1 Alloy shall be multiple melted. Melting cycles prior to final melting shall be made using vacuum consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The final melting cycle shall be made under vacuum using vacuum arc (VAR) electrode practice with no alloying additions permitted.

3.2.1.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be inert gas at a pressure not higher than 1000 mm of mercury.

3.2.1.2 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 AMS 7498.

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 AMS 2750:

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, 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 square inches (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 E 8 with the rate of strain maintained at 0.003 to 0.007 inch/inch/minute (0.003 to 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 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 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 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 E 21 on specimens heated to 800 °F ± 5 (427 °C ± 3), held at heat for 20 to 30 minutes before testing, and tested at 800 °F ± 5 (427 °C ± 3).

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 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 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 Table 2 and Table 3 apply to bars, rods, and shapes tested in the longitudinal direction and to flash welded rings tested in the circumferential direction.

3.5.1.2 Room-Temperature Notched Stress-Rupture Properties

Notched cylindrical specimens, 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 4 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 4 and increased to the specified stress, based on the initial diameter at root of notch, in increments of 10 ksi (69 MPa) at intervals of not less than 5 hours. Tests shall be conducted in accordance with ASTM E 292.

TABLE 4A - STRESS FOR NOTCHED RUPTURE TEST, INCH/POUND UNITS

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

TABLE 4B - STRESS FOR NOTCHED RUPTURE TEST, SI UNITS

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

3.5.1.3 Microstructure

Shall be that structure resulting from processing within the alpha-beta phase field. Microstructure shall conform to 3.5.1.3.1 or 3.5.1.3.2.

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

3.5.1.3.2 Essentially complete field of equiaxed and/or elongated alpha with or without intergranular beta and with no continuous network of alpha at prior beta grain boundaries.

3.5.1.4 Surface Contamination

Except as specified in 3.5.1.4.1, 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 400X magnification or other method agreed upon by purchaser and vendor.

3.5.1.4.1 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.

3.5.2 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 AMS 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 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 Test

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 (3.5.1.4) 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 vendor unless frequency of testing is specified by purchaser:

4.2.2.1 Tensile properties at 800 °F (427 °C) (3.5.1.1.2) and room-temperature notched stress-rupture properties of extrusions and flash welded rings (3.5.1.2).

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 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.

4.3.2 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.