AEROSPACE MATERIAL SPECIFICATION

AMS4978™	REV. J
Issued 1970-05 Revised 2022-05 Superseding AMS4978H	

Titanium Alloy Bars, Wire, Forgings, and Rings
6Al - 6V - 2Sn
Annealed
(Composition similar to UNS R56620)

RATIONALE

AMS4978J results from a Five-Year Review and update of this specification with changes to remove fracture toughness requirements, update general agreement language related to unauthorized exceptions (3.5.1.1.4, 3.9, 4.4.3, 5.1.1, 8.7), update applicable documents (section 2, 8.4), ordering information (8.8), and allow the use of the immediate prior specification revision (8.6).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of bars, wire, forgings, flash welded rings 4.000 inches (101.60 mm) and under in diameter, or least distance between parallel sides and stock of any size for forging or flash welded rings (see 8.8).

1.2 Application

These products have been used typically for parts which require high mechanical properties in the annealed condition and a high strength to weight ratio up to 750 °F (399 °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.

AMS2241 Tolerances, Corrosion- and Heat-Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire

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/AMS4978J/

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

AMS2750 Pyrometry

AMS2808 Identification, Forgings

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 E539 Analysis of Titanium Alloys by Wavelength Dispersive X-Ray Fluorescence Spectrometry

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 Test 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 E539, ASTM E2371, or ASTM E2994. Other analytical methods may be used if acceptable to the purchaser.

Table 1 - Composition

Element	Min	Max	
Aluminum	5.00	6.00	
Vanadium	5.00	6.00	
Tin	1.50	2.50	
Iron	0.35	1.00	
Copper	0.35	1.00	
Carbon	--	0.05	
Oxygen	--	0.20	
Nitrogen	--	0.04	(400 ppm)
Hydrogen	--	0.015	(150 ppm)
Yttrium (3.1.1) (3.1.3)	--	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 applicable requirements of AMS2249.

3.1.3 No variation over maximum will be permitted for yttrium.

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 using vacuum arc remelting (VAR) practice. Alloy additions are not permitted in the final melt cycle.

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

Hot finished with or without subsequent cold reduction, annealed, and descaled. The product shall be processed to the final thickness/diameter by metallurgical working operations prior to any straightening, dimensional sizing, or surface finishing operations. Bar shall not be cut from plate (see 4.4.2).

3.3.2 Wire

Cold drawn, annealed, and descaled.

3.3.3 Forgings and Flash Welded Rings

Annealed and descaled.

3.3.3.1 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.

3.3.4 Stock for Forging or Flash Welded Rings

As ordered by the forging or flash welded ring manufacturer.

3.4 Heat Treatment

3.4.1 Annealing

Bars, wire, forgings, and flash welded rings shall be annealed by heating to 1300 to 1450 °F (704 to 788 °C), holding at heat for 1 to 2 hours, and cooling as required. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

The product shall conform to the following requirements:

3.5.1 Bars, Wire, Forgings, and Flash Welded Rings

3.5.1.1 Tensile Properties

Shall be as specified in Table 2, 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.

3.5.1.1.1 Tensile property requirements apply in both the longitudinal and transverse directions. Transverse tensile properties of Table 2 apply only to product where a test specimen not less than 2.50 inches (63.5 mm) in length can be obtained.

3.5.1.1.2 Specimens for the longitudinal requirements of Table 2 shall be taken with the axis of the specimen within 15 degrees of parallel to the grain flow and specimens for flash welded rings shall be taken in the circumferential direction.

3.5.1.1.3 Yield strength and reduction of area requirements do not apply to wire under 0.125 inch (3.18 mm) in nominal diameter.

Table 2A - Tensile properties, inch/pound units

Nominal Diameter or Least Distance Between Parallel Sides Inches	Tensile Strength ksi, Min	Yield Strength at 0.2% Offset ksi, Min	Elongation in 2 inches or 4D %, Min Long.	Elongation in 2 inches or 4D %, Min Trans.	Reduction of area %, Min Long.	Reduction of area %, Min Trans.
Up to 2.000, incl	150	140 to 165	10	8	20	15
Over 2.000 to 4.000, incl	145	135 to 160	10	8	15	15

Table 2B - Tensile properties, SI units

Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Tensile Strength MPa, Min	Yield Strength at 0.2% Offset MPa, Min	Elongation in 50.8 mm or 4D %, Min Long.	Elongation in 50.8 mm or 4D %, Min Trans.	Reduction of Area %, Min Long.	Reduction of Area %, Min Trans.
Up to 50.80, incl	1034	965 to 1138	10	8	20	15
Over 50.80 to 101.60, incl	1000	931 to 1103	10	8	15	15

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 4.4.3.

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, 3.5.1.2.2, or 3.5.1.2.3 (see 8.2).

3.5.1.2.1 Equiaxed alpha in a transformed beta matrix.

3.5.1.2.2 Equiaxed alpha and elongated alpha in a transformed beta matrix.

3.5.1.2.3 Partially broken and distorted grain boundary alpha with plate-like alpha.

3.5.1.2.4 A microstructure showing a continuous network of alpha in prior beta grain boundaries is not acceptable.

3.5.1.3 Surface Contamination

Except as specified in 3.5.1.3.1 and 3.5.1.3.2, the product shall be free of any oxygen-rich layer (see 8.3), such as alpha case, or other surface contamination, determined by microscopic examination at not lower than 400X magnification or by other method agreed upon by purchaser and producer.

3.5.1.3.1 An oxygen-rich layer not thicker than 0.001 inch (0.025 mm) is permitted on bars other than round.

3.5.1.3.2 When permitted by purchaser, product to be machined all over may have an oxygen-rich layer, provided such layer is removable within the machining allowance on the product.

3.5.2 Forging Stock

When a sample of stock is forged to a test coupon and heat treated as in 3.4, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.1.1. If specimens taken from the stock after heat treatment as in 3.4 conform to the requirements of 3.5.1.1, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.3 Stock for Flash Welded Rings

Specimens taken from the stock after heat treatment 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

Bars and wire shall conform to all applicable requirements of AMS2241.

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 4.4.3.

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.

4.2.1.2 Hydrogen content (3.1), tensile properties (3.5.1.1), microstructure (3.5.1.2), and surface contamination (3.5.1.3) of bars, wire, forgings, and flash welded rings.

4.2.1.3 Tolerances (3.7) of bars and wire.

4.2.2 Periodic Tests

Ability of forging stock (3.5.2) and stock for flash welded rings (3.5.3) to develop specified properties are periodic tests and shall be performed at a frequency selected by the producer unless frequency of testing is specified by purchaser.

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.

4.3.1 For Acceptance Tests

4.3.1.1 Composition

At least 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

At least one sample from bars, wire, and flash welded rings from each lot. The number, location, and orientation of samples from each lot of forgings shall be as agreed upon by purchaser and producer (see 8.8).

4.3.1.2.1 Specimens from flash welded rings shall be from parent metal not including the weld heat-affected zone.

4.3.2 For Periodic Tests

As agreed upon by purchaser and producer (see 8.8).

4.4 Reports

4.4.1 The producer shall furnish with each shipment a report showing the producer identity, country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations), the results of tests for composition of each heat and for the hydrogen content, tensile properties, and surface contamination of each lot and state that the product conforms to the other technical requirements. The report shall include the purchase order number, heat and lot numbers, AMS4978J, product form and mill produced size (and/or part number, if applicable), specific annealing treatment used, and quantity. If forgings are supplied, the part number and the size and melt source of stock used to make the forgings shall also be included. The producer of stock for forging or flash welded rings shall furnish with each shipment a report showing the results of tests for composition of each heat and for the hydrogen content of each lot. This report shall include the purchase order number, heat number, AMS4978J, size, and quantity.

4.4.2 Report the nominal metallurgically worked cross sectional size and the cut size, if different (see 3.3.1).

4.4.3 When material produced to this specification is beyond the sizes allowed in the scope or tables, or other exceptions authorized by purchaser are taken to the technical requirements listed in Section 3, the report shall contain a statement "This material is certified as AMS4978J(EXC) because of the following exceptions:" and the specific exceptions shall be listed.

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. Results of all tests shall be reported.