AEROSPACE MATERIAL SPECIFICATION

AMS4981™	REV. J
Issued 1972-11 Revised 2022-08 Superseding AMS4981H	

Titanium Alloy Bars, Wire, and Forgings
6.0Al - 2.0Sn - 4.0Zr - 6.0Mo
Solution and Precipitation Heat Treated
(Composition similar to UNS R56260)

RATIONALE

AMS4981J results from a Five-Year Review and update of the specification. Changes have been made to prohibit unauthorized exceptions (3.5.1.1.5, 3.9, 4.4.3, 5.1.1, 8.6), update applicable documents (Section 2, 8.3), and ordering information (8.8), and allow use of immediate prior specification revision (8.7).

1. SCOPE

1.1 Form

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

1.2 Application

This alloy has been used typically for parts requiring high strength up to 1000 °F (538 °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

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

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/AMS4981J/

AMS2750 Pyrometry

AMS2808 Identification Forgings

AMS2809 Identification Titanium and Titanium Alloy Wrought Products

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 E139 Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

ASTM E292 Conducting Time-for-Rupture Notch Tension Tests of 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 Technique

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

Table 1 - Composition

Element	Min	Max	
Aluminum	5.50	6.50	
Zirconium	3.50	4.50	
Tin	1.75	2.25	
Molybdenum	5.50	6.50	
Iron	--	0.15	
Oxygen	--	0.15	
Carbon	--	0.04	
Nitrogen	--	0.04	(400 ppm)
Hydrogen (3.1.1)	--	0.0125	(125 ppm)
Yttrium (3.1.2)	--	0.005	(50 ppm)
Other Elements, each (3.1.2)	--	0.10	
Other Elements, total (3.1.2)	--	0.40	
Titanium	remainder		

3.1.1 Hydrogen content of forgings may be as high as 0.0150 (150 ppm).

3.1.2 Determination not required for routine acceptance.

3.1.3 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 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

Hot finished, solution and precipitation heat treated, and descaled. The product shall be produced using standard industry practices designed strictly for the production of bar stock to the procured size. Cut plate shall not be supplied in lieu of bar.

3.3.1.1 Round bars shall be solution and precipitation heat treated and ground, turned, or machined.

3.3.2 Wire

Cold drawn, solution and precipitation heat treated, and descaled.

3.3.3 Forgings

Solution and precipitation heat treated and descaled.

3.3.4 Forging Stock

As ordered by the forging manufacturer.

3.4 Heat Treatment

Bars and forgings 0.50 inch (12.7 mm) and over in nominal diameter or least distance between parallel sides shall be solution heat treated by heating in a suitable atmosphere to 1500 to 1675 °F (816 to 913 °C), holding at the selected temperature within ±25 °F (±14 °C) for not less than 1 hour, and cooling at a rate equivalent to an air cool or faster, and precipitation heat treated by heating to 1100 °F ± 15 °F (593 °C ± 8 °C), holding at heat for 4 to 8 hours, and cooling in air. Heat treatment for product under 0.50 inch (12.7 mm) nominal diameter or least distance between parallel sides shall be as agreed upon by purchaser and producer (see 8.8). Pyrometry shall be in accordance with AMS2750.

3.5 Properties

The product shall conform to the following requirements:

3.5.1 Bars, Wire, and Forgings

Product 4.000 inches (101.60 mm) and under in nominal diameter or least distance between parallel sides shall have the following properties:

3.5.1.1 Tensile Properties

3.5.1.1.1 At Room Temperature

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.

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

Form	Nominal Diameter or Least Distance Between Parallel Sides Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %		Reduction of Area %	
				L	T	L	T
Wire	Up to 0.500, incl	170	160	10	8	20	15
Bars	Over 0.500 to 2.500, incl	170	160	10	8	20	15
Bars	Over 2.500 to 3.000, incl	165	155	8	6	15	12
Forgings	Up to 3.000, incl	170	160	10	8	20	15
Bars and Forgings	Over 3.000 to 4.000, incl	160	150	8	6	15	12

Table 2B - Minimum tensile properties, SI units

Form	Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %		Reduction of Area %	
				L	T	L	T
Wire	Up to 12.70, incl	1172	1103	10	8	20	15
Bars	Over 12.70 to 63.50, incl	1172	1103	10	8	20	15
Bars	Over 63.50 to 76.20, incl	1138	1069	8	6	15	12
Forgings	Up to 76.20, incl	1172	1103	10	8	20	15
Bars and Forgings	Over 76.20 to 101.60, incl	1103	1034	8	6	15	12

3.5.1.1.2 At 800 °F (427 °C)

Product shall meet the requirements shown in Table 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) using strain rates as specified in 3.5.1.1.1:

Table 3 - Minimum tensile properties at 800 °F (427 °C)

Property	Value
Tensile Strength	135 ksi (931 MPa)
Yield Strength at 0.2% Offset	105 ksi (724 MPa)
Elongation in 4D	10%
Reduction of Area	30%

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.

3.5.1.1.4 Tensile property requirements apply in both the longitudinal and transverse directions, but tests in the transverse direction need be made only on product that specimens not less than 2.50 inches (63.5 mm) in length can be taken. Tests in the longitudinal direction are not required on product tested in the transverse direction.

3.5.1.1.5 Mechanical property requirements for product outside the size range covered by 1.1 shall be agreed upon between purchaser and producer and reported in 4.4.3.

3.5.1.2 Creep Test at 800 °F (427 °C)

A smooth tensile specimen shall be maintained at 800 °F ± 5 °F (427 °C ± 3 °C) under continuously applied axial stress of 95 ksi (655 MPa). Time to attain 0.2% plastic deformation shall be not less than 35 hours. If plastic deformation is less than 0.2% after 35 hours, the test may be discontinued; the amount of plastic deformation in 35 hours shall be reported. Gage dimensions of specimen and technique used to measure creep shall be as agreed upon by purchaser and producer (see 8.8). Test shall be conducted in accordance with ASTM E139.

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 (see 8.5).

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 Primary alpha in an age transformed beta matrix.

3.5.1.4 Surface Contamination

Except as specified in 3.5.1.4.1 and 3.5.1.4.2, product shall be free of any oxygen-enriched layer (see 8.2), 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.

3.5.1.4.1 An oxygen-rich layer not greater than 0.001 inch (0.025 mm) in depth will be permitted on bars other than round.

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

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 coupon shall conform to the requirements of 3.5.1.1.1. If specimens taken from the stock after heat treatment as in 3.4 conform to the requirements of 3.5.1.1.1, the tests shall be accepted as equivalent to tests of a forged coupon.

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 the 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 the 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), room-temperature tensile properties (3.5.1.1.1), microstructure (3.5.1.4), and surface contamination (3.5.1.5) of each lot of bars, wire, and forgings.

4.2.1.3 Tolerances (3.6) of bars and wire.

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) and creep properties at 800 °F (427 °C) (3.5.1.2) of bars, wire, and forgings.

4.2.2.2 Ability of forging stock to develop required properties (3.5.2).

4.3 Sampling and Testing

Shall be in accordance with AMS2368 and the following: a lot shall be all product of the same nominal size from the same heat, processed at the same time and heat treated in the same batch:

4.3.1 For 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

At least one sample from each lot of bars and wire. One longitudinal specimen from each lot of forgings from a section having maximum thickness and from a section having minimum thickness.