AEROSPACE MATERIAL SPECIFICATION

AMS6952™	REV. A
Issued 2018-03 Revised 2023-09 Superseding AMS6952	

Titanium Alloy, Forgings
5.8Al - 4.0Sn - 3.5Zr - 2.8Mo - 0.7Nb - 0.35Si - 0.06C
Solution and Precipitation Heat Treated
(Composition similar to UNS R56443)

RATIONALE

AMS6952A results from a Five-Year Review and update of this specification with changes to update general agreement language related to unauthorized exceptions (see 3.5.1.1.3, 3.8, 4.4.4, and 8.6), correct conversion of metric temperature values for solution heat treatment (see 3.4), update Form (see 1.1), Applicable Documents (see Section 2), Forgings (see 3.5.1), and Ordering Information (see 8.7), and allow use of the immediate prior specification revision (see 8.5).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of forgings 4.400 inches (111.76 mm) and under in nominal diameter or least distance between parallel sides and a maximum cross-sectional area of 63.8 square inches (411.6 cm^2) and under and forging stock of any size (see 8.7).

1.2 Application

These products have been used typically for parts requiring high strength and toughness and good creep resistance up to 1004 °F (540 °C), but usage is not limited to such applications.

1.2.1 Certain processing procedures and service conditions may cause these forgings 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)**
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For more information on this standard, visit
https://www.sae.org/standards/content/AMS6952A

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.

AMS2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys

AMS2750 Pyrometry

AMS2808 Identification, Forgings

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 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 Reactive Metals and Reactive Metal Alloys by Inert Gas Fusion with Detection by Thermal Conductivity or Infrared Spectrometry

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	5.30	6.30	
Tin	3.50	4.50	
Zirconium	3.10	3.90	
Molybdenum	2.30	3.30	
Niobium (Columbium)	0.45	0.95	
Silicon	0.20	0.50	
Oxygen	0.05	0.15	
Iron	--	0.10	
Carbon	0.03	0.10	
Nitrogen	--	0.10	(1000 ppm)
Hydrogen	--	0.020	(200 ppm)
Other Elements, each (3.1.1)	--	0.10	
Other Elements, total (3.1.1)	--	0.30	
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 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 argon and/or helium at an absolute 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 Forgings

Solution and precipitation heat treated, and descaled.

3.3.2 Forging Stock

As ordered by the forging manufacturer.

3.4 Heat Treatment

Forgings shall be solution heat treated by heating to a temperature 59 to 95 °F (33 to 53 °C) below the beta transus determined on each heat of alloy, holding at the selected temperature within ±15 °F (±8 °C) for 1 hour ± 0.25 hour, and cooling at a rate equivalent to an air cool or faster and precipitation heat treated by heating to 1175 °F ± 15 °F (635 °C ± 8 °C), holding at heat for 1 hour ± 0.25 hour, and cooling in air. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

The product shall conform to the following requirements:

3.5.1 Forgings

Forgings 4.400 inches (111.76 mm) and under in nominal diameter or least distance between parallel sides and 63.8 square inches (411.6 cm^2) and under in cross-sectional area shall conform to the following requirements:

3.5.1.1 Tensile Properties

Shall be as follows, determined on specimens having a gage diameter not less than 0.250 inch (6.35 mm).

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 2 - Minimum room temperature tensile properties

Property	Value
Tensile Strength	163 ksi (1124 MPa)
Yield Strength at 0.2% Offset	146 ksi (1007 MPa)
Elongation in 4D	3%
Reduction of Area	5%

3.5.1.1.2 At 1112 °F (600 °C)

Shall be as specified in Table 3, determined in accordance with ASTM E21 on specimens at 1112 °F ± 10 °F (600 °C ± 6 °C) using strain rates as specified in 3.5.1.1.1:

Table 3 - Minimum elevated temperature tensile properties

Property	Value
Tensile Strength	99 ksi (683 MPa)
Yield Strength at 0.2% Offset	78 ksi (538 MPa)
Elongation in 4D	18%
Reduction of Area	36%

3.5.1.1.3 Mechanical property requirements for product outside the size range covered by 1.1 shall be agreed upon between the purchaser and producer and reported per 4.4.4 (see 8.7).

3.5.1.2 Creep Properties at 1004 °F (540 °C)

An unnotched tensile specimen, maintained at 1004 °F ± 3 °F (540 °C ± 2 °C) while an axial stress of 36.3 ksi (250 MPa) is applied continuously, shall not exceed 0.2% plastic strain in 35 hours. Gage dimensions of specimens and techniques used to measure creep shall be as agreed upon by the purchaser and producer (see 8.7). 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.

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, forgings 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 acceptable to the purchaser.

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

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 and 3.5.1.2. If specimens taken from the stock after heat treatment as in 3.4 conform to the requirements of 3.5.1.1 and 3.5.1.2, the tests shall be accepted as equivalent to tests of a forged coupon.

3.6 Quality

The product, as received by the 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 Production, distribution, and procurement of metal stock shall comply with AS6279.

3.8 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.4.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for the producer's tests and shall be responsible for the performance of all required tests. The 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 (see 3.1) of each heat.

4.2.1.2 Hydrogen content (see 3.1), tensile properties (see 3.5.1.1.1 and 3.5.1.1.2), creep properties (see 3.5.1.2), microstructure (see 3.5.1.3), and surface contamination (see 3.5.1.4) of each lot of forgings.

4.2.2 Periodic Tests

Ability of forging stock (see 3.5.2) to develop required properties is a periodic test and shall be performed at a frequency selected by the producer unless frequency of testing is specified by the purchaser.