AEROSPACE MATERIAL SPECIFICATION

AMS4983	REV. F

Issued 1984-04
Revised 2015-01

Superseding AMS4983E

Titanium Alloy, Forgings
10V - 2Fe - 3Al
Consumable Electrode Melted, Single-Step Solution Heat Treated and Aged
180 ksi (1241 MPa) Tensile Strength
(Composition similar to UNS R56410)

RATIONALE

AMS4983F results from a Five Year Review and update of this specification that includes the removal of sample size allowance for hydrogen of Table 1 (covered by ASTM E1447), revises temperature tolerance on beta transus determination (3.4.1.2), requires agreement on mechanical property values for material outside specification ranges (3.5.1.1.2 and 8.5), the addition of AS6279 (3.7) and revises the report paragraphs (4.4).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of forgings 1.00 inch (25.4 mm) and under in nominal cross-sectional thickness and of forging stock any size.

1.2 Application

These forgings have been used typically for parts in high stress and stress-corrosion-resistant applications, but usage is not limited to such applications.

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: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
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SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS4983F

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.

AMS2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys

AMS2750 Pyrometry

AMS2808 Identification, Forgings

AS6279 Industry Standard Practices for Production, Distribution, and Procurement of Metal Stock

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 E384 Knoop and Vickers Hardness of Materials

ASTM E399 Plane-Strain Fracture Toughness of Metallic Materials

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

ASTM E1447 Determination of Hydrogen in Titanium and Titanium Alloys by the 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

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. Other analytical methods may be used if acceptable to the purchaser.

Table 1 - Composition

Element	min	max
Vanadium	9.0	11.0
Aluminum	2.6	3.4
Iron	1.6	2.2
Oxygen	--	0.13
Carbon	--	0.05
Nitrogen	--	0.05 (500 ppm)
Hydrogen	--	0.015 (150 ppm)
Yttrium (3.1.1)	--	0.005 (50 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. If yttrium content is determined, no variation over maximum will be permitted.

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 melt cycle.

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 heat treated, aged, and descaled.

3.3.2 Forging Stock

As ordered by the forging manufacturer.

3.4 Heat Treatment

Forgings shall be solution heat treated and aged as follows: Pyrometry shall be in accordance with AMS2750.

3.4.1 Solution Heat Treatment

Forgings shall be single solution heat treated by heating to a temperature 60 to 100 °F (33 to 55 °C) degrees below the beta transus (See 8.2.1), holding at heat for not less than 30 minutes, and cooling at a rate equivalent to an air cool or faster.

3.4.1.1 Other solution heat treatments may be employed when agreed upon by purchaser and producer.

3.4.1.2 Beta Transus Determination

The beta transus temperature shall be determined by a method acceptable to purchaser. Thermal controls and readouts shall be calibrated to an accuracy of ±5 °F (±3 °C). Beta transus accuracy shall be ±15 °F (±8 °C).

3.4.2 Aging

Heat to a temperature not lower than 900 °F (482 °C), hold at the selected temperature within ±10 °F (±6 °C) for not less than 8 hours, and cool to room temperature.

3.4.2.1 If a lot of forgings does not meet the minimum fracture toughness requirement of 3.5.1.2, the lot of forgings may be re-aged at a higher temperature, or held at the original aging temperature, for additional time as required, cooled to room temperature, and retested for fracture toughness and tensile properties.

3.5 Properties

The aged product shall conform to the following requirements:

3.5.1 Forgings

3.5.1.1 Tensile Properties

Shall be as shown in Table 2 for forgings 1.00 inch (25.4 mm) and under in nominal cross-sectional thickness, determined in accordance with ASTM E8 / E8M with the rate of strain set at 0.005 inch/inch/minute (0.005 mm/mm/minute) and maintained within a tolerance of ±0.002 inch/inch/minute (0.002 mm/mm/minute) through the 0.2% offset yield strain.

Table 2 - Minimum tensile properties

Property	Value
Tensile Strength	180 ksi (1241 MPa)
Yield Strength at 0.2% Offset	160 ksi (1103 MPa)
Elongation in 4D	4%
Reduction of Area	Shall be reported except when flat sheet-type specimens are used

3.5.1.1.1 Tensile requirements apply in both the longitudinal and transverse directions but tests in the transverse direction need be made only on forgings that a specimen not less than 2.50 inches (63.5 mm) in length can be taken.

3.5.1.1.2 Mechanical property requirements for product outside the range covered by 3.5.1.1 shall be agreed upon between purchaser and producer.

3.5.1.2 Fracture Toughness

K_{IC} shall be not lower than 40 ksi $\sqrt{inch}$ (44 MPa $\sqrt{m}$), determined in accordance with ASTM E399 for all specimen orientations. To facilitate determination of fracture toughness a tensile specimen taken immediately adjacent to the location of the fracture toughness specimen is required. Fracture planes of tensile and K_{IC} specimen shall be in the same direction, when possible. When a tensile specimen cannot be excised from the forging with the fracture plane in the same direction as that of the fracture toughness specimen, the orientation of the tensile specimen shall be as approved by purchaser.

3.5.1.2.1 Forgings not meeting the minimum fracture toughness requirements may be re-aged in accordance with 3.4.2 and retested for fracture toughness and tensile properties.

3.5.1.3 Microstructure

Microstructural examination shall be conducted using a magnification of not less than 200X on a suitably etched metallographic specimen.

3.5.1.3.1 The microstructure shall consist of primary alpha phase in a matrix of aged beta. An unbroken, continuous alpha phase network along prior beta grain boundaries is not acceptable unless purchaser and producer have agreed that such phase is acceptable and tensile and fracture toughness properties are met.

3.5.1.3.2 There shall be no evidence of rejectable beta flecks when examined at a magnification of 50 to 100X. A rejectable beta fleck exhibits no primary alpha in a 0.030 inch by 0.030 inch (0.762 mm by 0.762 mm) or equivalent area.

3.5.1.4 Surface Contamination

Except as specified in 3.5.1.4.2, 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 other method acceptable to purchaser.

3.5.1.4.1 A surface hardness more than 40 points higher than the subsurface hardness, determined in accordance with ASTM E384 on the Knoop scale using a 200 gram load, is evidence of unacceptable surface contamination.

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 forging.

3.5.2 Forging Stock

When a sample of stock is forged to a test coupon having a degree of mechanical working not greater than the forging 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 a sample taken directly from the forging stock and heat treated as in 3.4 conforms to 3.5.1.1, testing of a forged coupon is not required.

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.

3.6.1 Grain flow of die forgings, except in areas that contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of reentrant grain flow.

3.7 Production, distribution, and procurement of metal stock shall comply with AS6279. This requirement becomes effective June 01, 2016.

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 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

Composition (3.1), tensile properties (3.5.1.1), fracture toughness (3.5.1.2), microstructure (3.5.1.3), surface contamination (3.5.1.5), and beta-transus temperature (3.4.1.2) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests

Grain flow of die forgings (3.6.1) and tests of forging stock to demonstrate ability to meet specified requirements (3.5.2) 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 not less than the following; a lot shall be all forgings of the same nominal size and configuration from the same heat processed at the same time under the same fixed conditions and presented for producer's inspection at one time.

4.3.1 Acceptance Tests

4.3.1.1 Composition

One sample from each ingot; except for hydrogen determination one sample from each lot obtained after thermal and chemical processing is completed.

4.3.1.2 Tensile and Fracture Toughness Properties

4.3.1.2.1 Two samples from a forging or forging prolongation from each lot, sufficient to provide two test specimens for each property to be measured.

4.3.1.2.2 Location and orientation of tensile and fracture toughness specimens shall be as agreed upon by purchaser and producer. If not defined by purchaser, producer shall select test specimens from the heaviest section and shall select orientation in the following order of preference: transverse or longitudinal for tensile specimens and S-T, T-L, or L-T in accordance with ASTM E399 for fracture toughness specimens.

4.3.1.2.3 If a K_Q value is invalid solely on the basis of either W-a is less than 2.5 $(K_Q/T\text{-}YS)^2$ or P_{max}/PQ is greater than 1.10 and the thickest possible specimen had been used, the K_Q value may be used as K_{IC} to satisfy the requirements of 3.5.1.2. K_Q values invalid on the basis of criteria other than listed above (e.g., crack front curvature, etc.) shall not be used, but an additional specimen shall be tested for each of these invalid specimens. Where sufficient material does not exist for retest of the forging having invalid results, the retest may be performed from another forging from the same lot.

4.3.1.2.4 Tensile and fracture toughness properties shall be retested on forgings re-aged in accordance with 3.4.2.1.

4.3.1.3 Microstructure and Surface Contamination

One or more samples from each lot. Microstructural evaluations may be taken from any convenient location outside the machined part envelope for surface examination and from broken tensile specimens for general microstructure.

4.3.1.4 Beta Transus Determination

One sample each from the top and bottom of an ingot produced from a heat or one sample from each lot except that any lot comprising a full ingot shall be sampled on the top and bottom of the ingot.

4.4 Reports

4.4.1 The producer shall furnish with each shipment a report showing producer name, and 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 and beta transus temperature of each heat, and for hydrogen content, tensile and fracture toughness properties, and micrographs of microstructure as applicable, of each lot and state that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS4983F, mill produced size or part number (if applicable), quantity, reduction of area for each lot, heat-treat cycle, and the size and melt source of stock used to make the forgings. The producer of forging stock shall furnish with each shipment a report showing the results of tests for composition and beta transus temperature of each heat and hydrogen content of each lot. This report shall include the purchase order number, heat number, AMS4983F, size, and quantity.

4.4.2 Report the nominal metallurgically worked cross sectional size and the cut size, if different.

4.4.3 When the product size is outside the range covered by 3.5.1.1, the report shall contain a statement to that effect.