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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4983B

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Superseding AMS 4983A

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

1. SCOPE:

1.1 Form:

This specification covers a titanium alloy in the form of forgings under 1.00 inch (25 mm) in nominal cross-sectional thickness and of forging stock.

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 following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2750	Pyrometry
AMS 2808	Identification, Forgings

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7161 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM E 8 Tension Testing of Metallic Materials
ASTM E 8M Tension Testing of Metallic Materials, Metric
ASTM E 120 Chemical Analysis of Titanium and Titanium Alloys
ASTM E 399 Plane-Strain Fracture Toughness of Metallic Materials
ASTM E 1409 Determination of Oxygen 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 Method

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1, determined by analytical methods in accordance with ASTM E 120, ASTM E 1409, and ASTM E 1447, by spectrochemical methods, or by other analytical methods acceptable to 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)
Residual Elements, each (3.1.1)	--	0.10
Residual 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 AMS 2249.

3.2 Melting Practice:

Alloy shall be multiple melted. Melting cycle(s) prior to the final melting cycle shall be made using consumable electrode, nonconsumable electrode, electron beam, or plasma arc melting practice(s). The final melting cycle shall be made under vacuum using consumable electrode practice with no alloy additions permitted.

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:

3.4.1 Solution: Forgings shall be single solution heat treated by heating to a temperature temperature 60 to 100 F (33 to 55 C) degrees below the beta transus (see 8.2), holding at heat for not less than 30 minutes, and cooling at a rate equivalent to an air cool or faster. Pyrometry shall be in accordance with AMS 2750.

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

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.

3.5 Properties:

The product shall conform to the following requirements:

3.5.1 Forgings:

3.5.1.1 Tensile Properties: Shall be as shown in Table 2, determined in accordance with ASTM E 8 or ASTM E 8M with the rate of strain maintained at 0.003 to 0.007 inch/inch per minute (0.003 to 0.007 mm/mm per 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 per minute (0.005 mm/mm per minute) through the yield strength and a minimum cross head speed of 0.10 inch per minute (0.04 mm/s) above the yield strength. Tensile requirements apply in both the longitudinal and transverse directions but tests in the transverse direction need be made only on forgings from which a specimen not less than 2.50 inches (63.5 mm) in length can be taken; tests in the transverse direction are not required on forgings tested in the longitudinal direction.

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

3.5.1.2 Fracture Toughness: K_{IC} shall be not lower than 40 ksi $\sqrt{\text{inch}}$ (44 MPa $\sqrt{\text{m}}$), determined in accordance with ASTM E 399.

3.5.1.2.1 Test Data: At time of testing, the following data shall be recorded on the load-displacement test record:

Date
Specimen identification
Specimen orientation
Load scale calibration
Displacement scale calibration
Loading rate in terms of K_I in accordance with ASTM E 399
PQ
Pmax
Testing laboratory
Test machine
Operator

3.5.1.2.2 Reduction of Test Data: Test data shall be reduced in accordance with ASTM E 399 to calculate a K_Q value and to determine if a valid K_{IC} value has been measured. Tensile coupons shall be provided for validity verification wherever fracture toughness coupons are specified. In checking for validity, the yield strength value used shall be yield strength measured for the same forging from which the fracture toughness specimen was obtained. Not less than one 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 approved by purchaser.

3.5.1.3 Microstructure: Shall be that structure resulting from alpha-beta processing. Microstructure shall conform to 3.5.1.3.1, 3.5.1.3.2, 3.5.1.3.3, or 3.5.1.3.4. A microstructure showing a continuous network of alpha in prior beta grain boundaries is not acceptable.

3.5.1.3.1 Lamallar alpha with some equiaxed alpha in a transformed beta matrix.

3.5.1.3.2 Equiaxed alpha in a transformed beta matrix.

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

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

3.5.1.4 Macrostructure and Grain Flow: The grain flow pattern of macroetch sections taken from designated areas of a forging during initial evaluation, and for subsequent periodic evaluations, shall generally conform to the part shape. If areas are not designated by purchaser, two sections shall be taken normal to the parting line in areas having the greatest section variation. If standards are not established, photomacrographs of acceptable macrostructure of a forging from the first production lot shall be used as the standard. Presence of laps, seams, folds, etc is not acceptable.

3.5.1.5 Surface Contamination: Except as specified in 3.5.1.5.1, 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 100X magnification or other method acceptable to purchaser.

3.5.1.5.1 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.

3.5.1.6 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 ±10 °F (±6 °C).

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 which contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of re-entrant grain flow.

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 performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for 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 (3.5.1.6) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Tests for macrostructure and grain flow (3.5.1.4) and 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 vendor 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 vendor's inspection at one time.

4.3.1 For Acceptance Tests:

4.3.1.1 Composition: One sample from each ingot; 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 prolongations from each lot.

4.3.1.2.2 Location and orientation of tensile and fracture toughness specimens shall be as agreed upon by purchaser and vendor. If not defined by purchaser, vendor 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 E 399 for fracture toughness specimens.

4.3.1.2.3 If a K_Q value is invalid solely on the basis of either B is less than 2.5 $(K_Q/TYS)^2$ or P_{max}/PQ is greater than 1.10, 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. Retests shall be conducted on additional forgings.

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.

4.3.2 For Periodic Tests: As agreed upon by purchaser and vendor and as follows:

4.3.2.1 Photographs of the macrostructure and grain flow pattern (3.5.1.4) shall be provided to purchaser.

4.4 Reports:

4.4.1 The vendor of forgings shall furnish with each shipment a report showing the results of tests for chemical composition and beta transus temperature of each heat and for hydrogen content, tensile and fracture toughness properties, macrographs of grain flow, and micrographs of microstructure as applicable of each lot. This report shall include the purchase order number, heat and lot number, AMS 4983B, size, quantity, reduction of area for each lot, heat-treat cycle, part number, and the size and melt source of stock used to make the forgings.