SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6932

Issued JAN 2004

Titanium Alloy Bars, Forgings and Forging Stock
6.0Al - 4.0V Extra Low Interstitial
Annealed

(Composition Similar to UNS R56401)

1. SCOPE:

1.1 Form:

This specification covers a titanium alloy in the form of bars, forgings, and stock for forging.

1.2 Application:

These products have been used typically for parts requiring good weldability and ductility, combined with good notch-toughness down to -320 °F (-196 °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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org

SAE WEB ADDRESS: http://www.sae.org

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2241	Tolerances, Corrosion and Heat-Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
AMS 2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2368	Sampling and Testing of Wrought Titanium Raw Materials, Except Forging and Forging Stock
AMS 2631	Ultrasonic Inspection, Titanium and Titanium Alloy Bar and Billet
AMS 2643	Structural Examination of Titanium Alloys, Chemical Etch Inspection
AMS 2808	Identification, Forgings
AMS 2809	Identification, Titanium and Titanium Alloy Wrought Products
AMS-H-81200	Heat Treatment of Titanium and Titanium Alloys
ARP982	Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

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 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

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1. Oxygen shall be determined in accordance with ASTM E 1409, hydrogen in accordance with ASTM E 1447, and other elements by wet chemical methods in accordance with ASTM E 120, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	min	max
Aluminum	5.50	6.50
Vanadium	3.50	4.50
Iron	--	0.25
Oxygen	--	0.13
Carbon	--	0.08
Nitrogen	--	0.05 (500 ppm)
Hydrogen (3.1.2)	--	0.0125 (125 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 When using ASTM E 1447 for hydrogen determination, sample size may be as large as 0.35 gram.

3.1.3 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2249.

3.2 Melting Practice:

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

3.2.1.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be argon or helium at an absolute pressure not higher than 1000 mm of mercury.

3.2.1.2 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. A machined or ground surface is permitted unless prohibited by the purchaser.

3.3.2 Forgings: Annealed and descaled.

3.3.3 Stock for Forging: As ordered by the forging manufacturer.

3.4 Heat Treatment:

Bars and forgings shall be annealed in accordance with AMS-H-81200.

3.5 Properties:

The product shall conform to the following requirements:

3.5.1 Bars and Forgings:

3.5.1.1 Tensile Properties: Shall be as specified 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/minute (0.003 to 0.007 mm/mm/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/minute (0.005 mm/mm/minute) through the yield strength and a minimum cross head speed of 0.10 inch (2.5 mm) per minute above the yield strength.

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 from which a test specimen not less than 2.50 inches (63.5 mm) in length can be obtained.

3.5.1.1.2 Longitudinal requirements in Table 2 apply to specimens from product taken with the axis of the specimen within 15 degrees of parallel to the grain flow.

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

3.5.1.1.4 Table 2 properties are limited to product with a maximum cross-sectional area of 16 square inches (103.23 square cm). Properties for product with larger cross sectional area shall be as agreed upon between the purchaser and vendor.

TABLE 2 - Minimum Tensile Properties (See 8.2)

Nominal Diameter or Distance Between Parallel Sides Inch (mm)	Maximum Cross Sectional Area In^2 (m^2 X 10^4)	Tensile Strength ksi (Mpa)	Yield Strength At 0.2% Offset ksi (MPa)	Elongation in 2 Inches (50.8 mm) or 4D, %	Reduction of Area %
Up to 1.50 (38.10) incl.	16 (103.23)	130 (896)	120 (827)	10	25
Over 1.50 (38.10) to 3.00 (76.20), incl.	16 (103.23)	125 (861)	115 (793)	10	20

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 or 3.5.1.2.2 (See 8.3).

3.5.1.2.1 Equiaxed and/or elongated primary alpha in a transformed beta matrix with no continuous network of alpha at prior beta grain boundaries.

3.5.1.2.2 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.

3.5.1.3 Surface Contamination: Except as specified in 3.5.1.3.1, the product shall be free of any oxygen-rich layer (See 8.4), 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 vendor.

3.5.1.3.1 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.

3.5.1.4 Macrostructure: Product shall be uniform in quality and condition, homogenous, sound, and free from foreign materials and from internal imperfections detrimental to fabrication or performance of parts

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.

3.6 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 Ultrasonic Inspection: Product 0.500 inch (12.70 mm) to 1.500 (38.10 mm) inclusive in nominal thickness, diameter or least distance between parallel sides shall meet Class A1 requirements of AMS 2631. Product over 1.500 inch (38.10 mm) in nominal thickness, diameter or least distance between parallel sides shall meet Class A requirements of AMS 2631.

3.7 Tolerances:

Bars shall conform to all applicable requirements of AMS 2241.

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 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 the 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), surface contamination (3.5.1.3), macrostructure (3.5.1.4), and ultrasonic quality (3.6.1) of each lot of bars and forgings.

4.2.1.3 Tolerances (3.7) of bars.

4.2.2 Periodic Tests: Ability of forging stock (3.5.2) to develop specified properties is a periodic test 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 in accordance with AMS 2368 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 all thermal and chemical processing is completed.

4.3.1.2 Tensile Properties: At least one sample from bars from each lot. The number, location, and orientation of samples from each lot of forgings shall be as agreed upon by purchaser and vendor.

4.3.1.3 A specimen at least 0.5 inch (6.3 mm) long by full cross-section from each end of the bars selected for sampling shall be macrostructurally examined for conformance to the quality requirements. Unless otherwise specified, macrostructural examination shall be performed in accordance with AMS 2643. The number of bars selected for examination shall not be less than the amounts shown in Table 3.

Table 3 - Number of Bars Selected for Macrostructural Examination

Number of Bars in Lot	Number of Bars Selected
1 to 15	1
16 to 50	2
51 to 100	3
151 to 500	5
over 500	4 + amount shown above over 500