

AEROSPACE MATERIAL SPECIFICATION

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Superseding AMS 4978C

Titanium Alloy Bars, Wire, Forgings, and Rings 6Al - 6V - 2Sn Annealed

(Composition similar to UNS R56620)

1. SCOPE:

1.1 Form:

This specification covers a titanium alloy in the form of bars, wire, forgings, flash welded rings, and stock for forging or flash welded rings.

1.2 Application:

These products have been used typically for parts which require high mechanical properties in the annealed condition and a high strength to weight ratio up to 750 °F (399 °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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

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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
MAM 2241	Tolerances, Metric, 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 2750	Pyrometry
AMS 2808	Identification, Forgings
AMS 2809	Identification, Titanium and Titanium Alloy Wrought Products
AMS 7498	Rings, Flash Welded, Titanium and Titanium Alloys
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 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

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	5.00	6.00
Vanadium	5.00	6.00
Tin	1.50	2.50
Iron	0.35	1.00
Copper	0.35	1.00
Carbon	--	0.05
Oxygen	--	0.20
Nitrogen	--	0.04 (400 ppm)
Hydrogen	--	0.015 (150 ppm)
Yttrium (3.1.1) (3.1.4)	--	0.005 (50 ppm)
Residual Elements, each (3.1.1)	--	0.10
Residual Elements, total (3.1.1)	--	0.40
Titanium	remainder	

3.1.1 Determination not required for routine acceptance.

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

3.1.3 When using ASTM E 1447 for hydrogen determination, sample size may be as large as 0.35 gram.

3.1.4 No variation over maximum will be permitted for yttrium.

3.2 Melting Practice:

3.2.1 Alloy shall be multiple melted; at least one of the melting cycles shall be under vacuum. The first melt shall be made by consumable electrode, nonconsumable electrode, electron beam, or plasma arc melting practice. The subsequent melt or melts shall be made using consumable electrode practice with no alloy additions permitted in the last consumable electrode melt.

3.2.1.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be inert gas at a pressure not higher than 1000 mm of mercury.

3.2.1.2 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.

3.3.2 Wire: Cold drawn, annealed, and descaled.

3.3.3 Forgings and Flash Welded Rings: Annealed and descaled.

3.3.3.1 Flash welded rings shall not be supplied unless specified or permitted on purchaser's part drawing. When supplied, rings shall be manufactured in accordance with AMS 7498.

3.3.4 Stock for Forging or Flash Welded Rings: As ordered by the forging or flash welded ring manufacturer.

3.4 Heat Treatment:

Annealing: Bars, wire, forgings, and flash welded rings shall be annealed in accordance with AMS-H-81200.

3.5 Properties:

The product shall conform to the following requirements:

3.5.1 Bars, Wire, Forgings, and Flash Welded Rings:

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 bars and wire taken with the axis of the specimen within 15 degrees of parallel to the grain flow and to specimens from flash welded rings taken in the circumferential direction.

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.

TABLE 2A - Tensile Properties, Inch/Pound Units

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength ksi, min	Yield Strength at 0.2% Offset ksi	Elongation in 2 inches or 4D % , min Long.	Elongation in 2 inches or 4D % , min Trans.	Reduction of area % , min Long.	Reduction of area % , min Trans.
Up to 2.000, incl	150	140 to 165	10	8	20	15
Over 2.000 to 4.000, incl	145	135 to 160	10	8	15	15

TABLE 2B - Tensile Properties, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D % , min Long.	Elongation in 50.8 mm or 4D % , min Trans.	Reduction of Area % , min Long.	Reduction of Area % , min Trans.
Up to 50.80, incl	1034	965 to 1138	10	8	20	15
Over 50.80 to 101.60, incl	1000	931 to 1103	10	8	15	15

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, 3.5.1.2.2, or 3.5.1.2.3 (See 8.2).

3.5.1.2.1 Equiaxed alpha in a transformed beta matrix.

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

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

3.5.1.2.4 A microstructure showing a continuous network of alpha in prior beta grain boundaries is not acceptable.

3.5.1.3 Surface Contamination: Except as specified in 3.5.1.3.1 and 3.5.1.3.2, 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 by other method agreed upon by purchaser and vendor.

3.5.1.3.1 An oxygen-rich layer not thicker than 0.001 inch (0.025 mm) is permitted on bars other than round.

3.5.1.3.2 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 Fracture-Toughness: When specified, the product shall be subjected to fracture toughness testing. ASTM E 399 is a recommended method of test for product over 0.5 inch (12.7 mm) in nominal thickness. Method of test and standards for acceptance shall be as agreed upon by purchaser and vendor.
- 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.
- 3.5.3 Stock for Flash Welded Rings: Specimens taken from the stock after heat treatment as in 3.4 shall conform to the requirements of 3.5.1.1.
- 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 all applicable requirements of AMS 2241 or MAM 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), and when specified, fracture-toughness (3.5.1.4) of bars, wire, forgings, and flash welded rings.
- 4.2.1.3 Tolerances (3.7) of bars and wire.

4.2.2 Periodic Tests: Ability of forging stock (3.5.2) and stock for flash welded rings (3.5.3) to develop specified properties 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 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 thermal and chemical processing is completed.

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

4.3.1.2.1 Specimens from flash welded rings shall be from parent metal not including the weld heat-affected zone.

4.3.1.3 Other Requirements: As agreed upon by purchaser and vendor.

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

4.4 Reports:

The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and for the hydrogen content, tensile properties, and surface contamination of each lot, and stating that the product conforms to the other technical requirements. The report shall include the purchase order number, heat and lot numbers, AMS 4978D, size, specific annealing treatment used, and quantity. If forgings are supplied, the part number and the size and melt source of stock used to make the forgings shall also be included.

4.5 Resampling and Retesting:

If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Identification:

Shall be as follows: