NOTICE OF ADOPTION

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6 December 1993
AMS 4978C

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AEROSPACE MATERIAL SPECIFICATION

An American National Standard

AMS 4978C

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Superseding AMS 4978B

TITANIUM ALLOY BARS, WIRE, FORGINGS, AND RINGS
6A1 - 6V - 2Sn
Annealed

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: Primarily for parts that do not require heat treatment but require high mechanical properties in the annealed condition. This alloy exhibits a high strength-to-weight ratio up to 750°F (399°C). 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 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 documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

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 2350 - Standards and Test Methods
AMS 2808 - Identification, Forgings
AMS 2809 - Identification, Titanium and Titanium Alloy Wrought Products
AMS 7498 - Rings, Flash Welded, Titanium and Titanium Alloys

2.1.2 Aerospace Recommended Practice:

ARP982 - Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

ASTM E 8 - Tension Testing of Metallic Material
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

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Specifications:

MIL-H-81200 - Heat Treatment of Titanium and Titanium Alloys

2.3.2 Military Standards:

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

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, 0 determined by wet chemical methods in accordance with ASTM E 120, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	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)	--	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 applicable requirements of AMS 2249; no variation over maximum will be permitted for yttrium.

3.2 Condition: The product shall be supplied in the following condition:

3.2.1 Bars: Hot finished with or without subsequent cold reduction, annealed, and descaled.

3.2.2 Wire: Cold drawn, annealed, and descaled.

3.2.3 Forgings and Flash Welded Rings: Annealed and descaled.

3.2.3.1 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.

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

3.3 Annealing: Bars, wire, forgings, and flash welded rings shall be annealed 0 in accordance with MIL-H-81200.

3.4 Properties: The product shall conform to the following requirements:

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

3.4.1.1 Tensile Properties: Shall be as specified in Table I, determined in accordance with ASTM E 8 or ASTM E 8M with the rate of strain maintained at 0.003 - 0.007 inch/inch/minute (0.003 - 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.

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

3.4.1.1.2 Tensile property requirements apply in both the longitudinal and
0 transverse directions, but tests in the transverse direction need be made only on product from which a specimen not less than 2.50 inches (63.5 mm) in length can be taken. Tests in the longitudinal direction are not required on product tested in the transverse direction.

3.4.1.2 Microstructure: Shall be that structure resulting from alpha-beta
0 processing. Microstructure shall conform to 3.4.1.2.1, 3.4.1.2.2, or 3.4.1.2.3.

3.4.1.2.1 Equiaxed alpha in a transformed beta matrix.
0

3.4.1.2.2 Equiaxed alpha and elongated alpha in a transformed beta matrix.
0

3.4.1.2.3 Partially broken and distorted grain boundry alpha with plate-like
0 alpha.

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

3.4.1.3 Surface Contamination: The product shall be free of any oxygen-rich
0 layer, such as alpha case, or other surface contamination, determined by microscopic examination at not lower than 100X magnification or by other method acceptable to purchaser.

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

3.4.1.3.2 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.

3.4.1.4 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.

3.4.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.3, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.1.1. If specimens taken from the stock after heat treatment as in 3.3 conform to the requirements of 3.4.1.1, the tests shall be accepted as equivalent to tests of a forged coupon.

3.4.3 Stock for Flash Welded Rings: Specimens taken from the stock after heat
0 treatment as in 3.3 shall conform to the requirements of 3.4.1.1.

3.5 Quality:

3.5.1 Alloy shall be multiple melted; at least one of the melting cycles shall
0 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.

3.5.1.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be inert gas at a pressure not higher than 250 mm of mercury.

3.5.1.2 The electrode tip for nonconsumable electrode melting shall be water-cooled copper.

3.5.2 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 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 performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.4. 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 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 Tensile properties (3.4.1.1), microstructure (3.4.1.2), surface contamination (3.4.1.3), and when specified, fracture-toughness (3.4.1.4) of bars, wire, forgings, and flash welded rings.

4.2.1.3 Tolerances (3.6) of bars and wire.

4.2.2 Periodic Tests: Tests of forging stock (3.4.2) and stock for flash welded rings (3.4.3) to demonstrate ability 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 the following; the number of specimens to be sampled shall be the minimum number of specimens tested. 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 0 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 0 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 of this specification. This report shall include the purchase order number, lot number, AMS 4978C, 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 and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY

5.1 Identification: Shall be as follows:

5.1.1 Bars and Wire: In accordance with AMS 2809, as applicable. 0

5.1.2 Forgings: In accordance with AMS 2808.

5.1.3 Flash Welded Rings and Stock for Forging or Flash Welded Rings: As agreed upon by purchaser and vendor.

5.2 Packaging:

5.2.1 The product shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the product to ensure carrier acceptance and safe delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.2.2 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-163, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.2.1 will be acceptable if it meets the requirements of Level C.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Product not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES:

8.1 Marginal Indicia: The phi (0) symbol is used to indicate technical changes from the previous issue of this specification.

8.2 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.