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400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 4978B

Superseding AMS 4978A

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UNS R56620

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

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 requiring high mechanical properties in the annealed condition. This alloy exhibits high strength-to-weight ratios up to 750°F (400°C).

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 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
AMS 2249 - Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2350 - Standards and Test Methods
AMS 2375 - Control of Forgings Requiring First Article Approval
AMS 2808 - Identification, Forgings
AMS 7498 - Rings, Flash Welded, Titanium and Titanium Alloys

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E8 - Tension Testing of Metallic Materials
ASTM E120 - Chemical Analysis of Titanium and Titanium Alloys
ASTM E146 - Chemical Analysis of Zirconium and Zirconium Alloys
ASTM E385 - Oxygen Content Using a 14-MeV Neutron Activation and Direct-Counting Technique
ASTM E399 - 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 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

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, determined by wet chemical methods in accordance with ASTM E120 or by spectrographic methods in accordance with Federal Ø Test Method Standard No. 151, Method 112, except that hydrogen shall be determined in accordance with ASTM E146 and oxygen in accordance with ASTM E385; other methods of analysis may be used provided that such methods are approved by 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	--	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; Ø no variation over maximum will be permitted for yttrium, unless otherwise agreed upon by purchaser and vendor.

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, they 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 by heating in a suitable atmosphere to a temperature within the range 1300° - 1500°F (705° - 815°C), holding at the selected temperature within ±25°F (±15°C) for 2 hr ± 0.25, and cooling as required.

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 E8 with the rate of strain maintained at 0.003 - 0.007 in. per in. per min. (0.003 - 0.007 (mm/mm)/min.) 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 in. per in. per min. (0.005 (mm/mm)/min.) through the yield strength and a minimum cross head speed of 0.10 in. (2.5 mm) per min. above the yield strength.

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

3.4.1.1.2 Transverse tensile properties apply only to product from which a specimen not less than Ø 2 1/2 in. (63.5 mm) in length can be taken. Tests in the longitudinal direction are not required if tests in the transverse direction are made.

3.4.1.2 Microstructure: Shall be essentially that resulting from alpha-beta processing. Micro- Ø structure shall be cause for rejection if any area of the product exhibits an all-transformed beta structure.

3.4.1.3 Surface Contamination: The product shall be free of any oxygen enriched layer, such as Ø alpha case, or other surface contamination, determined by microscopic examination.

3.4.1.3.1 When permitted by purchaser, forgings and flash welded rings to be machined all over Ø may have an oxygen-rich layer, provided such layer is removable within the machining allowance on the forging or ring.

3.4.1.4 Fracture-Toughness: When specified, the product shall be subjected to fracture toughness testing. ASTM E399 is a recommended method of test for product over 0.5 in. (12.5 mm) in nominal thickness. Method of test and standards for acceptance shall be as agreed upon by purchaser and vendor.

3.4.2 Stock for Forging or Flash Welded Rings: 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.

3.5 Quality:

3.5.1 Alloy shall be multiple melted; the final melting cycle shall be under vacuum. The first melt Ø shall be made by either consumable or nonconsumable electrode practice. The subsequent melt or melts shall be made using consumable electrode practice.

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

3.5.1.2 The electrode tip for nonconsumable electrode melting shall be either graphite or water- Ø cooled copper.

3.5.2 The product, as received by purchaser, shall be uniform in quality and condition, sound, Ø and free from foreign materials and from internal and external imperfections detrimental to usage of the product.

3.6 Tolerances: Unless otherwise specified, tolerances for bars and wire shall conform to all applicable requirements of AMS 2241.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Results of such tests shall be reported Ø to the purchaser as required by 4.5. Purchaser reserves the right to sample and to perform such confirmatory testing as deemed necessary to ensure that material conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to the following requirements are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.2.1.1 Composition (3.1).

4.2.1.2 Tensile properties (3.4.1.1), microstructure (3.4.1.2), surface contamination (3.4.1.3), Ø and when a minimum value has been 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 stock for forging or flash welded rings to demonstrate ability to Ø develop specified properties (3.4.2) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests: Tests of forgings to determine conformance to all technical requirements of this specification when AMS 2375 is specified are classified as preproduction tests and shall Ø be performed on the first-article shipment of a forging to a purchaser, when a change in material or processing requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.

4.2.3.1 For direct U.S. Military procurement of forgings, substantiating test data and, when requested, preproduction forgings shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be in accordance with the following; 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: One sample from each heat except that for hydrogen determinations one Ø sample from each lot obtained after thermal and chemical processing is completed.

4.3.1.2 Tensile Properties: 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 cut from parent metal not including the weld- Ø heat-affected zone.

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

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

4.4 Approval: When specified, approval and control of forgings shall be in accordance with AMS 2375.

4.5 Reports:

4.5.1 The vendor of the product shall furnish with each shipment three copies of 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, heat number, AMS 4978B, size, specific annealing treatment used, and quantity from each heat. If forgings are supplied, the part number and the size and melt source of stock used to make the forgings shall also be included.

4.5.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, AMS 4978B, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.6 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: The product shall be identified as follows:

5.1.1 Bars and Wire:

5.1.1.1 Each straight bar over 0.500 in. (12.50 mm) in nominal diameter or least width of flat surface shall be marked in a row of characters recurring at intervals not greater than 3 ft (900 mm) with AMS 4978B, heat number, and manufacturer's identification. The characters shall be of such size as to be clearly legible, shall be applied using a suitable marking fluid whose residue shall contain not more than traces of halogen-bearing compounds, and shall be removable in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the product or its performance and shall be sufficiently stable to withstand normal handling.

5.1.1.2 Straight bars and wire 0.500 in. (12.50 mm) and under in nominal diameter or least width of flat surface shall be securely bundled and identified by a durable tag marked with the purchase order number, AMS 4978B, heat number, nominal size, and manufacturer's identification and attached to each bundle or shall be boxed and the box marked with the same information.

5.1.1.3 Coiled bars and wire shall be securely bundled and identified by a durable tag marked with the purchase order number, AMS 4978B, heat number, nominal size, and manufacturer's identification and attached to each coil or shall be boxed and the box marked with the same information.

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: