



AEROSPACE MATERIAL

Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N. Y. 10001

SPECIFICATION

AMS 4978A

Superseding AMS 4978

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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 (399 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., Two Pennsylvania Plaza, New York, New York 10001.

2.1.1 Aerospace Material Specifications:

AMS 2241 - Tolerances, Corrosion and Heat Resistant Steel Bars and Wire
and 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 - Approval and Control of Critical Forgings

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, Pennsylvania 19103.

ASTM E8 - Tension Testing of Metallic Materials

ASTM E120 - Chemical Analysis of Titanium Base Alloys

ASTM E399 - Plane-Strain Fracture Toughness of Metallic Materials

2.3 Government Publications: Available from Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.

2.3.1 Federal Standards:

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

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E120, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other approved analytical methods.

	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)
Other Elements, total (3.1.1)	--	0.040
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.

3.2 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 (704.4 - 815.6 C), holding at the selected temperature within ± 25 F (± 14 C) for 2 hr, and cooling as required.

3.4 Properties:

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. per min. (2.54 mm/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 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. Microstructure shall not be cause for rejection unless standards have been agreed upon by purchaser and vendor.

3.4.1.3 Surface Contamination: Material shall be free of any oxygen enriched layer, such as alpha case, or other surface contamination.

- 3.4.1.4 Fracture Toughness Properties: When specified, the product shall be subject to fracture toughness testing. ASTM E399 is a recommended method of test for product over 0.5 in. (12.7 mm) in 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: Unless otherwise specified, material shall be produced by multiple melting using consumable electrode practice; at least one of the melting cycles shall be under vacuum. The product shall be uniform in quality and condition, clean, sound, and free from foreign materials and from internal and external imperfections detrimental to fabrication or to performance of parts.
- 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 and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to assure that material conforms to the requirements of this specification.
- 4.2 Classification of Tests:
- 4.2.1 Routine Control Tests: Tests of the product to determine conformance to composition (3.1) requirements and of bars, wire, forgings, and flash welded rings to determine conformance to condition (3.2), tensile properties (3.4.1.1), microstructure (3.4.1.2), surface contamination (3.4.1.3), and tolerance (3.6) requirements are classified as routine control tests.
- 4.2.2 Periodic Control Tests: Tests of bars, wire, forgings, and flash welded rings to determine conformance to fracture toughness requirements (3.4.1.4) and of stock for forging and flash welded rings to demonstrate capability of developing required properties (3.4.2) are classified as qualification and/or periodic control tests.
- 4.3 Sampling: Shall be in accordance with the following; when sampling is on a lot basis, a lot shall be all material of the same nominal size from the same heat processed at the same time.
- 4.3.1 Routine Control Tests:
- 4.3.1.1 Composition: One sample from each heat except that for hydrogen determinations, one sample from each lot.
- 4.3.1.2 Tensile Properties: One sample from bars, wire, and flash welded rings from each lot. The number, location, and direction of samples from each lot of forgings shall be as agreed upon by purchaser and vendor.
- 4.3.1.3 Other Requirements: As agreed upon by purchaser and vendor.
- 4.3.2 Periodic Control Tests: As agreed upon by purchaser and vendor.
- 4.4 Approval: When specified, approval and control of critical 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 in the shipment, the results of tests on each lot to determine conformance to the hydrogen and tensile property requirements, and a statement that the product conforms to all other technical requirements of this specification. This report shall include the purchase order number, heat number, material specification number and its revision letter, size, specific annealing treatment used, and quantity from each heat. If forgings are supplied, the part number and size 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, material specification number and its revision letter, 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 testing of 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 material 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 0.500 in. (12.7 mm) and over in diameter or least width of flat surface shall be marked in a row of characters recurring at intervals not greater than 3 ft (9.14 mm) with AMS 4978A, 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 capable of being removed in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the material or its performance and shall be sufficiently stable to withstand normal handling.
- 5.1.1.2 Straight bars and wire less than 0.500 in. (12.7 mm) in diameter or least width of flat surface shall be securely bundled and identified by a metal or plastic tag embossed with the purchase order number, AMS 4978A, 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 metal or plastic tag embossed with the purchase order number, AMS 4978A, 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: The product shall be prepared for shipment in accordance with commercial practice to assure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to requirements of carrier rules and regulations applicable to the mode of transportation.