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AEROSPACE MATERIAL SPECIFICATION

AMS 4920

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Revised

TITANIUM ALLOY FORGINGS
6Al - 4V
Alpha-Beta or Beta Processed, Annealed

UNS R56400

1. SCOPE:

1.1 Form: This specification covers a titanium alloy in the form of forgings and forging stock.

1.2 Application: Primarily for parts that do not require heat treatment but requiring high mechanical properties in the annealed condition and for which processing above the beta transus is permissible. 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 SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

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

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

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

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2.3.1 Federal Standards:

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

2.3.2 Military Specifications:

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

2.3.3 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, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

	min	max	
Aluminum	5.50	6.75	
Vanadium	3.50	4.50	
Iron	--	0.30	
Oxygen	--	0.20	
Carbon	--	0.10	
Nitrogen	--	0.05	(500 ppm)
Hydrogen (3.1.1)	--	0.0125	(125 ppm)
Yttrium (3.1.2)	--	0.005	(50 ppm)
Residual Elements, each (3.1.2)	--	0.10	
Residual Elements, total (3.1.2)	--	0.40	
Titanium	remainder		

3.1.1 Hydrogen content of forgings may be as high as 0.0150 (150 ppm).

3.1.2 Determination not required for routine acceptance.

3.1.3 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 Forgings: Annealed and descaled.

3.2.2 Forging Stock: As ordered by the forging manufacturer.

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3.3 Annealing: Forgings shall be annealed by heating to a temperature within the range 1300° - 1400°F (705° - 760°C), holding at the selected temperature within ±25°F (±15°C) for a time commensurate with section thickness and the heating equipment and procedure used, and cooling at a rate which will produce forgings meeting the requirements of 3.4.1. Annealing shall be performed using equipment and procedural controls in accordance with MIL-H-81200.

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

3.4.1 Forgings:

3.4.1.1 Tensile Properties: Shall be as follows for cross-sectional thicknesses 6.000 in. (150 mm) and under, determined in accordance with ASTM E8 on specimens as in 4.3.1.2 with the rate of strain maintained at 0.003 - 0.007 in./in. per min. (0.003 - 0.007 mm/mm per 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./in. per min. (0.005 mm/mm per min.) through the yield strength and a minimum cross head speed of 0.10 in. (2.5 mm) per min. above the yield strength.

Tensile Strength, min	130,000 psi (895 MPa)
Yield Strength at 0.2% Offset, min	120,000 psi (825 MPa)
Elongation in 4D, min	8%
Reduction of Area, min	15%

3.4.1.1.1 Tensile property requirements for forgings over 6.000 in. (150 mm) in cross-sectional thickness shall be as agreed upon by purchaser and vendor.

3.4.1.1.2 Tensile properties shall be determined in the short transverse direction on forgings from which tensile specimens not less than 2.50 in. (62.5 mm) in length can be obtained.

3.4.1.1.3 Testing in the longitudinal direction is not required on forgings tested in the transverse direction.

3.4.1.2 Surface Contamination: Except as permitted by 3.4.1.2.1, forgings shall be free of any oxygen-rich layer, such as alpha case (See 8.2) or other surface contamination, determined by microscopic examination at not lower than 100X magnification or by other method agreed upon by purchaser and vendor.

3.4.1.2.1 When permitted by purchaser, forgings to be machined all over may have an oxygen-rich layer provided such layer is removable within the machining allowance on the forging.

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3.4.1.3 Microstructure: Shall be that structure resulting from alpha-beta processing or beta processing. 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.

3.5 Quality:

3.5.1 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.

3.5.1.1 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 internal and external imperfections detrimental to usage of the product.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product shall supply all samples for vendor's test 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 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 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) of each heat.

4.2.1.2 Tensile properties (3.4.1.1), surface contamination (3.4.1.2), and microstructure (3.4.1.3) of each lot of forgings.

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4.2.2 Periodic Tests: Tests to determine ability of forging stock (3.4.2) to develop required properties 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 applicable technical requirements of this specification when AMS 2375 is specified are classified as preproduction tests and shall be performed on the first-article shipment of a forging to a purchaser, when a change in material or processing, or both, 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 as follows; a lot shall be all product of the same part number from the same heat, processed at the same time, and annealed in the same heat treat batch.

4.3.1 For Acceptance Tests:

4.3.1.1 Composition: 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: 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 Surface Contamination and Microstructure: At least one sample from each lot.

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 forgings shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and for the hydrogen content and tensile properties of each lot, and stating that the forgings conform to the other technical requirements of this specification. This report shall include the purchase order number, heat number, AMS 4920, specific annealing treatment used, quantity from each heat, part number, and the size and melt source of stock used to make the forgings.

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