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AEROSPACE MATERIAL SPECIFICATION

AMS 4996A

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Submitted for recognition as an American National Standard

BILLETS AND PREFORMS
6AI - 4V
Premium Quality, Powder-Metallurgy Product

This specification has been declared "NONCURRENT" by the Aerospace Materials Division, SAE, as of April 1989. It is recommended that this specification not be specified for new designs.

This cover sheet should be attached to the original AMS 4996 of the subject specification.

Noncurrent refers to those materials which have previously been widely used and which may be required on some existing designs in the future. The Aerospace Materials Division does not recommend these as standard materials for future use in new designs. Each of these "Noncurrent" specifications is available on request.

REAFFIRMED

APR '94

This specification is under the jurisdiction of the AMS Committee "G".

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TITANIUM ALLOY BILLETS AND PREFORMS

6A1 - 4V

Premium Quality, Powder-Metallurgy Product

1. SCOPE:

- 1.1 Form: This specification covers a premium-quality, titanium alloy powder-metallurgy product in the form of billets and preforms for forgings.
- 1.2 Application: Primarily for highly-stressed parts, such as rotating parts in gas turbine engines, requiring high strength in the annealed condition.
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 2249 - Chemical Check Analysis Limits, Titanium and Titanium Alloys
 AMS 2350 - Standards and Test Methods
 AMS 2631 - Ultrasonic Inspection of Titanium Alloys
 AMS 4998 - Titanium Alloy Powder, 6A1- 4V, Premium Quality

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

- ASTM B311 - Density of Cemented Carbides
 ASTM E8 - Tension Testing of Metallic Materials
 ASTM E112 - Estimating the Average Grain Size of Metals
 ASTM E120 - Chemical Analysis of Titanium and Titanium-Base Alloys

2.3 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

2.4 ANSI Publications: Available from American National Standards Institute, 1430 Broadway, New York, NY 10018.

- ANSI B46.1 - Surface Texture

REAFFIRMED
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3. TECHNICAL REQUIREMENTS:

- 3.1 Material: Billets and preforms shall be produced by compaction of AMS 4998 powder by a suitable process to produce a product meeting the requirements of 3.2 through 3.6.
- 3.2 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, except that oxygen and hydrogen shall be determined by a vacuum fusion method:

	min	max
Aluminum	5.50	6.75
Vanadium	3.50	4.50
Oxygen	0.13	0.19
Iron	-	0.30
Carbon	-	0.10
Tin (3.2.1)	-	0.10
Molybdenum (3.2.1)	-	0.10
Copper (3.2.1)	-	0.10
Manganese (3.2.1)	-	0.10
Zirconium	-	0.10
Nitrogen	-	0.04 (400 ppm)
Hydrogen	-	0.0125 (125 ppm)
Yttrium		0.0010 (10 ppm)
Residual Elements, total (3.2.2)	-	0.20
Titanium		remainder

- 3.2.1 Tin plus molybdenum plus copper plus manganese shall not exceed 0.20%.
- 3.2.2 Determination not required for routine acceptance.
- 3.2.3 Check Analysis: Composition variations shall meet the requirements of AMS 2249; no variation over maximum for yttrium will be permitted, unless otherwise agreed upon by purchaser and vendor.
- 3.3 Condition: As ordered by the forging manufacturer.
- 3.4 Heat Treatment: When ordered annealed, billets and preforms, with the compaction container removed, shall be annealed by heating to $1300^{\circ}\text{F} \pm 25$ ($705^{\circ}\text{C} \pm 15$), holding at heat for 2 hr ± 0.5 , and cooling in air.
- 3.5 Properties: The product shall conform to the following requirements:
- 3.5.1 Density: Shall be not less than 0.1562 lb per cu in. (4.326 Mg/m^3), determined in accordance with ASTM B311 or other method agreed upon by purchaser and vendor. Protrusions, test rings, and fill spouts shall not be used for density determinations, unless otherwise approved by purchaser.
- 3.5.2 Thermally-Induced Porosity (TIP): Shall, when specified, not exceed the value agreed upon by purchaser and vendor, determined as follows:
- 3.5.2.1 Determine, as in 3.5.1, the density of a forged and annealed sample, approximately $0.5 \times 0.5 \times 0.5$ in. ($13 \times 13 \times 13$ mm). Heat the sample in vacuum to $2200^{\circ} - 2300^{\circ}\text{F}$ ($1200^{\circ} - 1260^{\circ}\text{C}$), hold at heat for 2 - 4 hr, and cool to below 700°F (370°C) before releasing vacuum. Determine the density of the heated sample and calculate the decrease in density.

3.5.3 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8 on specimens machined from billets or preforms or, when specified, from forged coupons having not less than 30% reduction and, in either case, heat treated as in 3.4:

3.5.3.1 Billet or Preform:

Tensile Strength, min	130 000 psi (896 MPa)
Yield Strength at 0.2% Offset, min	120 000 psi (827 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	5%
Reduction of Area, mm	10%

3.5.3.2 Forged Coupon:

Tensile Strength, min	130 000 psi (896 MPa)
Yield Strength at 0.2% Offset, min	120 000 psi (827 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	10%
Reduction of Area, min	20%

3.5.4 Grain Size: Shall be 3 or finer, unless otherwise specified, determined in accordance with ASTM E112 on a billet or preform annealed as in 3.4 or on a forged coupon similarly annealed.

3.6 Quality:

- 3.6.1 The product, as received by the 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.
- 3.6.2 Surface texture of billets and preforms shall be 125 microinches (3.2 μ m) or smoother, or as agreed upon by purchaser and vendor, determined in accordance with ANSI B46.1.
- 3.6.3 Billets and preforms shall be ultrasonically inspected in accordance with AMS 2631. Methods of test and standards of acceptance shall be as agreed upon by purchaser and vendor.

4. QUALITY ASSURANCE PROVISIONS:

- 4.1 Responsibility for Inspection: The vendor of the product 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 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 composition (3.2), density (3.5.1), grain size (3.5.4), surface texture (3.6.2), and ultrasonic inspection (3.6.3) requirements and, when specified, thermally-induced porosity (TIP) (3.5.2) and tensile property (3.5.3) requirements are classified as acceptance tests.
- 4.2.2 Periodic Tests: Tests to determine conformance to tensile property requirements of billets or preforms (3.5.3.1) or of forged coupons (3.5.3.2) are classified as periodic tests, except when purchaser specifies that such tests are acceptance tests.
- 4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests.