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INTERNATIONAL
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4996B

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Superseding AMS 4996A

Titanium Alloy Billets and Preforms
6Al - 4V
Premium Quality, Powder-Metallurgy Product

CANCELLATION NOTICE

This specification has been “CANCELLED” by the Aerospace Materials Division, SAE, as of July 2002. By this action, this document will remain listed in the Numerical Section of the Index of Aerospace Material Specifications.

Cancelled specifications are available from SAE.

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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 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 2631 Ultrasonic Inspection of Titanium Alloys
AMS 4998 Titanium Alloy Powder, 6Al - 4V, Premium Quality

2.2 ASTM Publications:

Available from ASTM, 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 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

2.4 ANSI Publications:

Available from American National Standards Institute, 1430 Broadway, New York, NY 10018.

ANSI B46.1 Surface Texture

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°F ± 25 (705°C ± 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 x 0.5 x 0.5 in. (13 x 13 x 13 mm). Heat the sample in vacuum to 2200° - 2300°F (1200° - 1260°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, min	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 µm) 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.

4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement (See 4.4.1).

4.3 Sampling:

Shall be as agreed upon by purchaser and vendor except as specified in 4.3.1; a lot shall be all product produced from one powder lot in one production run using the same equipment and processing parameters and presented for vendor's inspection at one time.

4.3.1 Each billet or preform shall be ultrasonically inspected, unless otherwise specified.

4.4 Approval:

4.4.1 Preproduction compaction of powder into billets or preforms shall be approved by purchaser before billets or preforms for production use are supplied, unless such approval be waived. Approval of preproduction billets and preforms shall in no way relieve the billet or preform vendor of responsibility for continued performance to all purchase order requirements.

4.4.2 The vendor shall establish for each size of billet and for preforms of each configuration the control factors of processing which will yield products meeting the requirements of this specification. These shall constitute the approved manufacturing procedures for each product and shall be used for subsequent production of the product. If necessary to make any change in control factors of processing, vendor shall submit for reapproval a statement of the proposed changes in material and processing and, when requested, sample product. Production product made by the revised procedure shall not be shipped prior to receipt of reapproval.

4.4.2.1 Control factors for producing the product include, but are not limited to, the following:

Source of metallurgical powder
Type of compaction equipment or process
Processing sequence or delineated number of operations, including thermal operations, that could result in different cross-sectional structure, grain flow, working of the metal, decreased density, or decreased mechanical properties
Protective atmosphere
Cleaning operations, (e.g., chemical descaling, mechanical cleaning, or container removal)
Inspection and testing

4.4.2.1.1 Control factors considered proprietary by the vendor may be assigned a code designation. Each variation in such factors shall be assigned a modified code designation. The vendor shall maintain complete records of all proprietary processes and factors.