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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4995B

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Submitted for recognition as an American National Standard

Superseding AMS 4995A

Billets and Preforms
5A1 - 2Sn - 2Zr - 4Cr - 4Mo - 0.100
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.

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 4997 - Titanium Alloy Powder, 5Al - 2Sn - 2Zr - 4Cr - 4Mo - 0.10O, Premium Quality

QUESTIONS REGARDING THIS DOCUMENT: (412) 772-7154 FAX: (412) 776-0243
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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

3. TECHNICAL REQUIREMENTS:

3.1 Material:

Billets and preforms shall be produced by compaction of AMS 4997 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 analytical methods approved by purchaser, except that oxygen and hydrogen shall be determined by a vacuum fusion method:

	min	max
Aluminum	4.50	5.50
Zirconium	1.50	2.50
Tin	1.50	2.50
Molybdenum	3.50	4.50
Chromium	3.50	4.50
Oxygen	0.08	0.13
Iron	--	0.30
Copper	--	0.10
Manganese	--	0.10
Carbon	--	0.05
Nitrogen	--	0.04 (400 ppm)
Hydrogen	--	0.0125 (125 ppm)
Yttrium	--	0.0050 (50 ppm)
Residual Elements, each (3.2.1)	--	0.10
Residual Elements, total (3.2.1)	--	0.30
Titanium	remainder	

3.2.1 Determination not required for routine acceptance.

3.2.2 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 specified, the product shall be heat treated as follows:

3.4.1 Solution Heat Treatment: Heat to 1475°F ± 15 (802°C ± 8), hold at heat for not less than 4 hr, and quench in water to room temperature. The water quench shall begin within 45 sec from the time the product is removed from the furnace.

3.4.2 Aging: Heat to a temperature within the range 1100° - 1250°F (593° - 677°C), hold at the selected temperature within ±15°F (±8°C) for not less than 8 hr, and air cool to room temperature. The product shall be charged directly into the furnace at the selected temperature and, in no case, shall be held at a temperature lower than the selected temperature.

3.5 Properties:

The product shall conform to the following requirements:

3.5.1 Density: Shall be not less than 0.163 lb per cu in. (4.51 Mg/m^3), determined in accordance with ASTM B311 or other method agreed upon by purchaser and vendor. Protrusions 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 an as-forged sample, approximately 0.5 x 0.5 x 0.5 in. (13 x 13 x 13 mm). Heat the sample in a vacuum furnace, at a pressure not higher than 100 microns of mercury, 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 forged coupons having not less than 30% reduction, forged at a temperature of 50° - 100°F (28° - 56°C) above the 100% beta transus, and heat treated in accordance with 3.4.

Tensile Strength,	min	163 000 psi (1124 MPa)
	max	183 000 psi (1262 MPa)
Yield Strength at 0.2% Offset,	min	153 000 psi (1055 MPa)
	max	173 000 psi (1193 MPa)
Elongation in 4D, min		5%
Reduction of Area, min		10%

3.5.4 Grain Size: Shall be 3 or finer, determined in accordance with ASTM E112 on a billet or preform or on a forged coupon heat treated in accordance with 3.4.

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 microin. (3.2 µm) or smoother, unless other surface texture is specified, 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 for 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 forged coupons (3.5.3) 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 parameters for 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 parameters for control factors of processing, vendor shall submit for reapproval a statement of the proposed changes in material and processing and, when requested, sample billets or preforms. Production billets or preforms 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, and container removal)
Inspection and testing

4.4.2.1.1 Any of the above control factors of processing for which parameters are considered proprietary by the vendor may be assigned a code designation. Each variation in parameters of such factors shall be assigned a modified code designation. The vendor shall maintain complete records of all proprietary processes and parameters.

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 to determine conformance to the acceptance test requirements and stating that the product conforms to the other technical requirements of this specification. This report shall include the purchase order number, material specification number, lot number, size of billet or part number of preform, quantity, and the source and lot number of powder used to make the billets or preforms.

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, 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.

4.5.3 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.