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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 4993A

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Superseding AMS 4993

TITANIUM ALLOY COMPACTS FOR B-NUTS
6Al - 4V
Blended Powder Product

UNS R56400

THIS REVISION CONTAINS ONLY EDITORIAL CHANGES.

1. SCOPE:

1.1 Form: This specification covers a titanium alloy in the form of compacts produced by pressing and sintering a blend of elemental titanium powder and aluminum-vanadium alloy powder and requiring minimum machining to achieve B-nut configuration.

1.2 Application: Primarily for light weight nuts used for connecting fluid lines to fittings and to equipment.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications 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 2350 - Standards and Test Methods
AMS 2635 - Radiographic Inspection
AMS 2645 - Fluorescent Penetrant Inspection

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 E120 - Chemical Analysis of Titanium and Titanium Alloys
ASTM E365 - Chemical Analysis of Ferrovanadium and Vanadium Alloying Additives

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

2.3.1 Military Specifications:

MIL-I-25135 - Inspection Material, Penetrant

2.3.2 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

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

ANSI B46.1 - Surface Texture

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall be that resulting from blending elemental titanium powder as in 3.1.2 and aluminum-vanadium alloy powder as in 3.1.3 and shall conform to the following percentages by weight, after pressing and sintering, determined by wet chemical methods in accordance with ASTM E120 or by spectrochemical or other analytical methods approved by purchaser:

	min	max
Aluminum (3.1.1)	5.50	6.75
Vanadium (3.1.1)	3.50	4.50
Iron	--	0.30
Oxygen	--	0.30
Sodium	--	0.15
Chlorine	--	0.15
Carbon	--	0.10
Silicon	--	0.05
Nitrogen	--	0.05 (500 ppm)
Hydrogen	--	0.010 (100 ppm)
Residual Elements, each	--	0.10
Residual Elements, total	--	0.40
Titanium	remainder	

3.1.1 The difference in aluminum concentration and vanadium concentration among three different locations in a lot of blended powder shall be not greater than 0.4%.

3.1.2 Titanium Powder: Shall conform to the following percentages by weight, determined as in 3.1:

	min	max
Iron	--	0.20
Oxygen	--	0.20
Sodium	--	0.20
Chlorine	--	0.20
Carbon	--	0.06
Silicon	--	0.05
Nitrogen	--	0.03 (300 ppm)
Hydrogen	--	0.015 (150 ppm)
Residual Elements, each	--	0.10
Residual Elements, total	--	0.40
Titanium	remainder	

3.1.3 Alloy Powder: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E365, by spectrochemical methods as in 3.1, or by other analytical methods approved by purchaser:

	min	max
Aluminum	56	64
Vanadium	38	42
Other Elements, by difference, total	--	3.0

3.2 Condition: As sintered (2100°F (1150°C) min). After sintering, compacts shall not be exposed to temperatures higher than 600°F (315°C).

3.3 Powder Lot Control: The titanium 6Al - 4V powder shall be blended in lots by a suitable process in a non-contaminating facility. A powder lot shall be all powder produced as a single mixture in one production blend of titanium powder and aluminum-vanadium alloy powder.

3.3.1 Whenever a production run of sintered compacts does not require an entire lot of blended powder, the powder used shall be identified as a sublot. The identity of sublots in a basic powder lot shall be maintained.

3.3.2 Unused portions of qualified powder lots not of sufficient size for a production run of sintered compacts may be added to, and blended with, titanium and aluminum-vanadium alloy powders in the production of a new powder lot.

3.4 Properties: Sintered compacts shall conform to the following requirements:

3.4.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8 on specimens made from the same basic powder lot and sintered with the parts represented:

Tensile Strength, min	130,000 psi (895 MPa)
Yield Strength at 0.2% Offset, min	120,000 psi (825 MPa)
Elongation in 4D, min	10%
Reduction in Area, min	10%

3.4.2 Proof Test: Sintered compacts shall pass a proof or failure test conducted by a procedure developed by the manufacturer and for which a correlation with the tensile properties of 3.4.1 has been established for each size of sintered compact.

3.4.3 Density: Shall be not lower than 0.157 lb per cu in. (4345 g/m^3), determined in accordance with ASTM B311 or other method agreed upon by purchaser and vendor.

3.4.4 Microstructure: Shall be homogeneous and free from inclusions, alloy segregation, laminations, and alpha case. Compacts shall also be free from interconnecting voids, porosity in excess of 0.010 in. (0.25 mm) in maximum dimension, and linear porosity in excess of 0.006 in. (0.15 mm) in maximum dimension.

3.4.4.1 Microstructure and porosity shall be determined by metallographic examination at 100X to 500X magnification after suitably polishing, or polishing and etching, as appropriate. Adjacent pores shall be treated as a single pore if they are closer to each other than the largest pore maximum dimension. Porosity whose length is more than three times its width shall be considered linear porosity.

3.5 Quality:

3.5.1 Sintered compacts shall be free from cracks, porosity, and other surface imperfections, determined by fluorescent penetrant inspection in accordance with AMS 2645 using MIL-H-25135, Group IV, Type I, penetrant.

3.5.2 Sintered compacts shall be free from low- and high-density inclusions and inhomogeneity, determined by radiographic inspection in accordance with AMS 2635.

3.5.3 Sintered compacts, as received by purchaser, shall be uniform in quality and condition, clean, and free of defects such as cracks, seams, grooves, laminations, pits, inclusions, and surface oxidation and from other imperfections detrimental to their usage. Surface texture of sintered compacts shall not exceed 125 microin. (3 μm), determined in accordance with ANSI B46.1.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of sintered compacts shall supply all samples for vendor's tests 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 sintered compacts conform 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 as specified in 4.2.1.1 and 4.2.1.2:

4.2.1.1 Powder Lot: On each powder lot prior to use for production of sintered compacts:

4.2.1.1.1 Composition (3.1).

4.2.1.1.2 Blend uniformity check analysis on aluminum and vanadium contents (3.1.1).

4.2.1.1.3 Tensile properties (3.4.1).

4.2.1.1.4 Density (3.4.3).

4.2.1.1.5 Microstructure (3.4.4).

4.2.1.2 Part Lot: On each lot of sintered compacts from each sinter run:

4.2.1.2.1 Composition (3.1).

4.2.1.2.2 Tensile properties (3.4.1).

4.2.1.2.3 Proof test (3.4.2), density (3.4.3), and quality (3.5).

4.2.1.2.4 Microstructure (3.4.4).

4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the first-article shipment of sintered compacts to a purchaser, when a change in material, processing, or both requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.2.1 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, contracting officer, or request for procurement.

4.3 Sampling: Shall be in accordance with the following; a powder lot shall be all powder blended from the same batches of titanium and aluminum-vanadium powders in a single blending operation; a lot of sintered compacts shall be all sintered compacts of the same configuration produced from one powder lot in one production run using the same equipment and processing procedures in one sinter furnace load and presented for vendor's inspection at one time:

4.3.1 For Acceptance Tests:

4.3.1.1 Powder Lot:

4.3.1.1.1 One pressed and sintered test specimen for composition.

4.3.1.1.2 Three pressed and sintered specimens taken from three different locations in the blend for aluminum and vanadium uniformity checks.

4.3.1.1.3 Twelve pressed and sintered test specimens for tensile properties and density.

4.3.1.1.4 Two pressed and sintered test specimens for microstructure.

4.3.1.2 Part Lot:

4.3.1.2.1 One sintered compact for composition.

4.3.1.2.2 One pressed and sintered test specimen for tensile properties.

4.3.1.2.3 Sintered compacts as specified in Table I, selected at random from the lot for proof tests, density, and quality.

4.3.1.2.4 One sintered compact for microstructure.

TABLE I

Tests to Determine Conformance to:

Number of Inspection Units In the Lot	Proof Test (3.4.2) and Density (3.4.3)	Quality 3.5
Up to 100	2	4
100 to 299	3	6
300 to 599	4	8
600 to 999	5	10
1,000 to 1,499	6	12
1,500 to 1,999	7	14
2,000 to 2,999	8	16
3,000 to 3,999	9	18
4,000 to 5,999	10	20
6,000 to 10,000	12	24
Over 10,000	15	30

4.3.2 For Preproduction Tests: As agreed upon by purchaser and vendor.

4.4 Approval:

4.4.1 Sample sintered compacts and the pressing and sintering procedures, powder storage and handling procedures, and sintering furnace leak rate shall be approved by purchaser before sintered compacts for production use are supplied, unless such approval be waived by purchaser. In addition, the proof or failure test procedure and values and the correlation with tensile property requirements shall be approved by the B-nut manufacturer and the cognizant engineering organization.

4.4.2 The producer shall establish for each size of sintered compacts parameters for the process control factors which will produce acceptable sintered blanks. These shall constitute the approved processing procedures and shall be used for producing production compacts. If necessary to make any change in parameters for the process control factors, the producer shall submit for reapproval a statement of the proposed changes in material, processing, or both and when requested, sample sintered compacts and tensile specimens. Production sintered compacts made by the revised procedure shall not be shipped prior to receipt of reapproval.

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

Powder storage, identification, and handling procedures
Type of sintering furnace
Size of furnace charge
Furnace atmosphere and its leak rate
Furnace temperature
Material on which the pressed compacts rest during sintering
Cleaning operations
Methods of inspection

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

4.5 Reports:

4.5.1 The vendor of sintered blanks shall furnish with each shipment a report showing the results of tests to determine conformance to the quality assurance provisions and stating that the sintered blanks conform to the other technical requirements of this specification. This report shall include the purchase order number, powder lot number, part lot number, AMS 4993A, size or part number, and quantity.