AEROSPACE MATERIAL SPECIFICATION

AMS4998™	REV. F

Issued 1977-03
Reaffirmed 2017-06
Revised 2022-05

Superseding AMS4998E

Titanium Alloy Powder
6Al - 4V
(Composition similar to UNS R56400)

RATIONALE

AMS4998F results from a Five-Year Review and update of the specification with changes to prohibit unauthorized exceptions (3.4.3, 3.6, 4.5.1, 5.1.6, 8.4), update applicable documents (Section 2, 8.2), ordering information (8.6), and powder production terminology from feed stock to input stock consistent with AMS additive manufacturing standards (3.2, 4.5), and allow use of immediate prior specification revision (8.5).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of prealloyed powder.

1.2 Application

This powder has been used typically for compaction into net or near net shapes and into forging stock in the form of billets or preforms, but usage is not limited to such applications.

1.3 Safety - Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS4998F/

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys

AS7766 Terms Used in Aerospace Metals Specifications

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B214 Sieve Analysis of Metal Powders

ASTM B215 Sampling Metal Powders

ASTM B243 Standard Terminology of Powder Metallurgy

ASTM B311 Density of Powder Metallurgy (PM) Materials Containing Less than Two Percent Porosity

ASTM B527 Tap Density of Metal Powders and Compounds

ASTM E539 Analysis of Titanium Alloys by Wavelength Dispersive X-Ray Fluorescence Spectrometry

ASTM E1409 Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion

ASTM E1447 Determination of Hydrogen in Titanium and Titanium Alloys by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

ASTM E1941 Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis

ASTM E2371 Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission Plasma Spectrometry (Performance-Based Test Methodology)

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1; carbon shall be determined in accordance with ASTM E1941, hydrogen in accordance with ASTM E1447, oxygen and nitrogen in accordance with ASTM E1409, and other elements in accordance with ASTM E539 and ASTM E2371. Other analytical methods may be used if acceptable to the purchaser.

Table 1 - Composition

Element	Min	Max	
Aluminum	5.50	6.75	
Vanadium	3.50	4.50	
Oxygen	0.13	0.18	
Iron	--	0.30	
Carbon	--	0.10	
Tin (3.1.1)	--	0.10	
Molybdenum (3.1.1)	--	0.10	
Copper (3.1.1)	--	0.10	
Manganese (3.1.1)	--	0.10	
Zirconium	--	0.10	
Nitrogen	--	0.04	(400 ppm)
Hydrogen (3.1.2)	--	0.012	(120 ppm)
Other Elements, total (3.1.3)	--	0.20	
Titanium	remainder		

3.1.1 Tin plus molybdenum plus copper plus manganese shall not exceed 0.20 weight percent.

3.1.2 Sample size may be as large as 0.35 g.

3.1.3 Determination not required for routine acceptance.

3.1.4 Check Analysis

Composition variations shall meet the applicable requirements of AMS2249.

3.2 Powder Production

Powder shall be produced in lots by a suitable process in an appropriate noncontaminating atmosphere. A lot shall be all powder produced from common input material (an ingot, billet, or cast electrode from a common ingot) in one production run of the equipment. When approved by purchaser, a lot may be the powder produced from common input material in a series of consecutive runs in the same equipment under essentially the same fixed parameters; the powder from all such runs shall be thoroughly blended. The total weight of powder blended in one lot shall not exceed 10000 pounds (4536 kg).

3.2.1 For Powder Production Processes That Involve the Melting of the Input Stock

Alloy shall be multiple melted. The first melt for the powder process input stock shall be made by consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The subsequent melt or melts for the powder process input stock shall be made using vacuum arc remelting (VAR) practice. Alloy additions are not permitted in the final VAR melt.

3.2.2 For Powder Production Processes That Do Not Melt the Input Stock

Alloy shall be melted a minimum of three times. The first melt for the powder process input stock shall be made by consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The subsequent melts for the powder process input stock shall be made using vacuum arc remelting (VAR) practice. Alloy additions are not permitted in the final VAR melt.

3.2.3 The atmosphere for nonconsumable electrode melting shall for the powder process input stock be vacuum or shall be argon and/or helium at an absolute pressure not higher than 1000 mm of mercury.

3.2.4 The electrode tip for nonconsumable electrode melting for the powder process input stock shall be water-cooled copper.

3.3 Condition

As manufactured.

3.4 Properties

The powder shall conform to the following requirements:

3.4.1 Particle Size

The particles shall pass through a No. 35 (500 µm) sieve, with not more than 5% by weight passing through a No. 325 (45 µm) sieve, determined in accordance with ASTM B214 or other method acceptable to purchaser.

3.4.2 Powder Tap Density

When specified, shall be not less than 60% of the density value obtained in 3.4.3, determined in accordance with ASTM B527 or other procedure acceptable to purchaser (see 8.6).

3.4.3 Powder Compaction and Evaluation

A sample, weighing not less than 0.75 pound (340 g), from each powder lot shall be hot-compacted using a method that will not contaminate the powder particles during compaction. Each compacted sample shall have a density, determined in accordance with ASTM B311, not less than 0.1594 lb/in^3 (4.412 mg/m^3) and shall be divided into panels or discs totaling not less than 18 square inches (116 cm^2) in area with thickness of 0.200 inch +0.015 inch, -0.025 inch (5.08 mm, +0.38 mm, -0.64 mm). Panels shall be free of any deleterious high- or low-density inclusions determined by radiographic method acceptable to purchaser. Exceptions shall be provided by standards agreed upon by purchaser and producer and reported as in 4.5.1 (see 8.6).

3.5 Quality

The powder, as received by purchaser, shall be uniform in color and quality, dry, free from agglomerated masses, and free from foreign materials and from imperfections detrimental to its performance during compaction or in resultant preforms or forgings.

3.6 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.5.1.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of powder shall supply all samples for producer's tests and shall be responsible for the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the powder conforms to specified requirements.

4.2 Classification of Tests

All technical requirements are acceptance tests and preproduction tests and shall be performed prior to or on the initial shipment of powder to a purchaser, on each lot, when a change in ingredients and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.3 Sampling and Testing

Shall be in accordance with ASTM B215; sufficient powder shall be taken from each lot to perform all required tests in duplicate.

4.4 Approval

4.4.1 The processes and control procedures, a preproduction sample, or both, whichever is specified, shall be approved by the cognizant engineering organization before powder for production parts is supplied.

4.4.2 The supplier shall make no significant changes to ingredients, processes, or controls from those that the approval was based, unless the change is approved by the cognizant engineering organization. A significant change is one that, in the judgment of the cognizant engineering organization, could affect the properties or performance of the powder.

4.5 Reports

The producer shall provide a copy of the original material manufacturer’s (producer’s) report (material certification) including: producer name and country where the material was melted (i.e., final melt in the case of metal processed by multiple melting operations). The report shall document the results of tests for composition of each heat and the oxygen and hydrogen content of each lot and stating that the powder conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS4998F, producer's product designation, input stock material, and quantity.