

Titanium Alloy Powder  
6Al - 4V

(Composition similar to UNS R56400)

## RATIONALE

AMS4998E results from a Five Year Review and update of this specification.

### 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.

#### 2.1 SAE Publications

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

AMS2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2012 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

**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](mailto:CustomerService@sae.org)  
**SAE WEB ADDRESS:** <http://www.sae.org>

**SAE values your input. To provide feedback  
on this Technical Report, please visit  
<http://www.sae.org/technical/standards/AMS4998E>**

## 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](http://www.astm.org).

ASTM B 214 Sieve Analysis of Granular Metal Powders

ASTM B 215 Sampling Metal Powders

ASTM B 311 Density Determination for Powder Metallurgy (P/M) Materials Containing Less than Two Percent Porosity

ASTM B 527 Determination of Tap Density of Metallic Powders and Compounds

ASTM E 539 X-Ray Emission Spectrometric Analysis of 6Al-4V Titanium Alloy

ASTM E 1409 Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique

ASTM E 1447 Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

ASTM E 1941 Determination of Carbon in Refractory and Reactive Metals and Their Alloys

ASTM E 2371 Analysis of Titanium and Titanium Alloys by Atomic Emission Plasma Spectrometry

## 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 E 1941, hydrogen in accordance with ASTM E 1447, oxygen and nitrogen in accordance with ASTM E 1409, and other elements in accordance with ASTM E 539 and ASTM E 2371. 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%.

3.1.2 Sample size may be as large as 0.35 gram.

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 feed 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 feed 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 10 000 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 shall be made by consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The subsequent melt or melts shall be made under vacuum 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 shall be made by consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The subsequent melts shall be made under vacuum 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 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 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  $\mu\text{m}$ ) sieve, with not more than 5% by weight passing through a No. 325 (45  $\mu\text{m}$ ) sieve, determined in accordance with ASTM B 214 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 B 527 or other procedure acceptable to purchaser.

### 3.4.3 Powder Compaction and Evaluation

A sample, weighing not less than 0.75 pound (340 grams), 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 B 311, not less than 0.1594 pounds per cubic inch ( $4.412 \text{ Mg/m}^3$ ) and shall be divided into panels or discs totaling not less than 18 square inches ( $116 \text{ cm}^2$ ) in area with thickness of 0.200 inch + 0.015, - 0.025 (5.08 mm, + 0.38, - 0.64). 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 vendor.

### 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.

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 Responsibility for Inspection

The vendor of powder shall supply all samples for vendor'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 B 215; 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 vendor 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, AMS4998E, vendor's product designation, feed material, and quantity.