



AEROSPACE MATERIAL SPECIFICATION

AMS4994™**REV. B**

Issued 1992-07
Reaffirmed 2018-11
Revised 2023-09

Superseding AMS4994A

Titanium Alloy Powdered Metal Products

6Al - 4V

Hot Isostatically Pressed, Annealed

(Composition similar to UNS R56400)

RATIONALE

AMS4994B results from a Five-Year Review and update of the specification with changes to prohibit unauthorized exceptions (see 3.6.2.1, 3.8, 4.5.3, and 8.3), relocate Definitions (see 2.4), update Applicable Documents (see Section 2, 3.2, and 3.6.8), Composition (see 3.2), Ordering Information (see 8.5), and allow use of immediate prior specification revision (see 8.4).

1. SCOPE

1.1 Form

This specification covers powdered metal products consolidated by hot isostatic pressing (HIP) of titanium alloy powder compacts.

1.2 Application

These products have been used typically for complex-shaped powdered metal products made to near net shape dimensions with properties similar to wrought products, but usage is not limited to such applications.

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 +1 724-776-4970 (outside USA), www.sae.org.

AMS2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys

AMS2750 Pyrometry

AMS4998 Titanium Alloy Powder, 6Al - 4V

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SAE WEB ADDRESS:

Full document details: SAE AMS4994B

For more information on this standard, visit
<https://www.sae.org/standards/content/AMS4994B>

Documents

Document Sharing Hub

AMS-STD-2154 Inspection, Ultrasonic, Wrought Metals, Process for

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

ASTM E8/E8M Tension Testing of Metallic Materials

ASTM E399 Linear-Elastic Plane-Strain Fracture Toughness of Metallic Materials

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 E1417 Liquid Penetrant Testing

ASTM E1447 Determination of Hydrogen in Reactive Metals and Reactive Metal Alloys by Inert Gas Fusion with Detection by Thermal Conductivity or Infrared Spectrometry

ASTM E1742 Radiographic Examination

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 Spectrometry (Performance-Based Test Methodology)

ASTM E2994 Analysis of Titanium and Titanium Alloys by Spark Atomic Emission Spectrometry and Glow Discharge Atomic Emission Spectrometry (Performance-Based Method)

2.3 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

ASME B46.1 Surface Texture (Roughness, Waviness, Lay)

2.4 Definitions

Terms used in AMS are defined in AS7766 and as follows:

2.4.1 Blend

For powder, powder from different lots that have been thoroughly blended by means such as V-cone blenders or other demonstrated means that ensure adequate particle size distributions.

2.4.2 Terminology relating to titanium microstructure is presented in AS1814.

3. TECHNICAL REQUIREMENTS

3.1 Powder

The powder used to make products shall conform to AMS4998 and shall be derived from prealloyed stock. Comminuted hydrided stock is not permitted.

3.2 Composition

Parts 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, ASTM E2371, or ASTM E2994. Other analytical methods may be used if acceptable to the purchaser (see 8.5).

Table 1 - Composition

Elements	Min	Max
Aluminum	5.50	6.75
Vanadium	3.50	4.50
Oxygen	0.13	0.20
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	--	0.05
Hydrogen	--	0.0125 (125 ppm)
Yttrium (3.2.2)	--	0.0050 (50 ppm)
Other Elements, each (3.2.2)	--	0.10
Other Elements, total (3.2.2)	--	0.30
Titanium	remainder	

3.2.1 The combined contents of tin, molybdenum, copper, and 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 applicable requirements of AMS2249.

3.3 Condition

Annealed.

3.4 Heat Treatment

Powdered metal products shall be annealed by heating under vacuum or in argon and/or helium to a temperature within the range 1275 to 1600 °F (691 to 871 °C), holding at the selected temperature within ± 25 °F (± 14 °C) for 4 hours $\pm$ 0.25 hour, and furnace cooling under vacuum or in argon and/or helium. Pyrometry shall be in accordance with AMS2750.

3.5 Consolidation Process

3.5.1 Powder shall be compacted in a single gas-hot-isostatic-pressing (HIP) cycle. Pressing parameters of time, temperature, and pressure shall be selected to provide parts that conform to the requirements of 3.6.

3.5.2 All consolidation shall be performed below 1750 °F (954 °C).

3.5.3 When metal containers are used to hold the powder during consolidation, all evidence of the metal container shall be removed mechanically or chemically before annealing.