



Designation: F2924 – 14 (Reapproved 2021)

Standard Specification for Additive Manufacturing Titanium-6 Aluminum-4 Vanadium with Powder Bed Fusion¹

This standard is issued under the fixed designation F2924; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers additively manufactured titanium-6aluminum-4vanadium (Ti-6Al-4V) components using full-melt powder bed fusion such as electron beam melting and laser melting. The components produced by these processes are used typically in applications that require mechanical properties similar to machined forgings and wrought products. Components manufactured to this specification are often, but not necessarily, post processed via machining, grinding, electrical discharge machining (EDM), polishing, and so forth to achieve desired surface finish and critical dimensions.

1.2 This specification is intended for the use of purchasers or producers, or both, of additively manufactured Ti-6Al-4V components for defining the requirements and ensuring component properties.

1.3 Users are advised to use this specification as a basis for obtaining components that will meet the minimum acceptance requirements established and revised by consensus of the members of the committee.

1.4 User requirements considered more stringent may be met by the addition to the purchase order of one or more Supplementary Requirements, which may include, but are not limited to, those listed in S1-S16.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standard-*

ization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:²

- B213** Test Methods for Flow Rate of Metal Powders Using the Hall Flowmeter Funnel
- B214** Test Method for Sieve Analysis of Metal Powders
- B243** Terminology of Powder Metallurgy
- B311** Test Method for Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity
- B600** Guide for Descaling and Cleaning Titanium and Titanium Alloy Surfaces
- B769** Test Method for Shear Testing of Aluminum Alloys
- B964** Test Methods for Flow Rate of Metal Powders Using the Carney Funnel
- D3951** Practice for Commercial Packaging
- E3** Guide for Preparation of Metallographic Specimens
- E8/E8M** Test Methods for Tension Testing of Metallic Materials
- E9** Test Methods of Compression Testing of Metallic Materials at Room Temperature
- E10** Test Method for Brinell Hardness of Metallic Materials
- E11** Specification for Woven Wire Test Sieve Cloth and Test Sieves
- E18** Test Methods for Rockwell Hardness of Metallic Materials
- E21** Test Methods for Elevated Temperature Tension Tests of Metallic Materials
- E23** Test Methods for Notched Bar Impact Testing of Metallic Materials
- E29** Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E238** Test Method for Pin-Type Bearing Test of Metallic Materials

¹ This specification is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.05 on Materials and Processes.

Current edition approved Oct. 1, 2021. Published October 2021. Originally approved in 2012. Last previous edition approved in 2014 as F2924-14. DOI: 10.1520/F2924-14R21.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

E384 Test Method for Microindentation Hardness of Materials

E399 Test Method for Linear-Elastic Plane-Strain Fracture Toughness of Metallic Materials

E407 Practice for Microetching Metals and Alloys

E466 Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials

E539 Test Method for Analysis of Titanium Alloys by Wavelength Dispersive X-Ray Fluorescence Spectrometry

E606 Test Method for Strain-Controlled Fatigue Testing

E647 Test Method for Measurement of Fatigue Crack Growth Rates

E1409 Test Method for Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion

E1417 Practice for Liquid Penetrant Testing

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

E1450 Test Method for Tension Testing of Structural Alloys in Liquid Helium

E1820 Test Method for Measurement of Fracture Toughness

E1941 Test Method for Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis

E2368 Practice for Strain Controlled Thermomechanical Fatigue Testing

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

F629 Practice for Radiography of Cast Metallic Surgical Implants

F1472 Specification for Wrought Titanium-6Aluminum-4Vanadium Alloy for Surgical Implant Applications (UNS R56400)

F2792 Terminology for Additive Manufacturing Technologies (Withdrawn 2015)³

2.2 *ISO/ASTM Standards*:²

52915 Specification for Additive Manufacturing File Format (AMF) Version 1.1

52921 Terminology for Additive Manufacturing—Coordinate Systems and Test Methodologies

2.3 *ASQ Standard*:⁴

ASQ C1 Specifications of General Requirements for a Quality Program

2.4 *ISO Standards*:⁵

ISO 148-1 Metallic materials—Charpy pendulum impact test—Part 1: Test method

ISO 1099 Metallic materials—Fatigue testing—Axial force-controlled method

ISO 4545 Metallic materials—Knoop hardness test—Part 2: Verification and calibration of testing machines

ISO 5832-3 Implants for Surgery—Metallic Materials—Part 3: Wrought Titanium 6-Aluminum 4-Vanadium Alloy Third Edition

ISO 6506-1 Metallic materials—Brinell hardness test—Part 1: Test method

ISO 6507-1 Metallic materials—Vickers hardness test—Part 1: Test method

ISO 6508 Metallic materials—Rockwell hardness test—Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)

ISO 6892-1 Metallic Materials—Tensile Testing at Ambient Temperature

ISO 6892-2 Metallic Materials—Tensile Testing—Part 2: Method of test at elevated temperature

ISO 9001 Quality Management System – Requirements

ISO 9044 Industrial Woven Wire Cloth – Technical Requirements and Testing

ISO 12108 Metallic materials—Fatigue testing—Fatigue crack growth method

ISO 12111 Metallic materials—Fatigue testing—Strain-controlled thermomechanical fatigue testing method

ISO 12135 Metallic materials—Unified method of test for the determination of quasistatic fracture toughness

ISO 12737 Metallic materials—Determination of plane-strain fracture toughness (withdrawn)

ISO 13485 Medical devices – Quality management systems – Requirements for regulatory Purposes

ISO 19819 Metallic materials—Tensile testing in liquid helium

2.5 *SAE Standards*:⁶

AMS2249 Chemical Check Analysis Limits Titanium and Titanium Alloys

AMS2801 Heat Treatment of Titanium Alloy Parts

AMSH81200 Heat Treatment of Titanium and Titanium Alloys

AS1814 Terminology for Titanium Microstructures

AS9100 Quality Systems – Aerospace – Model for Quality Assurance in Design, Development, Production, Installation and Servicing

2.6 *ASME Standards*:⁷

ASME B46.1 Surface Texture

2.7 *National Institute of Standards and Technology*:⁸

IR 7847 (March 2012) CODEN: NTN0EF

3. Terminology

3.1 Definitions:

3.1.1 *as built, n, adj*—refers to the state of components made by an additive process before any post processing except where removal from a build platform is necessary or powder removal or support removal is required.

3.1.2 *build cycle, n*—single cycle in which one or more components are built up in layers in the process chamber of the machine.

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from American Society for Quality (ASQ), 600 N. Plankinton Ave., Milwaukee, WI 53203, <http://www.asq.org>.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁶ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

⁷ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁸ Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.