



Designation: F3049 – 14 (Reapproved 2021)

Standard Guide for Characterizing Properties of Metal Powders Used for Additive Manufacturing Processes¹

This standard is issued under the fixed designation F3049; 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 guide introduces the reader to techniques for metal powder characterization that may be useful for powder-based additive manufacturing processes including binder jetting, directed energy deposition, and powder bed fusion. It refers the reader to other, existing standards that may be applicable for the characterization of virgin and used metal powders processed in additive manufacturing systems.²

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

1.3 *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.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization 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:³

B212 Test Method for Apparent Density of Free-Flowing Metal Powders Using the Hall Flowmeter Funnel

B213 Test Methods for Flow Rate of Metal Powders Using the Hall Flowmeter Funnel

B214 Test Method for Sieve Analysis of Metal Powders

B215 Practices for Sampling Metal Powders

B243 Terminology of Powder Metallurgy

B329 Test Method for Apparent Density of Metal Powders and Compounds Using the Scott Volumeter

B417 Test Method for Apparent Density of Non-Free-Flowing Metal Powders Using the Carney Funnel

B527 Test Method for Tap Density of Metal Powders and Compounds

B703 Test Method for Apparent Density of Metal Powders and Related Compounds Using the Arnold Meter

B783 Specification for Materials for Ferrous Powder Metallurgy (PM) Structural Parts

B822 Test Method for Particle Size Distribution of Metal Powders and Related Compounds by Light Scattering

B855 Test Method for Volumetric Flow Rate of Metal Powders Using the Arnold Meter and Hall Flowmeter Funnel

B923 Test Method for Metal Powder Skeletal Density by Helium or Nitrogen Pycnometry

B964 Test Methods for Flow Rate of Metal Powders Using the Carney Funnel

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

E572 Test Method for Analysis of Stainless and Alloy Steels by Wavelength Dispersive X-Ray Fluorescence Spectrometry

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

E1569 Test Method for Determination of Oxygen in Tantalum Powder by Inert Gas Fusion Technique (Withdrawn 2018)⁴

E1638 Terminology Relating to Sieves, Sieving Methods, and Screening Media

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

E2371 Test Method for Analysis of Titanium and Titanium

¹ This test method 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.

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² Cooke, A. L., Slotwinski, J. A., "Properties of Metal Powders for Additive Manufacturing: A Review of the State of the Art of Metal Powder Property Testing," NIST IR 7873, July, 2012. Online, Available: http://www.nist.gov/manuscript-publication-search.cfm?pub_id=911339

³ 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.

⁴ The last approved version of this historical standard is referenced on www.astm.org.

Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission Spectrometry (Performance-Based Test Methodology)

E2465 Test Method for Analysis of Ni-Base Alloys by Wavelength Dispersive X-Ray Fluorescence Spectrometry

E2594 Test Method for Analysis of Nickel Alloys by Inductively Coupled Plasma Atomic Emission Spectrometry (Performance-Based)

E2626 Guide for Spectrometric Analysis of Reactive and Refractory Metals (Withdrawn 2017)⁴

E2792 Test Method for Determination of Hydrogen in Aluminum and Aluminum Alloys by Inert Gas Fusion

F2792 Terminology for Additive Manufacturing Technologies (Withdrawn 2015)⁴

2.2 *ISO Standards:*⁵

ISO 3923-1, ISO 3923-2 Metallic Powders, Determination of Apparent Density

ISO 4497 Metallic Powders, Determination of Particle Size by Dry Sieving

ISO 8302 Thermal Insulation – Determination of Steady-State Areal Thermal Resistance and Related Properties – Guarded-Hot-Plate Apparatus

ISO 13320-1 Particle Size Analysis – Laser Diffraction Methods – Part 1: General Principles

2.3 *Metal Powder Industries Federation (MPIF) Standards:*⁶

MPIF Standard 01 Sampling Metal Powders

MPIF Standard 03 Flow Rate of Free-Flowing Metal Powders Using the Hall Apparatus

MPIF Standard 04 Apparent Density of Free-Flowing Metal Powders Using the Hall Apparatus

MPIF Standard 05 Sieve Analysis of Metal Powders

MPIF Standard 28 Apparent Density of Non-Free Flowing Metal Powders Using the Carney Apparatus

MPIF Standard 46 Tap Density of Metal Powders

MPIF Standard 48 Apparent Density of Metal Powders Using the Arnold Meter

3. Terminology

3.1 *Definitions:*

3.1.1 Terminology relating to powder metallurgy in Terminology **B243** shall apply.

3.1.2 Terminology relating to sieve analysis in Terminology **E1638** shall apply.

3.1.3 Terminology relating to additive manufacturing in Terminology **F2792** shall apply.

4. Significance and Use

4.1 Determining the properties of the feedstock powder used in these processes is a necessary condition for industry's confidence in powder selection and ability to produce consistent components with known and predictable properties. The intention of this guide is to provide purchasers, vendors, or producers of metal powder to be used in additive manufacturing

processes with a reference for existing standards or variations of existing standards that may be used to characterize properties of metal powders used for additive manufacturing processes. It will serve as a starting point for the future development of a suite of specific standard test methods that will address each individual property or property type that is important to the performance of metal-based additive manufacturing systems and the components produced by them. While the focus of this standard is on metal powder, some of the referenced methods may also be appropriate for non-metal powders.

5. Tests for Measuring Powder Properties

5.1 *Sampling:*

5.1.1 Practice **B215** outlines procedures for sampling metal powders transferred from blenders or storage tanks, as well as metal powders already packaged in containers such as bags. The techniques in this standard are readily applicable to metal powders used in additive manufacturing. MPIF Standard 01 provides similar procedures.

5.2 *Size Determination:*

5.2.1 The procedures outlined in Test Method **B214** give detailed specifications for determining powder particle sizes through a sieving process. This process is applicable for sieves with openings from 45 to 1000 μm , and therefore not suitable for powders with particles smaller than 45 μm . MPIF Standard 05 gives similar procedures, as does ISO 4497.

5.2.2 Test Method **B822** describes the use of light scattering to measure the particle size distribution. This test method describes the limitations of this technique, which may be used as agreed upon by user and manufacturer to measure particle size distribution for metal powders for additive manufacturing since the allowable particle diameters for this technique range from 0.4 μm to 2 mm.

5.2.3 Non-standardized methods such as image analysis may also be applicable for measuring the size distribution of a collection of metal particles.

5.3 *Morphology Characterization:*

5.3.1 Terminology **B243** establishes qualitative definitions for many powder shapes. However, no standards describe a means of quantifying the morphology of metal powder particles. Morphology can be determined via light scattering and image analysis methods.

5.4 *Chemical Composition:*

5.4.1 Several standards describe the inert gas fusion technique, and they are highly specific.

5.4.1.1 Test Method **E1447** describes the procedure for determining the hydrogen content in solid specimens of titanium and titanium alloys by using the inert gas fusion technique combined with measuring the water created by passing the hydrogen released through the inert gas fusion over heated copper oxide in an infrared cell.

5.4.1.2 Test Method **E1569** describes using inert gas fusion for determining the oxygen content in tantalum powder.

5.4.1.3 Test Method **E1941** describes the procedure using combustion analysis to determine carbon content in refractory and reactive metals.

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 Metal Powder Industries Federation (MPIF), 105 College Rd. East, Princeton, NJ 08540-6692, <http://www.mpif.org>.