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Standard Test Method for Particle Size Distribution of Metal Powders and Related Compounds by Light Scattering¹

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1. Scope*

1.1 This test method covers the determination of the particle size distribution by light scattering, reported as volume percent, of particulate materials including metals and compounds.

1.2 This test method applies to analyses with both aqueous and nonaqueous dispersions. In addition, analysis can be performed with a gaseous dispersion for materials that are hygroscopic or react with a liquid carrier.

1.3 This test method is applicable to the measurement of particulate materials in the range of 0.4 to 2000 μm , or a subset of that range, as applicable to the particle size distribution being measured.

1.4 The values stated in SI units are to be regarded as the standard.

1.5 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

B215 [Practices for Sampling Metal Powders](#)

B243 [Terminology of Powder Metallurgy](#)

B821 [Guide for Liquid Dispersion of Metal Powders and Related Compounds for Particle Size Analysis](#)

E1617 [Practice for Reporting Particle Size Characterization Data](#)

2.2 *ISO Standard* *ISO Standard:*³ \div

ISO13320-1 Particle Size Analysis—Laser Diffraction Methods—Part 1: General Principles

3. Terminology

3.1 *Definitions*—Definitions of powder metallurgy terms can be found in Terminology B243.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *background*—extraneous scattering of light by elements other than the particles to be measured; includes scattering by contamination in the measurement path.

3.2.2 *Fraunhofer Diffraction*—the optical theory that describes the low-angle scattering of light by particles that are large compared to the wavelength of the incident light.⁴

3.2.3 *Mie Scattering*—the complex electromagnetic theory that describes the scattering of light by spherical particles. It is usually applied to particles with diameters that are close to the wavelength of the incident light. The real and imaginary indices of light refraction of the particles are needed.⁴

3.2.4 *multiple scattering*—the rescattering of light by a particle in the path of light scattered by another particle. This usually occurs in heavy concentrations of a particle dispersion.

4. Summary of Test Method

4.1 A prepared sample of particulate material is dispersed in water, or a compatible organic liquid, and circulated through the path of a light beam or some other suitable light source. A dry sample may be aspirated through the light in a carrier gas. The

¹ This test method is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.02 on Base Metal Powders.

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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.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁴ Muly, E. C., Frock, H. N., "Industrial Particle Size Measurement Using Light Scattering," *Optical Engineering*, Vol 19, No 6, 1980, pp. 861-869.

*A Summary of Changes section appears at the end of this standard.

particles pass through the light beam and scatter it. Photodetector arrays collect the scattered light that is converted to electrical signals, which are then analyzed in a microprocessor. The signal is converted to a size distribution using Fraunhofer Diffraction or Mie Scattering, or a combination of both. Scattering information is analyzed assuming a spherical model. Calculated particle sizes are therefore presented as equivalent spherical diameters. Additional information pertaining to the general principles of particle size distribution analysis by light scattering can be found in ISO Standard 13320-1.

5. Significance and Use

5.1 Reported particle size measurement is a function of both the actual particle dimension and shape factor as well as the particular physical or chemical properties being measured. Caution is required when comparing data from instruments operating on different physical or chemical parameters or with different particle size measurement ranges. Sample acquisition, handling, and preparation can also affect reported particle size results.

5.1.1 It is important to recognize that the results obtained by this test method, or any other method for particle size determination using different physical principles, may disagree. The results are strongly influenced by the physical principles employed by each method of particle size analysis. The results of any particle sizing method should be used only in a relative sense; they should not be regarded as absolute when comparing results obtained by other methods.

5.2 Light scattering theory has been available for many years for use in the determination of particle size. Several manufacturers of testing equipment now have units based on these principles. Although each type of testing equipment uses the same basic principles for light scattering as a function of particle size, different assumptions pertinent to application of the theory, and different models for converting light measurements to particle size, may lead to different results for each instrument. Therefore, the use of this test method cannot guarantee directly comparable results from different types of instruments.

5.3 Knowledge of the particle size distribution of metal powders is useful in predicting the powder-processing behavior and ultimate performance of powder metallurgy parts. Particle size distribution is related closely to the flowability, moldability, compressibility, and die-filling characteristics of a powder, as well as to the final structure and properties of finished powder metallurgy (P/M) parts.

5.4 This test method is useful to both suppliers and users of powders in determining the particle size distributions for product specifications, manufacturing control, development, and research.

5.5 This test method may be used to obtain data for comparison between lots of the same material or for establishing conformance, as in acceptance testing.

6. Interferences

6.1 Air bubbles entrained in the circulating fluid will scatter light and then be reported as particles. Circulating fluids may not require degassing, but they should be bubble-free upon visual inspection.

6.2 Contaminants, such as nonaqueous solvents, oil, or other organic coatings on the sample, may emulsify in an aqueous carrier, scatter light, and thus be reported as part of the particle size distribution. Samples containing such contaminants may be analyzed in a nonaqueous carrier solvent to dissolve the contaminant, or they may be washed free of the contaminant with a compatible aqueous solvent.

6.3 The presence of oil, water, or foreign substances in a gaseous dispersion will cause clogging or agglomeration or will bias the particle size results. The gas supplied should be free of these substances.

6.4 Reagglomeration or settling of particulates during analysis will cause erroneous results. Dispersions shall be prepared in accordance with Guide B821, and a stable dispersion shall be maintained throughout the analysis.

6.5 Insufficient sample loading may cause electrical noise interference and poor data repeatability. Excessive sample loading may cause excessive light attenuation and multiple scattering, resulting in erroneous particle size distributions.

7. Apparatus

7.1 *Particle Size Analyzer*, based on Fraunhofer Diffraction or Mie Scattering, or a combination of both light scattering analysis techniques. Care must be taken to ensure that the analyzer system or subsystem is optimum for the size range of the powder being tested.

7.2 *Liquid or Gaseous Sample Handling System*.

8. Reagents and Materials

8.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society.⁵ Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

⁵ *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.