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Standard Guide for Worldwide Published Standards Relating to Particle and Spray Characterization¹

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1. Scope

1.1 This guide covers the awareness and use of available standard methods for characterizing solid and liquid particles, and provides information for subsequent evaluation and standardization.

1.2 The principal purpose of this guide is the identification of particle characterization standard methods that have been developed and published by various standards organizations worldwide. Although this is an extensive list of methods, it is not all inclusive. WD working drafts, CD committee drafts, DIS draft International Standards and FDIS final Draft International Standards may not be completed documents. These standards have been divided into the following twelve sections related to particle characterization.

- Section 1 — Representation and Treatment of Data
- Section 2 — Sedimentation, Classification, Gravity and Centrifugal Methods
- Section 3 — Surface Area and Porosity Measurement Methods
- Section 4 — Sieving Methods
- Section 5 — Electrical Sensing Methods
- Section 6 — Laser Diffraction Methods
- Section 7 — Photon Correlation Spectroscopy Methods
- Section 8 — Image Analysis Methods
- Section 9 — Single Particle Light Interaction Methods
- Section 10 — Small Angle X-Ray Scattering Method
- Section 11 — Sampling Methods
- Section 12 — General Methods and Information

2. Terminology

2.1 Abbreviations:

- 2.1.1 ASME—American Society of Mechanical Engineers
- 2.1.2 BSI—British Standard Specification
- 2.1.3 DIN—Deutsches Institut für Normung; German Standard Institution
- 2.1.4 DIN and VDI—German Standards
- 2.1.5 ISO—International Organization for Standardization
- 2.1.6 ISO/DIS—Draft International Standards

¹ This guide is under the jurisdiction of ASTM Committee E29 on Particle and Spray Characterization and is the direct responsibility of subcommittee E29.03 on International Cooperation on Particle and Spray Characterization.

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- 2.1.7 JSA/JIS—Japanese Standards Association/Japanese Industrial Standard
- 2.1.8 MPIF—Metal Powders Industry Federation
- 2.1.9 NF X—Normalization Francaise (AFNOR) French Standards (E) - English Translation
- 2.1.10 TAPPI—Technical Association of Pulp and Paper Industry
- 2.1.11 VDI—Verein Deutscher Ingenieure; Society of German Engineers
- 2.1.12 CD—Committee Draft
- 2.1.13 DIS—Draft International Standard
- 2.1.14 FDIS—Final Draft International Standard
- 2.1.15 TS—Technical Specification
- 2.1.16 WD—Working Draft

3. Significance and Use

3.1 Reported particle size measurement is a function of both the actual dimension and/or shape factor as well as the particular physical or chemical properties of the particle 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.

4. Referenced Documents

SECTION 1—REPRESENTATION AND TREATMENT OF DATA

4.1 Related Standards:

4.1.1 ASTM Standards:²

ASTM E177	Practice for Use of the Terms Precision and Bias in ASTM Test Methods
ASTM E799	Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis
ASTM E1617	Practice for Reporting Particle Size Characterization Data
ASTM F658	Practice for Calibration of a Liquid-Borne Particle Counter Using an Optical System Based Upon Light Extinction

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.

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4.1.2 *British Standard:*³

BS 3406 Test Method for the Determination of Particle Size Distribution

4.1.3 *German Standards:*⁴

DIN 66 141 Representation of (grain) Particle Size Distributions, Basic Standard
 DIN 66 142 T 1 Representation and Identification of Separated Fractions of Dispersed Matter; Fundamentals
 DIN 66 142 T 2 Representation and Identification of Separated Fractions of Dispersed Matter, Application to Analytical Separations
 DIN 66 142 T 3 Representation and Identification of Separated Fractions to Dispersed Matter, Selection and Determination of Parameters of
 DIN 66 143 Representation of (Grain) Particle Size Distributions, Power Function Grid
 DIN 66 144 Representation of (Grain) Particle Size Distributions, Logarithmic Gaussian Grid
 DIN 66 145 Representation of (Grain) Particle Size Distributions; RRSB Grid
 DIN EN 1822 High efficiency particulate air filters (HEPA and ULPA) — Part 2: Aerosol production, measuring equipment, particle counting statistics

4.1.4 *ISO Standards:*⁵

ISO 9276-1 Representation of Results of Particle Size Analysis - Part 1 - Graphical Representation
 ISO 9276-2 Representation of Results of Particle Size Analysis—Part 2: Calculation of Average Particle Sizes/Diameters and Moments from Particle Size Distributions
 ISO 9276-3 Representation of Results of Particle Size Analysis—Part 3: Adjustment of an Experimental Curve to a Reference Model
 ISO 9276-4 Representation of Results of Particle Size Analysis—Part 4: Characterization of a Classification Process
 ISO 9276-5 Representation of Results of Particle Size Analysis—Part 5: Methods of Calculation Relating to Particle Size Analyses Using Logarithmic Normal Probability Distribution
 ISO 9276-6 Representation of Results of Particle Size Analysis—Part 6: Descriptive and Quantitative Representation of Particle Shape and Morphology

4.1.5 *French Standards:*⁶

NF X 11-632 Particle Size Analysis—Expression of Experimental Results of Particle Size Analysis (E)
 NF X 11-634 Particle Size Analysis—Characterization of the Size and Form of the Elements of a Granular Population
 NF X 11-635 Particle Size Analysis—Representation of Particle Size Distributions - Reference Models
 NF X 11-636 Particle Size Analysis—Representation of Particle Size Distributions - Adjustment of an Experimental Cumulative Curve to a Reference Model—Case of Sieving

SECTION 2—SEDIMENTATION, CLASSIFICATION, GRAVITY AND CENTRIFUGAL METHODS

4.2 *Related Standards:*

4.2.1 *ASTM Standards:*²

ASTM B330 Test Method for Fisher Number of Metal Powders and Related Compounds
 ASTM B430 Test Method for Particle Size Distribution of Refractory Metal Powders and Related Compounds by Turbidimetry
 ASTM B761 Test Method for Particle Size Distribution of Metal Powders Related Compounds by X-Ray Monitoring of Gravity Sedimentation
 ASTM C721 Test Method for Average Particle Size of Alumina and Silica Powders by Air Permeability
 ASTM C775 Test Method for Particle-Size Analysis of Whiteware Clays
 ASTM C958 Test Method for Particle Size Distribution of Alumina or Quartz by X-Ray Monitoring of Gravity Sedimentation
 ASTM C1282 Test Method for Determining the Particle Size Distribution of Advanced Ceramics by Centrifugal Photosedimentation

4.2.2 *British Standards:*³

BS 3406: Part 2 Recommendations for Gravitational Liquid Sedimentation Methods for Powders and Suspensions
 BS 3406: Part 3 Air Elutriation Methods
 BS 3406: Part 6 Recommendations for Centrifugal Liquid Sedimentation Methods for Powders and Suspensions

4.2.3 *German Standards:*⁴

DIN 66 111 Particle Size Analysis; Sedimentation Analysis; Principles
 DIN 66 111 Bbl.1 Particle Size Analysis; Sedimentation Analysis; Principles; Evaluation Equations for Determination of Quantities in the Field of Centrifugal Force
 DIN 66 115 Test Method for Particle Size Analysis, Sedimentation Analysis in the Gravitational Field
 DIN 66 116 Grain (particle) Size Analysis; Sedimentation Analysis in the Gravitational Field, Sedimentation Balance
 DIN 66 118 Particle Size Analysis, Size Analysis by Air Classification, Fundamentals
 DIN 66 119 Particle Size Analysis, Size Analysis by Air Classification with Gravitational Counterflow
 DIN 66 120 Particle Size Analysis, Size Analysis by Air Classification with Centrifugal Counterflow Classifier

4.2.4 *ISO Standards:*⁵

ISO 10076 Metallic Powders - Determination of Particle Size Distribution by Gravitational Sedimentation in a Liquid and Attenuation Measurement
 ISO 13317-1 Determination of Particle Size Distribution by Gravitational Liquid Sedimentation Methods Part 1: General Principles and Guidelines
 ISO 13317-2 Determination of Particle Size Distribution by Gravitational Liquid Sedimentation Methods Part 2: Fixed Pipette Method
 ISO 13317-3 Determination of Particle Size Distribution by Gravitational Liquid Sedimentation Methods Part 3: X-Ray Gravitational Technique
 ISO 13318-1 Determination of Particle Size Distribution by Centrifugal Liquid Sedimentation Methods Part 1: General Principles and Guidelines
 ISO 13318-2 Determination of Particle Size Distribution by Centrifugal Liquid Sedimentation Methods Part 2: Photocentrifuge Method
 ISO 13318-3 Determination of Particle Size Distribution by Centrifugal Liquid Sedimentation Methods Part 3: Centrifugal X-Ray Method

³ Available from British Standards Institute (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., <http://www.bsi-global.com>.

⁴ Available from Beuth Verlag GmbH (DIN-- DIN Deutsches Institut für Normung e.V.), Burggrafenstrasse 6, 10787, Berlin, Germany, <http://www.en.din.de>.

⁵ Available from International Organization for Standardization (ISO), 1 rue de Varembe, Case postale 56, CH-1211, Geneva 20, Switzerland, <http://www.iso.ch>.

⁶ Available from AFNOR Association Française de Normalisation (AFNOR), 11, rue Francis de Pressensé, 93571 La Plaine Saint-Denis Cedex.

4.2.5 Japanese Standards:⁷

JIS Z8820	General Rules for the Determination of Particle Size Distribution by Sedimentation in Liquid
JIS Z8821	Determination of Particle Size Distribution by the Sedimentation in Liquid Using the Pipette Apparatus
JIS Z8822	Determination of Particle Size Distribution by the Weight of Sedimentation in Liquid

4.2.6 French Standards:⁶

NF X 11-680	Test Method for Particle Size Analysis—Separation by Fluids - Particle Size Analysis by Gravity Sedimentation in a Liquid Medium (E)
NF X 11-681	Test Method for Particle Size Analysis—Particle Size Analysis by Gravity Sedimentation in a Liquid Medium (E)
NF X 11-682	Test Method for Particle Size Analysis—Particle Size Analysis by Gravitational Liquid Sedimentation - Photosedimentation Technique (E)
NF X 11-683	Test Method for Particle Size Analysis—Particle Size Analysis of a Powder by Variable Height Gravity Sedimentation in a Liquid - Method Using X-ray Absorption Measurement (E)
NF X 11-684	Test Method for Particle Size Analysis—Particle Size Analysis by Cumulative Sedimentation in a Static Liquid - Sedimentation Balance Method
NF X 11-685	Test Method for Particle Size Analysis by Centrifugal Sedimentation in a Liquid Which is at Rest in Relation to the Axis of Centrifugation (E)
NF X 11-690	Test Method for Particle Size Analysis by Gravity in a Moving Fluid (Levigation-Elutriation) (E)

SECTION 3—SURFACE AREA AND POROSITY MEASUREMENT METHODS

4.3 Related Standards:

4.3.1 ASTM Standards:²

ASTM B527	Test Method for Determination of Tap Density of Metallic Powders and Compounds
ASTM C20	Test Methods for Apparent Porosity, Water Absorption, Apparent Specific Gravity, and Bulk Density of Burned Refractory Brick and Shapes by Boiling Water
ASTM C1274	Test Method for Advanced Ceramic Specific Surface Area by Physical Adsorption
ASTM C1069	Test Method for Specific Surface Area of Alumina or Quartz by Nitrogen Adsorption
ASTM D1993	Test Method for Precipitated Silica-Surface Area By Multipoint BET Nitrogen Adsorption
ASTM D2752	Test Methods for Air Permeability of Asbestos Fibers
ASTM D2873	Test Method for Interior Porosity of Poly (Vinyl Chloride) (PVC) Resins by Mercury Intrusion Porosimetry
ASTM D3765	Test Method for Carbon Black—CTAB (Cetyltrimethylammonium Bromide) Surface Area
ASTM D3860	Practice for Determination of Adsorptive Capacity of Activated Carbon by Aqueous Phase Isotherm Technique
ASTM D3908	Test Method for Hydrogen Chemisorption on Supported Platinum on Alumina Catalysts and Catalyst Carriers by Volumetric Vacuum Method
ASTM D4222	Test Method for Determination of Nitrogen Adsorption and Desorption Isotherms of Catalysts By Static Volumetric Measurements
ASTM D4284	Test Method for Determining Pore Volume Distribution of Catalysts by Mercury Intrusion Porosimetry
ASTM D4365	Test Method for Determining Micropore Volume and Zeolite Area of a Catalyst
ASTM D4404	Test Method for Determination of Pore Volume and Pore Volume Distribution of Soil and Rock by Mercury Intrusion Porosimetry
ASTM D4567	Test Method for Single-Point Determination of Specific Surface Area of Catalysts Using Nitrogen Adsorption by Continuous Flow Method
ASTM D4641	Practice for Calculation of Pore Size Distribution of Catalysts from Nitrogen Desorption Isotherms

ASTM D4780	Test Method for Determination of Low Surface Area of Catalysts by Multipoint Krypton Adsorption
ASTM D4820	Test Methods for Carbon Black—Surface Area by Multipoint BET Nitrogen Adsorption
ASTM D4824	Test Method for Determination of Catalyst Acidity by Ammonia Chemisorption
ASTM D5816	Test Method for Carbon Black-External Surface Area by Multipoint Nitrogen Adsorption
ASTM E1294	Test Method for Pore Size Characteristics of Membrane Filters Using Automated Liquid Porosimeter

4.3.2 British Standards:³

BS 4359	Test Method for Determination of the Specific Surface Area of Powders
BS 4359: Part 1	Test Method for Recommendation for Gas Adsorption (BET)
BS 4359: Part 2	Test Method for Recommended Air Permeability Guide for Determination of Surface Area

4.3.3 German Standards:⁴

DIN 66 126 T 1	Test Method for Determination of the Specific Surface Area of Disperse Solids by Permeability Technique Fundamentals
DIN 66 126 T 2	Test Method for Determination of the Specific Surface Area of Disperse Solids by Permeability Technique, Blaine Method and Apparatus
DIN 66 131	Test Method for Determination of the Specific Surface Area of Solids by Gas Adsorption According to the Method of Brunauer, Emmett and Teller (BET)
DIN 66 132	Test Method for Determination of the Specific Surface Area of Solids by Nitrogen Adsorption, Single Point Differential Method According to Haul and Dumbgen

4.3.4 ISO Standards:⁵

ISO 9277	Determination of the Specific Surface Area of Solids by Gas Adsorption — BET Method
ISO 10070	Test Method for Metallic Powders—Determination of Envelope-Specific Surface Area from Measurements of the Permeability to Air of a Powder Bed Under Steady-State Flow Conditions
ISO 15901-1	Pore Size Distribution and Porosity of Solid Materials Evaluation by Mercury Porosimetry and Gas Adsorption Part 1: Mercury Porosimetry
ISO 15901-2	Pore Size Distribution and Porosity of Solid Materials Evaluation by Mercury Porosimetry and Gas Adsorption Part 2: Analysis of Mesopores and Macropores by Gas Adsorption
ISO 15901-3	Pore Size Distribution and Porosity of Solid Materials by Mercury Porosimetry and Gas Adsorption — Part 3: Analysis of Micropores by Gas Adsorption

4.3.5 Japanese Standard:⁷

JIS Z8830	Test Method for Determination of Specific Surface Area of Powders by Gas Adsorption
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4.3.6 French Standards:⁶

NF X 11-601	Test Method for Sieving and Particle Size Analysis—Determination of the Specific/or Volumetric Surface of Powders by Permeametry—Lea and Nurse Method (E)
NF X 11-602	Test Method for Determination of the Specific Surface of Powders by Various Air Permeametry Methods (E)
NF X 11-621	Test Method for Determination of the Area Per Unit of Mass (Specific Surface) of Powders by Gas Adsorption—BET method: Volumetric Measurement by Adsorption of Nitrogen at Low Temperature (E)
NF X 11-622	Test Method for Determination of the Area Per Unit of Mass (Specific Surface) of Powders by Gas Adsorption—Variation of the Basic Method (E)
NF ISO 9277	Determination of the Specific Surface Area of Solids by Gas Adsorption using the BET Method

SECTION 4—SIEVING METHODS

4.4 Related Standards:

4.4.1 ASTM Standards:²

ASTM B214	Test Method for Sieve Analysis of Metal Powders
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⁷ Available from Japanese Standards Organization (JSA), 4-1-24 Akasaka Minato-Ku, Tokyo, 107-8440, Japan, <http://www.jsa.or.jp>.