



Designation: E2834 – 12 (Reapproved 2022)

Standard Guide for Measurement of Particle Size Distribution of Nanomaterials in Suspension by Nanoparticle Tracking Analysis (NTA)¹

This standard is issued under the fixed designation E2834; 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 deals with the measurement of particle size distribution of suspended particles, from ~10 nm to the onset of sedimentation, sample dependent, using the nanoparticle tracking analysis (NTA) technique. It does not provide a complete measurement methodology for any specific nanomaterial, but provides a general overview and guide as to the methodology that should be followed for good practice, along with potential pitfalls.

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:²

[C322 Practice for Sampling Ceramic Whiteware Clays](#)
[E456 Terminology Relating to Quality and Statistics](#)
[E1617 Practice for Reporting Particle Size Characterization Data](#)

¹ This guide is under the jurisdiction of ASTM Committee E56 on Nanotechnology and is the direct responsibility of Subcommittee E56.02 on Physical and Chemical Characterization.

Current edition approved Sept. 1, 2022. Published October 2022. Originally approved in 2012. Last previous edition approved in 2018 as E2834 – 12 (2018). DOI: 10.1520/E2834-12R22.

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.

[E2490 Guide for Measurement of Particle Size Distribution of Nanomaterials in Suspension by Photon Correlation Spectroscopy \(PCS\)](#)

2.2 ISO Standards:³

[ISO 13320 Particle Size Analysis—Laser Diffraction Methods](#)

[ISO 13321 Particle Size Analysis—Photon Correlation Spectroscopy](#)

[ISO 14488 Particulate Materials—Sampling And Sample Splitting for the Determination of Particulate Properties](#)

[ISO 22412 Particle Size Analysis—Dynamic Light Scattering \(DLS\)](#)

3. Terminology

3.1 Definitions:

3.1.1 *diffusion coefficient, n* —a measure to characterize the rate a particular molecule or particle moves in a particular medium when driven by random thermal agitation (Brownian motion).

3.1.1.1 *Discussion*—After measurement, the value is to be inputted into the Stokes-Einstein equation ([Eq 1](#), see [7.2.1.2\(3\)](#)). Diffusion coefficient units in nanoparticle tracking analysis (NTA) measurements are typically cm^2/s , rather than the correct SI units of m^2/s .

3.1.2 *repeatability, n* —in NTA and other particle sizing techniques, this usually refers to a measure of the precision of repeated consecutive measurements on the same group of particles under identical conditions and is normally expressed as a relative standard deviation (RSD) or coefficient of variation (CV).

3.1.2.1 *Discussion*—The repeatability value reflects the stability (instrumental, but mainly the sample) of the system over time. Changes in the sample could include dispersion, aggregation and settling.

3.1.3 *reproducibility, n* —in NTA and particle sizing this usually refers to a measure of the deviation of the results obtained from the first aliquot to that obtained for the second and further aliquots of the same bulk sample (and therefore is subject to the homogeneity or heterogeneity of the starting

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

material and the sampling method employed). Normally expressed as a relative standard deviation (RSD) or coefficient of variation (CV).

3.1.3.1 *Discussion*—In a heterogeneous and polydisperse (for example, slurry) system, it is often the largest error when repeated samples are taken. Other definitions of reproducibility also address the variability among single test results gathered from different laboratories when inter-laboratory testing is undertaken, or operator-to-operator, instrument-to-instrument, location-to-location, or even day-to-day. It is to be noted that the same group of particles can never be measured in such a system of tests and therefore reproducibility values may typically be considerably in excess of repeatability values.

3.1.4 *robustness, n*—a measure of the change of the required parameter with deliberate and systematic variations in any or all of the key parameters that influence it.

3.1.4.1 *Discussion*—For example, dispersion energy input (that is, ultrasound power and duration) almost certainly will affect the reported results. Variation in pH is likely to affect the degree of agglomeration and so forth. A useful discussion of robustness experiment considerations is found in the ICH Validation of Analytical Procedures Q2(R1) Guideline (1).⁴

3.1.5 *rotational diffusion, n*—a process by which the equilibrium statistical distribution of the overall orientation of molecules or particles is maintained or restored.

3.1.6 *translational diffusion, n*—a process by which the equilibrium statistical distribution of molecules or particles in space is maintained or restored.

3.1.7 *visualization, n*—as it relates to the NTA technique, the particles themselves are not imaged, being below the diffraction limit. Each particle acts as a point scatterer, meaning that the imaging system only sees the scattered light from the particle. This allows the position of each particle to be identified and followed with respect to time. See 7.2.

3.1.7.1 *Discussion*—The intensity and shape of the scattered light pattern for each particle may vary, and some additional information may be obtained from these differences, at least qualitatively, but is outside the scope of this guide.

3.1.8 *percentile, n*—a statistical measure of the distribution of sizes. The size below which a certain percent of the distribution falls. For example, the 10th percentile is the size below which 10 percent of the particles may be found. Expressed in ISO form as x_{10} , x_{50} , x_{90} , and also commonly expressed as D10, D50, D90. The 50th percentile is the median.

3.1.9 *coefficient of variation, n*—in statistics, a normalized measure of dispersion of a distribution. Defined as the standard deviation divided by the mean value. (Note: $CV = SD/Mean$)

3.1.10 *relative standard deviation, n*—in statistics, the absolute value of the coefficient of variation, expressed as a percentage. (Note: $RSD = 100 \cdot SD/Mean$)

NOTE 1—Other common statistical measures are defined in Terminology E456.

⁴ The boldface numbers in parentheses refer to the list of references at the end of this standard.

3.2 Acronyms:

3.2.1 *CV*—coefficient of variation

3.2.2 *CCD*—charge-coupled device

3.2.3 *CMOS*—complementary metal-oxide-semiconductor

3.2.4 *DLS*—dynamic light scattering

3.2.5 *EMCCD*—electron-multiplying charge-coupled device

3.2.6 *NTA*—nanoparticle tracking analysis

3.2.7 *PCS*—photon correlation spectroscopy

3.2.8 *RSD*—relative standard deviation

4. Summary of Guide

4.1 Nanoparticle tracking analysis (NTA) is a method for the direct and real-time visualization and analysis of nanoparticles in liquids. Particles in suspension are illuminated with a focused laser beam. Light scattered from each particle is visible through magnifying optics fitted to a digital camera such as a CCD. The software analyzes the video stream from the camera, identifying and tracking the motion of each particle with time. Because each particle in the field of view is being simultaneously but separately tracked and analyzed, the particle size distribution profile obtained by NTA is a direct number-based distribution.

4.2 The laser beam is focused such that only particles in the focal plane of the magnifying optics are illuminated. Particles out of the focal plane are not illuminated and at the size range under discussion are not visible to the camera. This yields a high signal to noise image, allowing particles as small as 10 nm to be visualized, depending on sample material. While outside the scope of this document, the technique is generally able to measure particles as large as approximately 1 μm .

4.3 The average distance each particle moves in the image is automatically calculated by the software. From this value, the particle diffusion coefficient can be obtained and through the use of the Stokes-Einstein equation, particle size can be determined.

4.4 This guide discusses the scientific basis for the technique, size limits, concentration ranges, sampling and sample preparation considerations, condition and analysis selection, data interpretation and comparison to other complementary techniques.

5. Significance and Use

5.1 NTA is one of the very few techniques that are able to deal with the measurement of particle size distribution in the nano-size region. This guide describes the NTA technique for direct visualization and measurement of Brownian motion, generally applicable in the particle size range from several nanometers until the onset of sedimentation in the sample. The NTA technique is usually applied to dilute suspensions of solid material in a liquid carrier. It is a first principles method (that is, calibration in the standard understanding of this word, is not involved). The measurement is hydrodynamically based and therefore provides size information in the suspending medium (typically water). Thus the hydrodynamic diameter will almost certainly differ from size diameters determined by other