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Particle characterization of particulate systems — Vocabulary

Caractérisation des particules dans les systèmes particulaires — Vocabulaire

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Foreword

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The committee responsible for this document is ISO/TC 24, *Particle characterization including sieving*, Subcommittee SC 4, *Particle characterization*.

Introduction

Since 1995, some 20 International Standards have been published by ISO/TC 24/SC 4, and at the time of publication of this International Standard, about 12 projects were under development, not to mention revisions of existing standards. Therefore it was not before time that terms defined in standards that were relevant for others be collected and adjusted into a single, uniform vocabulary.

In particular, the interdisciplinary application fields of particle and particulate systems characterization — from mining and construction, the pharmaceutical and food industries, medicine and life sciences, the chemical industry, microelectronics and nanotechnology — need clear and unambiguous terminology. The development of international trade, not only in measurement devices for particle characterization, but also of process equipment for the production and treatment of particulate systems, underlines the need for comparability of quality and performance parameters, as well as in international health, safety and environmental protection regulations.

The structuring and presentation rules applied to the terminological entries, based on a clause structure, represents the methods of results presentation and the analysis methods, and starts with general terms in each clause.

Particle characterization of particulate systems — Vocabulary

Scope

This International Standard establishes a vocabulary of terms and definitions relevant to the particle characterization of particulate systems. It covers such fields as the representation of results of particle size analysis, the descriptive and quantitative representation of particle shape and morphology, sample preparation, specific surface area and porosity characterization and measurement methods including sedimentation, classification, acoustic methods, laser diffraction, dynamic light scattering, single particle light interaction methods, differential electrical mobility analysis and image analysis, in a size scale from nanometre to millimetre.

1 General terms, representation of particle size and classification analysis

1.1
particle
minute piece of matter with defined physical boundaries

Note 1 to entry: A physical boundary can also be described as an interface.

Note 2 to entry: A particle can move as a unit.

Note 3 to entry: This general particle definition applies to nano-objects.

[SOURCE: ISO 14644-6:2007, 2.102, modified — The subject field "<general>" has been removed and the notes added.]

1.2
agglomerate
collection of weakly or medium strongly bound particles where the resulting external surface area is similar to the sum of the surface areas of the individual components

Note 1 to entry: The forces holding an agglomerate together are weak forces, for example van der Waals forces or simple physical entanglement.

Note 2 to entry: Agglomerates are also termed secondary particles and the original source particles are termed primary particles.

[SOURCE: ISO/TS 27687:2008, 3.2, modified.]

1.3
aggregate
particle comprising strongly bonded or fused particles where the resulting external surface area is significantly smaller than the sum of surface areas of the individual components

Note 1 to entry: The forces holding an aggregate together are strong forces, for example covalent bonds, or those resulting from sintering or complex physical entanglement, or otherwise combined former primary particles.

Note 2 to entry: Aggregates are also termed secondary particles and the original source particles are termed primary particles.

[SOURCE: ISO/TS 27687:2008, 3.3, modified.]

1.4
primary particle

original source particle of agglomerates or aggregates or mixtures of the two

Note 1 to entry: Constituent particles of agglomerates or aggregates at a certain actual state may be primary particles, but often the constituents are aggregates.

Note 2 to entry: Agglomerates and aggregates are also termed secondary particles.

1.5
particle size

x

d

linear dimension of a particle determined by a specified measurement method and under specified measurement conditions

Note 1 to entry: Different methods of analysis are based on the measurement of different physical properties. Independent of the particle property actually measured, the particle size is reported as a linear dimension, e.g. as the equivalent spherical diameter.

Note 2 to entry: Examples of size descriptors are those based at the opening of a sieve or a statistical diameter, e.g. the Feret diameter, measured by image analysis.

Note 3 to entry: In ISO 9276-1:1998, the symbol x is used to denote the particle size. However, it is recognized that the symbol d is also widely used to designate these values. Therefore the symbol x may be replaced by d.

[SOURCE: ISO 9276-1:1998, 4.2, modified.]

1.6
equivalent spherical diameter

x

d

diameter of a sphere having the same physical properties as the particle in the measurement

Note 1 to entry: Physical properties are for instance the same settling velocity or electrolyte solution displacing volume or projection area under a microscope.

Note 2 to entry: The physical property to which the equivalent diameter refers shall be indicated using a suitable subscript, for example x_S for equivalent surface area diameter or x_V for equivalent volume diameter.

[SOURCE: ISO 9276-1:1998, 4.2, modified.]

1.7
type of quantity

r

specification of the quantity of a distribution, a cumulative or a density measure

Note 1 to entry: The type is indicated by the general subscript, r, or by the appropriate value of r as follows:

— number: $r = 0$

— length: $r = 1$

— area: $r = 2$

— volume or mass: $r = 3$

[SOURCE: ISO 9276-1:1998, 4.3, modified.]

1.8

cumulative distribution

$Q_r(x)$

distribution of the fraction of material smaller (undersize) than given particle sizes

Note 1 to entry: If the cumulative distribution, $Q_r(x)$, is calculated from histogram data, only individual points $Q_{r,i} = Q_r(x_i)$ are obtained. Each individual point of the distribution, $Q_r(x_i)$, defines the relative amount of particles smaller than or equal to x_i. The continuous curve is calculated by suitable interpolation algorithms. The normalized cumulative distribution extends between 0 and 1, i.e. 0 and 100 %.

$$Q_{r,i} = \sum_{v=1}^{i} \Delta Q_{r,v} = \sum_{v=1}^{i} \bar{q}_{r,v} \Delta x_v \quad \text{with } 1 \le v \le i \le n$$

where

i (subscript) number of the size class with upper limit x_i

v (integer, see subscript i)

n total number of size classes

$Q_{r,v}$ relative amount of particles in size class with upper limit x_v

Note 2 to entry: When plotted on a graph paper with a logarithmic abscissa the cumulative values, $Q_{r,i}$, i.e. the ordinates of a cumulative distribution, do not change. However, the course of the cumulative distribution curve changes but the relative amounts smaller than a certain particle size remain the same. Therefore, the following formula holds:

$$Q_r(x) = Q_r(\mathrm{In}\, x)$$

Note 3 to entry: The cumulative oversize distribution is given by $1 - Q_r(x)$.

[SOURCE: ISO 9276-1:1998, 5.2, modified.]

1.9

distribution density

$q_r(x)$

distribution of the fraction of material in a size class, divided by the width of that class

Note 1 to entry: Under the presupposition that the cumulative distribution, $Q_r(x)$, is differentiable, the continuous distribution density, $q_r(x)$, is obtained from

$$q_r(x) = \frac{dQ_r(x)}{dx}$$

Conversely, the cumulative distribution, $Q_r(x)$, is obtained from the distribution density, $q_r(x)$, by integration:

$$Q_r(x_i) = \int_{x_{\min}}^{x_i} q_r(x)dx$$

Note 2 to entry: Differential distribution is also named in statistics “density of a probability or frequency”.

Note 3 to entry: The term “density distribution” can be misunderstood in the context of sedimentation methods with different materials and will be not used in standards developed by ISO/TC24/SC 4.

[SOURCE: ISO 9276-1:1998, 5.3, modified — Notes 2 and 3 have been added.]

1.10
distribution density on a logarithmic abscissa

$q_r^*(x)$

distribution density, transformed for a logarithmic abscissa

Note 1 to entry: The density values of a histogram, $\bar{q}_{r,i}^* = \bar{q}_r^*(x_{i-1}, x_i)$, shall be recalculated using the following formula which indicates that the corresponding areas underneath the distribution density curve remain constant. In particular, the total area is equal to 1 or 100 %, independent of any transformation of the abscissa.

$$\bar{q}_r^*(\xi_{i-1}, \xi_i)\Delta\xi_i = \bar{q}_r(x_{i-1}, x_i)\Delta x_i$$

where ξ is any function of x.

Thus the following transformation shall be carried out to obtain the distribution density with a logarithmic abscissa:

$$q_r^*(x_i) = q_{r,i} \cdot x_i \quad \text{or} \quad \bar{q}_r^*(\mathrm{In}\,x_{i-1}, \mathrm{In}\,x_i) = \frac{\bar{q}_r(x_{i-1}, x_i)\Delta x_i}{\mathrm{In}\,x_i - \mathrm{In}\,x_{i-1}} = \frac{\bar{q}_{r,i}\Delta x_i}{\mathrm{In}(x_i/x_{i-1})} = \frac{\Delta Q_{r,i}}{\mathrm{In}(x_i/x_{i-1})}$$

Note 2 to entry: This formula also holds if the natural logarithm is replaced by the logarithm to base 10.

[SOURCE: ISO 9276-1:1998, 6.2, modified.]

1.11
histogram

$\bar{q}_r(x)$

normalized histogram, $\bar{q}_r(x)$, of a *distribution density* (1.9), $q_r(x)$, comprising a successive series of rectangular columns, the area of each of which represents the relative quantity $\Delta Q_{r,i}(x)$, where

$$\Delta Q_{r,i} = \Delta Q_r(x_{i-1}, x_i) = \bar{q}_r(x_{i-1}, x_i)\Delta x \quad \text{or} \quad q_{r,i} = \bar{q}_r(x_{i-1}, x_i) = \frac{\Delta Q_r(x_{i-1}, x_i)}{\Delta x_i} = \frac{\Delta Q_{r,i}}{\Delta x_i}$$

Note 1 to entry: The sum of all the relative quantities, $\Delta Q_{r,l}$ forms the area beneath the histogram $q_r(x)$, normalized to 100 % or 1 (condition of normalization). Therefore, the following formula holds:

$$\sum_{i=1}^{n} \Delta Q_{r,i} = \sum_{i=1}^{n} \bar{q}_{r,i}\Delta x_i = 1 = 100\ \%$$

[SOURCE: ISO 9276-1:1998, 5.1, modified.]

1.12
concentration distribution density

distribution of the concentration of material in a size class, divided by the width of that class

Note 1 to entry: In aerosol measurement, e. g. the distribution density of the particle number concentration, is represented as a function of the particle size.

Note 2 to entry: The concentration distribution density can be calculated from the distribution density function of the particle size by multiplication with the overall sizes measured concentration.

1.13
analytical cut size

x_a

cut size with the coarse and the fine material containing equal quantities of misplaced material

Note 1 to entry: Since the relative mass of the fine material as determined by the classification process, is taken to be equal to the relative mass of the undersize material in the feed, that is $Q_{3,s}(x)$, an analytical cut size x corresponding to this definition has to be found.

[SOURCE: ISO 9276-4:2001, 4.3.2, modified.]

1.14

equiprobable cut size

x_e

cut size, which represents the median of the grade efficiency curve $T(x_e) = 0,5$

Note 1 to entry: The weighted distribution density curves of the fine and the coarse fraction intersect at the equiprobable cut size x_e. Independently from other particle sizes, particles of this size have the equal probability to be classified into the fine and into the coarse fraction.

[SOURCE: ISO 9276-4:2001, 4.3.1, modified.]

1.15

grade efficiency

Tromp's curve

$T(x)$

representation, for a certain particle size x, of the ratio of the amount of material present in the coarse material to the amount of the same size initially present in the feed material

Note 1 to entry: In the dust collection field, this efficiency is called "partial separation efficiency".

[SOURCE: ISO 9276-4:2001, 4.4, modified — The note has been added.]

2 Sedimentation analysis

2.1

effective particle density

particle mass divided by the volume of liquid it displaces

[SOURCE: ISO 13317-1:2001, 3.1.7, modified.]

2.2

true particle density

particle mass divided by the volume it would occupy excluding all pores, closed or open, and surface fissures

Note 1 to entry: True particle density is sometimes referred to as the absolute particle density.

[SOURCE: ISO 13317-1:2001, 3.1.8.]

2.3

oversize

portion of the charge which has not passed through the apertures of a stated sieve

[SOURCE: ISO 13317-1:2001, 3.1.5.]

2.4

pycnometry

method wherein particle density is obtained from the measured mass of sample with a given calibrated volume

2.5

Stokes diameter

equivalent spherical diameter of the particle that has the same density and terminal settling velocity as the real particle in the same liquid under creeping flow conditions

[SOURCE: ISO 13317-1:2001, 3.1.2.]

2.6
terminal settling velocity
velocity of a particle through a still liquid at which the force due to gravity on the particle is balanced by the drag exerted by the liquid

[SOURCE: ISO 13317-1:2001, 3.1.1.]

2.7
undersize
portion of the charge which has passed through the apertures of a stated sieve

[SOURCE: ISO 13317-1:2001, 3.1.6.]

3 Pore size distribution, porosity and surface area analysis

3.1
molecular cross-sectional area
molecular area of the adsorbate, i.e. the area occupied by an adsorbate molecule in the complete monolayer

[SOURCE: ISO 9277:2010, 3.10.]

3.2
free space
volume of the sample holder not occupied by the sample

Note 1 to entry: Also called head space, dead space, or dead volume.

[SOURCE: ISO 9277:2010, 3.14.]

3.3
specific surface area
absolute surface area of the sample divided by sample mass

[SOURCE: ISO 9277:2010, 3.15.]

3.4
apparent density
mass of a powder divided by the total volume of the sample, including closed and inaccessible pores, as determined by the stated method

[SOURCE: ISO 15901-1:2005, 3.23.]

3.5
bulk density
powder density under defined conditions

[SOURCE: ISO 15901-1:2005, 3.1.]

3.6
blind pore
dead end pore
open pore having a single connection with an external surface

[SOURCE: ISO 15901-2:2006, 3.6.]

3.7
closed pore
cavity not connected to the external surface

[SOURCE: ISO 15901-1:2005, 3.3.]

3.8
contact angle
angle that a non-wetting liquid makes with a solid material

[SOURCE: ISO 15901-1:2005, 4.4.]

3.9
external surface area
area of external surface including roughness but outside pores

[SOURCE: ISO 15901-1:2005, 3.5.]

3.10
ink bottle pore
narrow necked open pore

[SOURCE: ISO 15901-1:2005, 3.3.]

3.11
interconnected pore
pore which communicates with one or more other pores

[SOURCE: ISO 15901-1:2005, 3.7.]

3.12
internal surface area
area of internal pore walls

[SOURCE: ISO 15901-1:2005, 3.8.]

3.13
intraparticle porosity
ratio of the volume of open pores internal to the particle to the total volume occupied by the solid

[SOURCE: ISO 15901-1:2005, 3.9.]

3.14
interparticle porosity
ratio of the volume of space between particles in a powder to the apparent volume of the particles or powder

[SOURCE: ISO 15901-1:2005, 3.10.]

3.15
macropore
pore of internal width greater than 50 nm

[SOURCE: ISO 15901-1:2005, 3.11.]

3.16
mesopore
pore of internal width between 2 nm and 50 nm

[SOURCE: ISO 15901-1:2005, 3.12.]

3.17
micropore
pore of internal width less than 2 nm which is accessible for a molecule to be adsorbed

[SOURCE: ISO 15901-1:2005, 3.13.]

3.18

open pore

cavity or channel with access to an external surface

[SOURCE: ISO 15901-1:2005, 3.14.]

3.19

open porosity

ratio of the volume of open pores and voids to the total volume occupied by the solid

[SOURCE: ISO 15901-1:2005, 3.15.]

3.20

pore size

pore width, for example, the diameter of a cylindrical pore or the distance between the opposite walls of a slit

Note 1 to entry: One of the methods to determine pore sizes is by mercury porosimetry.

[SOURCE: ISO 15901-1:2005, 3.16.]

3.21

pore volume

volume of pores determined by stated method

[SOURCE: ISO 15901-1:2005, 3.17.]

3.22

porosimeter

instrument for measuring porosity and pore size distribution

[SOURCE: ISO 15901-1:2005, 3.18.]

3.23

porosimetry

methods for the estimation of porosity and pore size distribution

[SOURCE: ISO 15901-1:2005, 3.19.]

3.24

porosity

ratio of total pore volume to apparent volume of particle or powder

[SOURCE: ISO 15901-1:2005, 3.20.]

3.25

porous solid

solid with cavities or channels which are deeper than they are wide

[SOURCE: ISO 15901-1:2005, 3.21.]

3.26

powder density

mass of a powder divided by its apparent volume, which is taken to be the total volume of the solid material, open and closed pores and interstices

[SOURCE: ISO 15901-1:2005, 3.24.]

3.27

skeleton density

mass of a powder divided by the total volume of the sample, including closed pores but excluding open pores

[SOURCE: ISO 15901-1:2005, 3.22.]

3.28
surface area
extent of available surface area as determined by given method under stated conditions

[SOURCE: ISO 15901-1:2005, 3.25.]

3.29
surface tension
force required to separate a film of liquid from either a solid material or a film of the same liquid

[SOURCE: ISO 15901-1:2005, 3.26.]

3.30
through pore
pore which passes all the way through the sample

[SOURCE: ISO 15901-1:2005, 3.27.]

3.31
total porosity
ratio of the volume of void plus the volume of open and closed pores to the total volume occupied by the solid and the volume of void plus pores, e.g. apparent solid volume

[SOURCE: ISO 15901-1:2005, 3.28.]

3.32
true density
mass of the particle divided by its volume, excluding open and closed pores

[SOURCE: ISO 15901-1:2005, 3.29.]

3.33
void
space between particles, i.e. an interparticle pore

[SOURCE: ISO 15901-1:2005, 3.30.]

3.34
adsorbate
adsorbed gas

[SOURCE: ISO 15901-2:2006, 3.1.]

3.35
amount adsorbed
na
number of moles of gas adsorbed at a given pressure p and temperature T[SOURCE: ISO 15901-2:2006, 3.2.]

3.36
adsorbent
solid material on which adsorption occurs

[SOURCE: ISO 15901-2:2006, 3.3.]

3.37
adsorption
enrichment of the adsorptive gas at the external and accessible internal surfaces of a solid material

[SOURCE: ISO 15901-2:2006, 3.4.]

3.38
adsorptive
gas or vapour to be adsorbed

[SOURCE: ISO 15901-2:2006, 3.5.]

3.39
equilibrium adsorption pressure
p
pressure of the adsorptive gas in equilibrium with the adsorbate

[SOURCE: ISO 15901-2:2006, 3.7.]

3.40
adsorption isotherm
relationship between the amount of gas adsorbed and the equilibrium pressure of the gas, at constant temperature

[SOURCE: ISO 15901-3:2007, 3.5.]

3.41
monolayer amount
$n'm$
number of moles of the adsorbate that form a monomolecular layer over the surface of the adsorbent

[SOURCE: ISO 15901-2:2006, 3.14.]

3.42
monolayer capacity
Vm
volumetric equivalent of monolayer amount expressed as gas at standard conditions of temperature and pressure (STP)

[SOURCE: ISO 15901-2:2006, 3.15.]

3.43
relative pressure
ratio of the equilibrium adsorption pressure, p, to the saturation vapour pressure, p_0[SOURCE: ISO 15901-2:2006, 3.18.]

3.44
right cylindrical pore
cylindrical pore perpendicular to the surface

[SOURCE: ISO 15901-2:2006, 3.19.]

3.45
saturation vapour pressure
vapour pressure of the bulk liquefied adsorptive gas at the temperature of adsorption

[SOURCE: ISO 15901-2:2006, 3.20.]

3.46
volume adsorbed
volumetric equivalent of adsorbed amount expressed as gas at standard conditions of temperature and pressure (STP)

[SOURCE: ISO 15901-2:2006, 3.22.]

3.47
physisorption

weak bonding of the adsorbate, reversible by small changes in pressure or temperature

[SOURCE: ISO 15901-3:2007, 3.13.]

4 Representation of particle shape analysis

4.1
particle shape

external geometric form of a particle

Note 1 to entry: Macroshape is a description of the overall form of a particle defined in terms of the geometrical proportions of the particle. In general, simple geometrical descriptors calculated from size measurements made on the particle silhouette are used.

Note 2 to entry: Mesoshape description provides information about details of the particle shape and/or surface structure that are in a size range not much smaller than the particle proportions.

Note 3 to entry: Microshape determines the roughness of shape boundaries using fractal dimension or higher-order Fourier coefficients for surface-textural analysis.

[SOURCE: ISO 3252:1999, 1401.]

4.2
Legendre ellipse of inertia

ellipse with its centre at the particle's centroid and with the same geometrical moments of inertia, up to the second order, as the original particle area

Note 1 to entry: The ellipse can be characterized by its major and minor diameters, the position of its centre of gravity and its orientation.

Note 2 to entry: Macroshape descriptor, geometrical descriptor.

[SOURCE: ISO 9276-6:2008, 8.1.2, modified.]

4.3
geodesic length and thickness

x_{LG} and x_E

approximations for very long and concave particles, such as fibres, calculated from the projection area A and perimeter P:

$$A = x_E \cdot x_{LG} \quad P = 2(x_E + x_{LG})$$

Note 1 to entry: Macroshape descriptor, geometrical descriptor.

[SOURCE: ISO 9276-6:2008, 8.1.2, modified.]

4.4
ellipse ratio

ratio of the lengths of the axes of the Legendre ellipse of inertia)

Note 1 to entry: Macroshape descriptor, proportion descriptor.

[SOURCE: ISO 9276-6:2008, 8.1.3, modified.]

4.5
aspect ratio

ratio of the minimum to the maximum Feret diameter

Note 1 to entry: For not very elongated particles.

Note 2 to entry: Macroshape descriptor, proportion descriptor.

[SOURCE: ISO 9276-6:2008, 8.1.3, modified.]

4.6
elongation

ratio of the geodesic thickness to the geodesic length

Note 1 to entry: For very elongated particles, such as fibres.

Note 2 to entry: Macroshape descriptor, proportion descriptor.

[SOURCE: ISO 9276-6:2008, 8.1.3, modified.]

4.7
straightness

ratio of the maximum *Feret diameter* (8.6) to the geodesic length

Note 1 to entry: For very elongated particles (reciprocal of curl).

Note 2 to entry: Macroshape descriptor, proportion descriptor.

[SOURCE: ISO 9276-6:2008, 8.1.3, modified.]

4.8
irregularity

ratio of the diameter of the maximum inscribed circle d_{imax} and that of the minimum circumscribed circle d_{cmin}

Note 1 to entry: Macroshape descriptor, proportion descriptor, (modification ratio).

[SOURCE: ISO 9276-6:2008, 8.1.3, modified.]

4.9
compactness

degree to which the projection area A of the particle is similar to a circle, considering the overall form of the particle with the maximum Feret diameter x_{Fmax}:

$$\text{compactness} = \frac{\sqrt{(4A/\pi}}{x_{\text{Fmax}}}$$

Note 1 to entry: Macroshape descriptor, proportion descriptor.

[SOURCE: ISO 9276-6:2008, 8.1.3, modified.]

4.10
box ratio

ratio of the Feret box area to the projected area A

Note 1 to entry: Macroshape descriptor, proportion descriptor.

[SOURCE: ISO 9276-6:2008, 8.1.3, modified.]

4.11
sphericity

Ψ

square of the ratio of the volume equivalent diameter x_V to the surface equivalent diameter x_S

$$\Psi = (x_V / x_S)^2 = \pi \cdot x_V^2 / S$$

Note 1 to entry: Wadell's sphericity, Ψ, also derived from surface area, S.

Note 2 to entry: Mesoshape descriptor.

[SOURCE: ISO 9276-6:2008, 8.2, modified.]

4.12
circularity
C
degree to which the projection area of the particle *A* is similar to a circle, considering the smoothness of the perimeter *P*:

$$C = \sqrt{\frac{4\pi A}{P^2}} = \frac{x_A}{x_P}$$

Note 1 to entry: Mesoshape descriptor, also derived from the area equivalent diameter x_A to the perimeter equivalent diameter x_P.

[SOURCE: ISO 9276-6:2008, 8.2, modified.]

4.13
solidity
ratio of the projected area *A* to the area of the convex hull A_C (envelope)

$$\text{Solidity} = A / A_C$$

Note 1 to entry: Measure of the overall concavity of a particle.

Note 2 to entry: Mesoshape descriptor.

[SOURCE: ISO 9276-6:2008, 8.2, modified.]

5 Electrical sensing methods

5.1
dead time
time during which the electronics are not able to detect particles due to the signal processing of a previous pulse

[SOURCE: ISO 13319:2007, 3.1.]

5.2
aperture
small-diameter hole through which suspension is drawn

[SOURCE: ISO 13319:2007, 3.2.]

5.3
sampling volume
volume of suspension that is analysed

[SOURCE: ISO 13319:2007, 3.3.]

5.4
sensing zone
volume of electrolyte solution within, and around, the aperture in which a particle is detected

[SOURCE: ISO 13319:2007, 3.3.]

5.5

channel

size interval

[SOURCE: ISO 13319:2007, 3.4.]

5.6

envelope size

external size of a particle as seen in a microscope

[SOURCE: ISO 13319:2007, 3.5.]

5.7

envelope volume

volume of the envelope given by the three-dimensional boundary of the particle to the surrounding medium

[SOURCE: ISO 13319:2007, 3.6.]

6 Laser diffraction methods

6.1

light absorption

reduction of intensity of a light beam not due to scattering

[SOURCE: ISO 13320:2009, definition 3.1.1.]

6.2

coefficient of variation

CV

standard deviation divided by the mean

Note 1 to entry: The coefficient of variation is commonly reported as a percentage.

[SOURCE: ISO 3534-1:2006, 2.38.]

6.3

complex refractive index

refractive index of a particle, consisting of a real and an imaginary (absorption) part

Note 1 to entry: The complex refractive index of a particle can be expressed mathematically as

$$\underline{n}_{\mathrm{p}} = n_{\mathrm{p}} - ik_{\mathrm{p}}$$

where

i is the square root of –1;

k_{p} is the positive imaginary (absorption) part of the refractive index of a particle;

n_{p} is the positive real part of the refractive index of a particle.

Note 2 to entry: In contrast to ISO 80000-7:2008, item 7–5, this International Standard follows the convention of adding a minus sign to the imaginary part of the refractive index.

[SOURCE: ISO 13320:2009, 3.1.3.]

6.4

relative refractive index

m_{rel}

ratio of the complex refractive index of a particle to the real part of the dispersion medium

Note 1 to entry: Adapted from ISO 24235:2007.

Note 2 to entry: In most applications, the medium is transparent and, thus, its refractive index has a negligible imaginary part.

Note 3 to entry: The relative refractive index can be expressed mathematically as

$$m_{\mathrm{rel}} = \underline{n}_{\mathrm{p}} / n_{\mathrm{m}}$$

where

n_{m} is the real part of the refractive index of the medium;

$\underline{n}_{\mathrm{p}}$ is the complex refractive index of a particle.

[SOURCE: ISO 13320:2009, 3.1.4.]

6.5

deconvolution

mathematical procedure whereby the size distribution of an ensemble of particles is inferred from measurements of their scattering pattern

[SOURCE: ISO 13320:2009, 3.1.5.]

6.6

diffraction

scattering of light around the contour of a particle, observed at a substantial distance (in the ‘far field’)

[SOURCE: ISO 13320:2009, 3.1.6.]

6.7

light extinction

attenuation of a light beam traversing a medium through absorption and scattering

[SOURCE: ISO 13320:2009, 3.1.7.]

6.8

model matrix

matrix containing vectors of the scattered light signals for unit volumes of different size classes, scaled to the detector’s geometry, as derived from model computation

[SOURCE: ISO 13320:2009, 3.1.8.]

6.9

multiple scattering

consecutive scattering of light by more than one particle, causing a scattering pattern that is no longer the sum of the patterns from all individual particles

Note 1 to entry: See *single scattering* (6.20).

[SOURCE: ISO 13320:2009, 3.1.9.]

6.10

obscuration

optical concentration

fraction of incident light that is attenuated due to extinction (scattering and/or absorption) by particles

Note 1 to entry: Adapted from ISO 8130-14:2004, 2.21.

Note 2 to entry: Obscuration can be expressed as a percentage.

Note 3 to entry: When expressed as fractions, obscuration plus transmission equal unity.

[SOURCE: ISO 13320:2009, 3.1.10.]

6.11

optical model

theoretical model used for computing the model matrix for optically homogeneous and isotropic spheres with, if necessary, a specified complex refractive index

EXAMPLE Fraunhofer diffraction model, Mie scattering model.

[SOURCE: ISO 13320:2009, 3.1.11.]

6.12

light reflection

change of direction of a light wave at a surface without a change in wavelength or frequency

[SOURCE: ISO 13320:2009, 3.1.12.]

6.13

refraction

process by which the direction of a radiation is changed as a result of changes in its velocity of propagation in passing through an optically non-homogeneous medium, or in crossing a surface separating different media

Note 1 to entry: The process occurs in accordance with Snell's law: $n_\mathrm{m}\sin\theta_\mathrm{m} = n_\mathrm{p}\sin\theta_\mathrm{p}$

[SOURCE: IEC 60050-845:1987.]

6.14

repeatability

<instrument>closeness of agreement between multiple measurement results of a given property in the same dispersed sample aliquot, executed by the same operator in the same instrument under identical conditions within a short period of time

Note 1 to entry: This type of repeatability does not include variability due to sampling and dispersion.

[SOURCE: ISO 13320:2009, 3.1.14.]

6.15

repeatability

<method>closeness of agreement between multiple measurement results of a given property in different aliquots of a sample, executed by the same operator in the same instrument under identical conditions within a short period of time

Note 1 to entry: This type of repeatability includes variability due to sampling and dispersion.

[SOURCE: ISO 13320:2009, 3.1.15.]

6.16
reproducibility

<method>closeness of agreement between multiple measurement results of a given property in different aliquots of a sample, prepared and executed by different operators in similar instruments according to the same method

[SOURCE: ISO 13320:2009, 3.1.16.]

6.17
light scattering

change in propagation of light at the interface of two media having different optical properties

[SOURCE: ISO 13320:2009, 3.1.17.]

6.18
scattering angle

angle between the principal axis of the incident light beam and the scattered light

[SOURCE: ISO 13320:2009, 3.1.18.]

6.19
scattering pattern

angular pattern of light intensity, $I(\theta)$, or spatial pattern of light intensity, $I(r)$, originating from scattering, or the related energy values taking into account the sensitivity and the geometry of the detector elements

[SOURCE: ISO 13320:2009, 3.1.19.]

6.20
single scattering

scattering whereby the contribution of a single member of a particle population to the total scattering pattern remains independent of the other members of the population

[SOURCE: ISO 13320:2009, 3.1.20.]

6.21
single shot analysis

analysis, for which the entire content of a sample container is used

[SOURCE: ISO 13320:2009, 3.1.21.]

6.22
light transmission

fraction of incident light that remains unattenuated by the particles

Note 1 to entry: Transmission can be expressed as a percentage.

Note 2 to entry: When expressed as fractions, *obscuration* (6.10) plus transmission equal unity.

[SOURCE: ISO 13320:2009, 3.1.22.]

7 Dynamic light scattering

7.1
average particle diameter

x_{DLS}

harmonic intensity-weighted arithmetic average particle diameter

Note 1 to entry: Average particle diameter is expressed in nanometres. Typical average particle diameters are in the range 1 nm to about 1 000 nm.

Note 2 to entry: In ISO 13321:1996, the symbol x_{PCS} is used.

[SOURCE: ISO 22412:2008, 3.1, modified — Note 2 has been added.]

7.2
polydispersity index
PI
dimensionless measure of the broadness of the size distribution

Note 1 to entry: Adapted from ISO 13321:1996, 2.2.

Note 2 to entry: The *PI* typically has values less than 0,1 for a monodisperse test sample.

[SOURCE: ISO 22412:2008, 3.2.]

7.3
qualification
proof with reference material that an instrument is operating in agreement with its specifications

[SOURCE: ISO 22412:2008, 3.5.]

7.4
scattering volume
V
section of the incident laser beam viewed by the detector optics

Note 1 to entry: Adapted from ISO 13321:1996, 2.3.

[SOURCE: ISO 22412:2008, 3.3.]

7.5
scattered intensity
count rate
photocurrent
I_S
intensity of the light scattered by the particles in the scattering volume; in practice, a number of photon pulses per unit time or a photodetector current which is proportional to the scattered intensity as measured by a detector

[SOURCE: ISO 22412:2008, 3.4.]

7.6
validation
proof with reference material that a procedure is acceptable for all elements of its scope

[SOURCE: ISO 22412:2008, 3.6.]

8 Image analysis methods

8.1
binary image
digitized image consisting of an array of pixels, each of which has a value of 0 or 1, whose values are normally represented by dark and bright regions on the display screen or by the use of two distinct colours

[SOURCE: ISO 13322-1:2004, 3.1.3.]

8.2
connectivity
logical criteria for the connection of a pixel to neighbouring pixels

Note 1 to entry: For rectangular pixels, two neighbouring pixels share the same side, in which case it is called 4-connectivity. If they share the same corner, it is called 8-connectivity.

8.3

edge finding

one of many edge detection methods used to detect transition between objects and background

[SOURCE: ISO 13322-1:2004, 3.1.4.]

8.4

equivalent circular diameter

ecd

diameter of a circle having the same area as the projected image of the particle

Note 1 to entry: It is also known as the Haywood diameter.

[SOURCE: ISO 13322-1:2004, 3.1.7.]

8.5

Euler number

number of objects minus the number of holes inside the objects, which describes the connectedness of a region, not its shape

Note 1 to entry: A connected region is one in which all pairs of points may be connected by a curve lying entirely in the region. If a complex two-dimensional object is considered to be a set of connected regions, where each one can have holes, the Euler number for such an object is defined as; (number of connected regions) - (number of holes). The number of holes is one less than the connected regions in the set compliment of the object. Euler number should be reported together with the connectivity applied, i.e. 4-conenctivity or 8-connectivity.

[SOURCE: ISO 13322-1:2004, 3.1.5.]

8.6

Feret diameter

distance between two parallel tangents on opposite sides of the image of a particle

Note 1 to entry: Maximum diameter x_{Fmax} corresponding to the “length” of the particle and minimum diameter x_{Fmin} corresponding to the “breadth” of the particle.

[SOURCE: ISO 13322-1:2004, 3.1.6.]

8.7

grey image

image in which multiple grey level values are permitted for each pixel

[SOURCE: ISO 13322-1:2004, 3.1.8.]

8.8

image analysis

processing and data reduction operation which yields a numerical or logical result from an image

[SOURCE: ISO 13322-1:2004, 3.1.9.]

8.9

measurement frame

field in a view field in which particles are counted for image analysis

Note 1 to entry: The set of measurement frames composes the total measurement field.

[SOURCE: ISO 13322-1:2004, 3.1.2.]

8.10
numerical aperture
NA
product of the refractive index of the object space and the sine of the semi-aperture of the cone of rays entering the entrance pupil of the objective lens from the object point

[SOURCE: ISO 13322-1:2004, 3.1.10.]

8.11
pixel
picture element
individual sample in a digital image that has been formed by uniform sampling in both the horizontal and vertical directions

[SOURCE: ISO 13322-1:2004, 3.1.11.]

8.12
raster pattern
scanning order of measurement frames in the total measurement field

8.13
segmentation
part into which something can be divided; subdivision or section

[SOURCE: ISO 13322-1:2004, 3.1.12.]

8.14
threshold
grey level value which is set to discriminate objects of interest from background

[SOURCE: ISO 13322-1:2004, 3.1.14.]

8.15
view field
field which is viewed by a viewing device, e.g. optical microscope or electron scanning microscope

[SOURCE: ISO 13322-1:2004, 3.1.1.]

8.16
depth of field
region where the sharpness of the edges of the images reaches the pre-set optimum

[SOURCE: ISO 13322-2:2006, 3.1.6.]

8.17
flow-cell
measurement cell inside which the fluid-particle mixture flows

[SOURCE: ISO 13322-2:2006, 3.1.1.]

8.18
image capture device
matrix camera or line camera

[SOURCE: ISO 13322-2:2006, 3.1.7.]

8.19
measurement volume
volume in which particles are measured by an image analyser

[SOURCE: ISO 13322-2:2006, 3.1.5.]

8.20

orifice tube

tube with an aperture through which a stream of fluid with dispersed particles flows

[SOURCE: ISO 13322-2:2006, 3.1.2.]

8.21

particle illumination

continuous illumination for image capture device with an electronic exposure time controller, or illumination of short duration for synchronized image capture device

[SOURCE: ISO 13322-2:2006, 3.1.4.]

8.22

sheath flow

clean fluid flow surrounding particle-laden fluid for directing particles into a specific measurement zone

[SOURCE: ISO 13322-2:2006, 3.1.3.]

9 Single particle light interaction methods

9.1

aerosol spectrometer

instrument that measures the particle size with high size resolution and high size classification accuracy and that counts the measured particles depending on the size

Note 1 to entry: There are optical aerosol spectrometers (ISO 21501-1) and aerodynamic aerosol spectrometers.

Note 2 to entry: The typical sampling flow rate is about 0,5 to 5 l/min.

9.2

border zone error

particle sizing error that occurs when particles pass through the optical border of the sensing zone

[SOURCE: ISO 21501-1:2009, 3.10.]

9.3

coincidence error

probability of the presence of more than one particle inside the sensing zone simultaneously

Note 1 to entry: Coincidence error is related to particle number concentration and size of sensing zone.

[SOURCE: ISO 21501-1:2009, 3.8.]

9.4

counting efficiency

relation of the concentration determined from the counting rate of the measuring instrument and the real concentration at the inlet of the instrument in a specified size range

[SOURCE: ISO 21501-1:2009, 3.10.]

9.5

light scattering equivalent particle diameter

$x_{\mathrm{sca\,v}}$

equivalent diameter of a homogeneous sphere of a reference substance (e.g. latex) which scatters defined incident light with the same radiation efficiency into a defined solid angle element

[SOURCE: ISO 21501-1:2009, 3.5.]

9.6

number concentration distribution density

distribution density (frequency) of the particle number concentration represented as a function of the particle size

[SOURCE: ISO 21501-1:2009, 3.6.]

9.7

particle concentration

indication of, e.g. particle number, particle mass, particle surface related to the unit volume of the carrier gas or liquid

Note 1 to entry: For the exact concentration indication, information on the gaseous condition (temperature and pressure) or the reference to a standard volume indication is necessary.

[SOURCE: ISO 21501-1:2009, 3.7.]

9.8

calibration particles

mono-disperse spherical particles with a known mean particle size, e.g. polystyrene latex (PSL) particles, that are traceable to an international standard of length, and where the standard uncertainty of the mean particle size is equal to or less than 2,5 %

Note 1 to entry: The refractive index of polystyrene latex calibration particles is close to 1,59 at a wavelength of 589 nm (sodium D line).

[SOURCE: ISO 21501-3:2007, 2.1.]

9.9

particle counter

instrument that counts the number of particles and measures their size using the light scattering method or the light extinction method

[SOURCE: ISO 21501-2:2007, 2.3.]

9.10

pulse height analyser

instrument that analyses the distribution of pulse heights

[SOURCE: ISO 21501-3:2007, 2.4.]

9.11

size resolution

measure of the ability of an instrument to distinguish between particles of different sizes

[SOURCE: ISO 21501-2:2007, 2.5.]

10 Small angle X-Ray scattering method

10.1

small angle X-Ray scattering

SAXS

method in which the elastically scattered intensity of X-rays is measured for small-angle deflections

Note 1 to entry: The angular scattering is usually measured within the range 0,1° to 10°. This provides structural information on macromolecules as well as periodicity on length scales typically larger than 5 nm and less than 200 nm for ordered or partially ordered systems.

Note 2 to entry: Wide-angle X-ray scattering (WAXS) is an analogous technique, similar to X-ray crystallography, in which scattering at larger angles, which is sensitive to periodicity on smaller length scales, is measured.

Note 3 to entry: The X-ray source may be a synchrotron, in which case the term synchrotron radiation small-angle X-ray scattering (SRXAS) is occasionally encountered.

[SOURCE: ISO 18115-1:2010, 4.18.]

10.2
radius of gyration
R_g
square root of the ratio of the moment of inertia to the particle mass

Note 1 to entry: Guinier radius (i.e. radius of gyration) is expressed in nanometres. Typical average radii are in the range of 1 nm to 50 nm.

11 Sample preparation and reference materials

11.1
clump
assemblage of particles which are either rigidly joined or loosely coherent

[SOURCE: ISO 14887:2000, 3.3.]

11.2
critical micelle concentration
CMC
concentration of dispersing agent above which micelles will form

[SOURCE: ISO 14887:2000, 3.4.]

11.3
floc
assemblage of particles which are very loosely coherent

[SOURCE: ISO 14887:2000, 3.5.]

11.4
Tyndall effect
light scattered perpendicular to a beam of light passing through a liquid that contains particles

[SOURCE: ISO 14887:2000, 3.8.]

11.5
bias
estimate of a systematic measurement error

[SOURCE: ISO/IEC Guide 99:2007, 2.18.]

11.6
error
measured quantity value minus a reference quantity value

Note 1 to entry: Errors may have a random or a systematic nature.

[SOURCE: ISO/IEC Guide 99:2007, 2.16.]

11.7
grab sample
sample that has not been taken under well-defined conditions

[SOURCE: ISO 14488:2007, 3.5.]

11.8
gross sample
primary sample, composed of several sample increments

[SOURCE: ISO 14488:2007, 3.4.]

11.9
primary sample
sample (single or composed) taken from a defined bulk product

[SOURCE: ISO 14488:2007, 3.6.]

11.10
representative sample
sample that has the same properties as a defined batch of material and represents the bulk material, within a defined confidence limit

[SOURCE: ISO 14488:2007, 3.7.]

11.11
sample
part of a defined bulk product taken for the purpose of characterization

[SOURCE: ISO 14488:2007, 3.8.]

11.12
sample increment
single sample, taken from any of a defined set of locations in a bulk product or at any of a defined set of times from a production/ transportation line, to be mixed with other increments to form a gross sample

[SOURCE: ISO 14488:2007, 3.9.]

11.13
sampling sequence
sequence of sampling, sample division and combination steps that result in a test sample for a defined bulk product

[SOURCE: ISO 14488:2007, 3.10.]

11.14
spot sample
sample, taken at a defined location or production time, from a batch of material

[SOURCE: ISO 14488:2007, 3.11.]

11.15
test sample
sample that is entirely used for a property characterization

[SOURCE: ISO 14488:2007, 3.12.]

12 Electrical mobility and number concentration analysis for aerosol particles

12.1
aerosol
system of solid or liquid particles suspended in gas

[SOURCE: ISO 15900:2009, 2.1.]

12.2

attachment coefficient

attachment probability of ions and aerosol particles

[SOURCE: ISO 15900:2009, 2.2.]

12.3

condensation particle counter

CPC

instrument that measures the particle number concentration of an aerosol

Note 1 to entry: The sizes of particles detected are usually smaller than several hundred nanometres and larger than a few nanometres.

Note 2 to entry: A CPC is one possible detector for use with a DEMC.

Note 3 to entry: In some cases, a condensation particle counter may be called a condensation nucleus counter (CNC).

[SOURCE: ISO 15900:2009, 2.5.]

12.4

critical mobility

instrument parameter of a DEMC that defines the electrical mobility of aerosol particles that exit the DEMC in aerosol form, which may be defined by the geometry, aerosol and sheath air flow rates, and electrical field intensity

Note 1 to entry: Particles larger or smaller than the critical mobility migrate to an electrode or exit with the excess flow and do not exit from the DEMC in aerosol form.

[SOURCE: ISO 15900:2009, 2.6.]

12.5

differential electrical mobility classifier

DEMC

classifier that is able to select aerosol particles according to their electrical mobility and pass them to its exit

Note 1 to entry: A DEMC classifies aerosol particles by balancing the electrical force on each particle with its aerodynamic drag force in an electrical field. Classified particles are in a narrow range of electrical mobility determined by the operating conditions and physical dimensions of the DEMC, while they can have different sizes due to difference in the number of charges that they have.

[SOURCE: ISO 15900:2009, 2.7.]

12.6

differential mobility analysing system

DMAS

system to measure the size distribution of submicrometre aerosol particles consisting of a DEMC, flow meters, a particle detector, interconnecting plumbing, a computer and suitable software

[SOURCE: ISO 15900:2009, 2.8.]

12.7

electrical mobility

mobility of a charged particle in an electrical field

Note 1 to entry: Electrical mobility can be defined as the migration velocity dependent on the strength of the electrical field, the mechanical mobility and the number of charges per particle.

[SOURCE: ISO 15900:2009, 2.9.]

12.8
Knudsen number

Kn

ratio of gas molecular mean free path to the radius of the particle, which is an indicator of free molecular flow versus continuum gas flow

[SOURCE: ISO 15900:2009, 2.13.]

12.9
laminar flow

gas flow with no temporally or spatially irregular activity or turbulent eddy flow

[SOURCE: ISO 15900:2009, 2.14.]

12.10
migration velocity

steady-state velocity of a charged airborne particle within an externally applied electric field

[SOURCE: ISO 15900:2009, 2.15.]

12.11
Peclet number

Pe

dimensionless number representing the ratio of a particle's convective to diffusive transport

[SOURCE: ISO 15900:2009, 2.17.]

12.12
Reynolds number

Re

dimensionless number expressed as the ratio of the inertial force to the viscous force; for example, applied to an aerosol particle or a tube carrying aerosol particles

[SOURCE: ISO 15900:2009, 2.18.]

12.13
slip correction

Sc

dimensionless factor that is used to correct the drag force acting on a particle for non-continuum effects that become important when the particle size is comparable to or smaller than the mean free path of the gas molecules

[SOURCE: ISO 15900:2009, 2.19.]

12.14
Stokes' drag

drag force acting on a particle that is moving relative to a continuum fluid in the creeping flow (low Reynolds number) limit

[SOURCE: ISO 15900:2009, 2.21.]

12.15
system transfer function

transfer function defined as the ratio of the particle concentration at the particle concentration measurement detector of a DMAS to the particle concentration at the inlet of the DMAS, which is normally expressed as a function of electrical mobility

[SOURCE: ISO 15900:2009, 2.22.]

12.16

transfer function

ratio of particle concentration at the outlet of a DEMC to the particle concentration at the inlet of the DEMC, which is normally expressed as a function of electrical mobility

[SOURCE: ISO 15900:2009, 2.23.]

12.17

electrometer

device that measures electrical current ranging from about 1 femtoampere (fA) to about 10 picoamperes (pA)

[SOURCE: ISO 15900:2009, 2.10.]

12.18

Faraday-cup aerosol electrometer

FCAE

electrometer designed for the measurement of electrical charges carried by aerosol particles

Note 1 to entry: A Faraday-cup aerosol electrometer consists of an electrically conducting and electrically grounded cup as a guard to cover the sensing element that includes aerosol filtering media to capture charged aerosol particles, an electrical connection between the sensing element and an electrometer circuit, and a flow meter.

[SOURCE: ISO 15900:2009, 2.12.]

13 Electrical charge conditioning

13.1

space charge

net charge spatially distributed in a gas

[SOURCE: ISO 15900:2009, 2.20.]

13.2

charge neutralization

process that leaves the aerosol particles with a distribution of charges that is in equilibrium and makes the net charge of the aerosol nearly zero, which is usually achieved by exposing aerosol particles to an electrically neutral cloud of positive and negative gas charges

[SOURCE: ISO 15900:2009, 2.4.]

13.3

equilibrium charge distribution

charging condition for aerosol particles that is stable after exposure to bipolar ions for a sufficiently long period of time

Note 1 to entry: Bipolar ions are positive and negative ions which are produced by either a radioactive source or a corona discharge.

[SOURCE: ISO 15900:2009, 2.11.]

13.4

particle charge conditioner

device used to establish a known size-dependent charge distribution on the sampled aerosol of an unknown charging state, which is either a bipolar or unipolar charger

[SOURCE: ISO 15900:2009, 2.16.]

13.5
bipolar charger
device to attain the equilibrium steady state of charging by exposing aerosol particles to both positive and negative ions within the device

[SOURCE: ISO 15900:2009, 2.3.]

13.6
unipolar charger
device to attain a steady-state charge distribution of aerosol particles by exposing them to either positive or negative ions within the device

[SOURCE: ISO 15900:2009, 2.24.]

14 Acoustic methods

14.1
ultrasonic absorption
direct reduction of incident ultrasonic energy by means other than scattering

[SOURCE: ISO 20998-1:2006, 2.1, modified — "Ultrasonic" has been added to the term.]

14.2
attenuation
total reduction of incident ultrasonic energy, including both scattering and absorption

Note 1 to entry: The recommended measurement unit is the decibel (dB), which is defined as 10 times the common (base 10) logarithm of the ratio of incident intensity to transmitted intensity, or equivalently 20 times the common logarithm of the ratio of incident amplitude to transmitted amplitude. The Neper (Np) is a permitted alternative measurement unit based on the natural logarithm rather than the common logarithm. The conversion factor is 1 Np = 8,686 dB.

[SOURCE: ISO 20998-1:2006, 2.2, modified — The synonym "extinction" has not been included with the term.]

14.3
attenuation coefficient
extinction coefficient
attenuation (extinction) per unit length of ultrasonic propagation through a material, measured in units of dB/cm or Np/cm

Note 1 to entry: Attenuation coefficients are sometimes scaled by frequency, or frequency-squared, to identify the dominant attenuation mechanism. For clarity, in this part of ISO 20998, only the attenuation per unit length (in dB/cm) is considered.

[SOURCE: ISO 20998-1:2006, 2.3.]

14.4
attenuation spectrum
attenuation coefficient measured as a function of frequency

[SOURCE: ISO 20998-1:2006, 2.4.]

14.5
bandwidth
range of frequencies contained in an ultrasonic signal, typically measured as the frequency difference between the −3 dB points on a spectrum analyser

[SOURCE: ISO 20998-1:2006, 2.5.]

14.6
broadband
characterized as having a bandwidth that is equal to at least half of the centre frequency

[SOURCE: ISO 20998-1:2006, 2.6.]

14.7
digitization
act of generating a digital (quantized) representation of a continuous signal

Note 1 to entry: The number of bits determines the resolution (fidelity), and the sampling rate determines the bandwidth (Nyquist criterion).

[SOURCE: ISO 20998-1:2006, 2.7.]

14.8
excess attenuation
incremental attenuation caused by the presence of particles in the continuous phase

[SOURCE: ISO 20998-1:2006, 2.8.]

14.9
Fourier transform
mathematical transform that converts a time-varying signal into its frequency components, which is often implemented in computers as a Fast Fourier Transform (FFT) algorithm

[SOURCE: ISO 20998-1:2006, 2.9.]

14.10
interference
wave phenomenon of cancellation or enhancement observed when two or more waves overlap

[SOURCE: ISO 20998-1:2006, 2.10.]

14.11
intrinsic response
frequency-dependent response of the ultrasonic spectrometer itself

Note 1 to entry: This is not to be confused with the intrinsic absorption of the sample component materials.

[SOURCE: ISO 20998-1:2006, 2.11.]

14.12
path length
distance traversed by the ultrasonic wave between the emitting transducer and the receiver

[SOURCE: ISO 20998-1:2006, 2.12.]

14.13
pulse
wave of sufficiently short duration to contain broadband Fourier components

[SOURCE: ISO 20998-1:2006, 2.13.]

14.14
ultrasonic reflection
return of an ultrasonic wave at an interface or surface

[SOURCE: ISO 20998-1:2006, 2.14, modified — “Ultrasonic” has been added to the term.]

14.15
ultrasonic scattering
removal of ultrasonic energy from the incident wave by redirection

[SOURCE: ISO 20998-1:2006, 2.15, modified — “Ultrasonic” has been added to the term.]

14.16
spectrum
frequency components of a signal, typically arranged as magnitude versus frequency

[SOURCE: ISO 20998-1:2006, 2.16.]

14.17
tone-burst
short duration of a few (typically 5–10) cycles of a sinusoidal wave

[SOURCE: ISO 20998-1:2006, 2.17, modified — The term has been hyphenated and the accompanying note relating to the typical number of cycles incorporated into the definition.]

14.18
transducer
device for generating ultrasound from an electrical signal or vice versa

Note 1 to entry: Piezoelectric devices are commonly used for this purpose.

[SOURCE: ISO 20998-1:2006, 2.18.]

14.19
ultrasonic transmission
passage of ultrasound through a sample

[SOURCE: ISO 20998-1:2006, 3.21, modified — “Ultrasonic” has been added to the term.]

14.20
transmission spectrum
the transmission value measured as a function of frequency

[SOURCE: ISO 20998-1:2006, 2.20.]

14.21
transmission value
amplitude of an ultrasonic signal (or a component thereof) that has been transmitted through a sample; measured in volts or arbitrary units

[SOURCE: ISO 20998-1:2006, 2.21.]

14.22
ultrasound
high frequency (over 20 kHz) sound waves which propagate through fluids and solids

Note 1 to entry: The range employed in particle characterization is typically 100 kHz to 100 MHz.

[SOURCE: ISO 20998-1:2006, 2.22.]

14.23
wave
fluctuation (e.g. pressure, shear, or thermal) that propagates through a physical medium

[SOURCE: ISO 20998-1:2006, 2.23.]

14.24
waveform
shape of the wave when seen on an oscilloscope or digitized display

[SOURCE: ISO 20998-1:2006, 2.24.]

14.25
wavelength
length of a wave, determined by the distance between corresponding points on successive waves

[SOURCE: ISO 20998-1:2006, 2.25.]

15 Focused beam methods

15.1
focused beam reflectance method
method whose probe uses a focused light beam passing particles in a suspension or aerosol and which measures a chord length distribution (CLD) different from a particle size distribution (PSD)

Note 1 to entry: In order to compare results obtained by an FBRM probe with other measurement technologies such as laser diffraction, it is necessary to reconstruct the PSD from a measured CLD.

16 Characterization of particle dispersion in liquids

16.1
agglomeration
coagulation
flocculation
assembly of particles in a dispersed system into loosely coherent structures that are held together by weak physical interactions

Note 1 to entry: Agglomeration is a reversible process.

Note 2 to entry: The synonym “flocculation” has been frequently used to denote agglomeration facilitated by the addition of a flocculating agent (e.g. a polyelectrolyte).

16.2
aggregation
assembly of particles into rigidly joined structures

Note 1 to entry: Aggregation is an irreversible process.

Note 2 to entry: The forces holding an aggregate together are strong, for example covalent bonds, or those resulting from sintering or complex physical entanglement.

Note 3 to entry: In common use, the terms aggregation and agglomeration are often applied interchangeably.

16.3
coalescence
disappearance of the boundary between two particles (usually droplets or bubbles) in contact, or between one of these and a bulk phase followed by changes of shape leading to a reduction of the total surface area

Note 1 to entry: The flocculation of an emulsion, viz. the formation of aggregates, may be followed by coalescence.

16.4
creaming
rise (separation) of the dispersed phase in an emulsion due to the lower density of the dispersed phase (droplets) compared to the continuous phase

Note 1 to entry: Creaming velocity has a negative sign as particle movement is opposite to the acting force.

16.5
dispersion
microscopic multi-phase system in which discontinuities of any state (solid, liquid or gas: discontinuous phase) are dispersed in a continuous phase of a different composition or state

Note 1 to entry: If solid particles are dispersed in a liquid, the dispersion is referred to as a suspension. If the dispersion consists of two or more liquid phases, it is termed an emulsion. A *suspoemulsion* consists of both solid and liquid phases dispersed in a continuous liquid phase.

16.6
dispersion stability
ability to resist change or variation in the initial properties (state) of a dispersion over time; quality of a dispersion in being free from alterations over a given time scale.

Note 1 to entry: In this context, e.g. agglomeration or creaming represents a loss of dispersion stability.

16.7
flotation
migration of a dispersed solid phase to the top of a liquid continuous phase, when the effective particle density is lower relative to the continuous phase density

Note 1 to entry: May be facilitated by adhering gas bubbles, for example dissolved air flotation, or the application of lipophilic surfactants (e.g. in ore processing).

16.8
Ostwald ripening
dissolution of small particles and the redeposition of the dissolved species on the surfaces of larger particles

Note 1 to entry: The process occurs because smaller particles have a higher surface energy, hence higher total Gibbs energy, than larger particles, giving rise to an apparent higher solubility.

16.9
phase inversion
phenomenon whereby the phases of a liquid-liquid dispersion (emulsion) interchange such that the dispersed phase spontaneously inverts to become the continuous phase, and vice versa, under conditions determined by the system properties, volume ratio and energy input

16.10
phase separation
process by which a macroscopically homogeneous suspension, emulsion or foam separates into two or more new phases

16.11
sedimentation
settling (separation) of the dispersed phase due to the higher density of the dispersed particles compared to the continuous phase

Note 1 to entry: The accumulation of the dispersed phase at the bottom of the container is evidence that sedimentation has taken place.

Note 2 to entry: In the case of a dispersed liquid (emulsion), droplets can sediment if their density is higher than that of the continuous liquid phase (e.g. water in oil emulsion).

16.12
shelf life
recommended time period during which products (dispersions) can be stored and the defined quality of a specified property of the product remains acceptable under expected (or specified) conditions of distribution, storage, display and usage

17 Methods for zeta potential determination

17.1
electric double layer
EDL
spatial distribution of electric charges that appears on and at the vicinity of the surface of an object when it is placed in contact with a liquid

17.1.1
Debye–Hückel approximation
model assuming small electric potentials in the electric double layer

[SOURCE: ISO 13099-1:2012, 2.1.1.]

17.1.2
Debye length
κ^{-1}
characteristic length of the electric double layer in an electrolyte solution

Note 1 to entry: The Debye length is expressed in nanometres.

[SOURCE: ISO 13099-1:2012, 2.1.2.]

17.1.3
diffusion coefficient
D
mean squared displacement of a particle per unit time

[SOURCE: ISO 13099-1:2012, 2.1.3.]

17.1.4
Dukhin number
Du
dimensionless number which characterizes contribution of the surface conductivity in electrokinetic and electroacoustic phenomena, as well as in conductivity and dielectric permittivity of heterogeneous systems

[SOURCE: ISO 13099-1:2012, 2.1.4.]

17.1.5
dynamic viscosity
η
ratio between the applied shear stress and the rate of shear of a liquid

Note 1 to entry: For the purposes of this part of ISO 13099, dynamic viscosity is used as a measure of the resistance of a fluid which is being deformed by shear stress.

Note 2 to entry: Dynamic viscosity determines the dynamics of an incompressible Newtonian fluid.

Note 3 to entry: Dynamic viscosity is expressed in pascal seconds.

[SOURCE: ISO 13099-1:2012, 2.1.5.]

17.1.6
electric surface charge density
σ
charges on an interface per area due to specific adsorption of ions from the liquid bulk, or due to dissociation of the surface groups

Note 1 to entry: Electric surface charge density is expressed in coulombs per square metre.

[SOURCE: ISO 13099-1:2012, 2.1.6.]

17.1.7
electric surface potential
ψ^{s}
difference in electric potential between the surface and the bulk liquid

Note 1 to entry: Electric surface potential is expressed in volts.

[SOURCE: ISO 13099-1:2012, 2.1.7.]

17.1.8
zeta-potential
electrokinetic potential
ζ-potential
ζ
difference in electric potential between that at the slipping plane and that of the bulk liquid

Note 1 to entry: Electrokinetic potential is expressed in volts.

[SOURCE: ISO 13099-1:2012, 2.1.8.]

17.1.9
Gouy–Chapman–Stern model
model describing the electric double layer

[SOURCE: ISO 13099-1:2012, 2.1.9.]

17.1.10
isoelectric point
condition of liquid medium, usually the value of pH, that corresponds to zero zeta-potential of dispersed particles

[SOURCE: ISO 13099-1:2012, 2.1.10.]

17.1.11
slipping plane
shear plane
abstract plane in the vicinity of the liquid/solid interface where liquid starts to slide relative to the surface under influence of a shear stress

[SOURCE: ISO 13099-1:2012, 2.1.11.]

17.1.12
Stern potential
ψ^{d}
electric potential on the external boundary of the layer of specifically adsorbed ions

Note 1 to entry: Stern potential is expressed in volts.

[SOURCE: ISO 13099-1:2012, 2.1.12.]

17.1.13
Brownian motion
random movement of particles suspended in a liquid cause by thermal movement of medium molecules

[SOURCE: ISO 13099-2:2012, 3.1.1.]

17.1.14
Doppler shift
change in frequency and wavelength of a wave for an observer moving relative to the source of the wave

[SOURCE: ISO 13099-2:2012, 3.1.2.]

17.1.15

electroosmosis

motion of liquid through or past a charged surface, e.g. an immobilized set of particles, a porous plug, a capillary or a membrane, in response to an applied electric field, which is the result of the force exerted by the applied field on the countercharge ions in the liquid

[SOURCE: ISO 13099-1:2012, 2.2.1.]

17.1.16

electroosmotic velocity

v_{eo}

uniform velocity of the liquid far from the charged interface

Note 1 to entry: Electroosmotic velocity is expressed in metres per second.

[SOURCE: ISO 13099-2:2012, 3.1.6.]

17.1.17

electrophoretic mobility

μ_{e}

electrophoretic velocity per electric field strength

Note 1 to entry: Electrophoretic mobility is positive if the particles move toward lower potential (negative electrode) and negative in the opposite case.

Note 2 to entry: Electrophoretic mobility is expressed in metres squared per volt second.

[SOURCE: ISO 13099-1:2012, 2.2.5.]

17.1.18

electrophoretic velocity

v_{e}

particle velocity during electrophoresis

Note 1 to entry: Electrophoretic velocity is expressed in metres per second.

[SOURCE: ISO 13099-1:2012, 2.2.3.]

17.2 Electrokinetic phenomena

NOTE Electrokinetic phenomena are associated with tangential liquid motion adjacent to a charged surface.

17.2.1

electroosmotic counter-pressure

Δp_{eo}

pressure difference that is applied across the system to stop the electroosmotic flow

[SOURCE: ISO 13099-1:2012, 2.2.2.]

17.2.2

electrophoresis

movement of charged colloidal particles or polyelectrolytes, immersed in a liquid, under the influence of an external electric field

[SOURCE: ISO 13099-1:2012, 2.2.4.]

17.2.3
sedimentation potential
U_{sed}
potential difference sensed by two electrodes placed some vertical distance apart in a suspension in which particles are sedimenting under the effect of gravity

Note 1 to entry: When the sedimentation is produced by a centrifugal field, the phenomenon is called centrifugation potential.

Note 2 to entry: Sedimentation potential is expressed in volts.

[SOURCE: ISO 13099-1:2012, 2.2.1.]

17.2.4
streaming current
I_{str}
current through a porous body resulting from the motion of fluid under an applied pressure gradient

Note 1 to entry: Streaming current is expressed in amperes.

[SOURCE: ISO 13099-1:2012, 2.2.1.]

17.2.5
streaming current density
J_{str}
streaming current per area

Note 1 to entry: Streaming current density is expressed in coulombs per square metre.

[SOURCE: ISO 13099-1:2012, 2.2.1.]

17.2.6
streaming potential
U_{str}
potential difference at zero electric current, caused by the flow of liquid under a pressure gradient through a capillary, plug, diaphragm or membrane

Note 1 to entry: Streaming potentials are created by charge accumulation caused by the flow of countercharges inside capillaries or pores.

Note 2 to entry: Streaming potential is expressed in volts.

[SOURCE: ISO 13099-1:2012, 2.2.1.]

17.2.7
surface conductivity
K^{σ}
excess electrical conduction tangential to a charged surface

Note 1 to entry: Surface conductivity is expressed in siemens.

[SOURCE: ISO 13099-1:2012, 2.2.1.]

17.3 Electroacoustic phenomena

NOTE Electroacoustic phenomena arise from the coupling between the ultrasound field and electric field in a liquid that contains ions. Either of these fields can be primary driving force. Liquid might be a simple Newtonian liquid or complex heterogeneous dispersion, emulsion or even a porous body. There are several different electroacoustic effects, depending on the nature of the liquid and type of the driving force.

17.3.1
colloid vibration current
CVI

I_{CVI}

a.c. current generated between two electrodes, placed in a dispersion, if the latter is subjected to an ultrasonic field

[SOURCE: ISO 13099-1:2012, 2.3.1.]

17.3.2
colloid vibration potential
CVU

a.c. potential difference generated between two electrodes, placed in a dispersion, if the latter is subjected to an ultrasonic field

Note 1 to entry: Colloid vibration potential is expressed in volts.

[SOURCE: ISO 13099-1:2012, 2.3.1.]

17.3.3
electrokinetic sonic amplitude
ESA

A_{ESA}

amplitude is created by an a.c. electric field in a dispersion with electric field strength, E; it is the counterpart of the colloid vibration potential method

Note 1 to entry: Electrokinetic sonic amplitude is expressed in pascals.

[SOURCE: ISO 13099-1:2012, 2.3.1.]

17.3.4
ion vibration current
IVI

a.c. electric current created from different displacement amplitudes in an ultrasound wave due to the difference in the effective mass or friction coefficient between anion and cation

Note 1 to entry: Ion vibration current is expressed in amperes.

[SOURCE: ISO 13099-1:2012, 2.3.1.]

17.3.5
streaming vibration current
SVI

streaming current that arises in a porous body when ultrasound wave propagates through it

Note 1 to entry: A similar effect can be observed at a non-porous surface, when sound is bounced off at an oblique angle.

Note 2 to entry: Streaming vibration current is expressed in amperes.

[SOURCE: ISO 13099-1:2012, 2.3.1.]

17.3.6
seismoelectric effect
SEI

non-isochoric streaming current that arises in a porous body when an ultrasound wave propagates through

Note 1 to entry: A similar effect can be observed at a non-porous surface, when sound is bounced off at an oblique angle.

Note 2 to entry: Seismoelectric effect is expressed in amperes.

17.3.7

electroseismic effect

ESI

non-isochoric electroosmotic pressure wave that arises in a porous body under influence of high frequency electric field

Note 1 to entry: Electroseismic effect is expressed in pascals.

17.3.8

dynamic electrophoretic mobility

μ_d

the electrophoretic velocity per unit electric field strength in high frequency (MHz) electric field

Note 1 to entry: Traditional electrophoretic mobility is low frequency asymptotic of the dynamic electrophoretic mobility.

Note 2 to entry: Electrophoretic mobility is expressed in metres squared per volt second.

Annex A
(informative)

Alphabetical index