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**Particle characterization of particulate  
systems — Vocabulary**

*Caractérisation des particules dans les systèmes particulaires —  
Vocabulaire*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 24, *Particle characterization including sieving*, Subcommittee SC 4, *Particle characterization*.

This second edition cancels and replaces the first edition (ISO 26824:2013), which has been technically revised.

The main changes are as follows:

- All definition clauses have been rearranged as subclauses in [Clause 3](#) and all terms and clauses have been renumbered.
- Latest revisions and documents from ISO/TC 24/SC 4 have been incorporated, as well as harmonization with ISO/TC 229 general definitions.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

Since the last revision of this document in 2013, about 24 ISO standards have been published by ISO/TC 24/SC 4 and about 15 projects are currently under construction together with the 5-year revision of the existing standards. Therefore, terms and definitions of each standard, which are relevant for other standards should be collected and adjusted to a uniform nomenclature.

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

The structuring and presentation rules applied to the terminological entries are based on a clause structure, which represents the methods of sample preparation, measurement results presentation and the analysis methods, starting with more general terms in each clause.

The clause headlines address "Terms related to" technical fields, which are understood as a kind of domain with validity of the definitions limited to the indicated field.

The following particle properties are covered in the clauses given in brackets:

- particle size ([3.1](#), [3.4](#) to [3.10](#), [3.12](#) to [3.15](#))
- particle shape ([3.2](#), [3.8](#))
- particle number concentration ([3.5](#), [3.9](#) and [3.12](#))
- pore size, pore volume ([3.3](#))
- surface area ([3.3](#), [3.10](#))
- electrical charge in aerosols ([3.13](#))
- zeta potential in liquid dispersion ([3.17](#))
- particle dispersion in liquids ([3.16](#)).

Data uncertainty related definitions are given in [3.1](#) and [3.11](#)

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# Particle characterization of particulate systems — Vocabulary

## 1 Scope

This document defines terms that are relevant to the characterization of particles and particulate systems. This document includes 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 such measurement methods as sedimentation, classification, acoustic methods, laser diffraction, dynamic light scattering, single particle light interaction methods, differential electrical mobility analysis, image analysis and others in a size scale from nanometre to millimetre.

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

### 3.1 Terms related to representation of size and classification analysis data

#### 3.1.1 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* (3.1.7).

[SOURCE: ISO 26824:2013, 1.1]

#### 3.1.2 agglomerate

collection of weakly or medium strongly bound *particles* (3.1.1) 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* (3.1.4).

[SOURCE: ISO 26824:2013, 1.2]

3.1.3

**aggregate**

*particle* (3.1.1) 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* (3.1.4).

Note 2 to entry: Aggregates are also termed secondary particles and the original source particles are termed *primary particles* (3.1.4).

[SOURCE: ISO 26824:2013, 1.3]

3.1.4

**primary particle**

original source *particle* (3.1.1) of *agglomerates* (3.1.2) or *aggregates* (3.1.3) or mixtures of the two

Note 1 to entry: *Constituent particles* (3.1.5) of *agglomerates* (3.1.2) or *aggregates* (3.1.3) at a certain actual state can be primary particles, but often the constituents are aggregates.

Note 2 to entry: *Agglomerates* (3.1.2) and *aggregates* (3.1.3) are also termed secondary particles.

[SOURCE: ISO 26824:2013, 1.4]

3.1.5

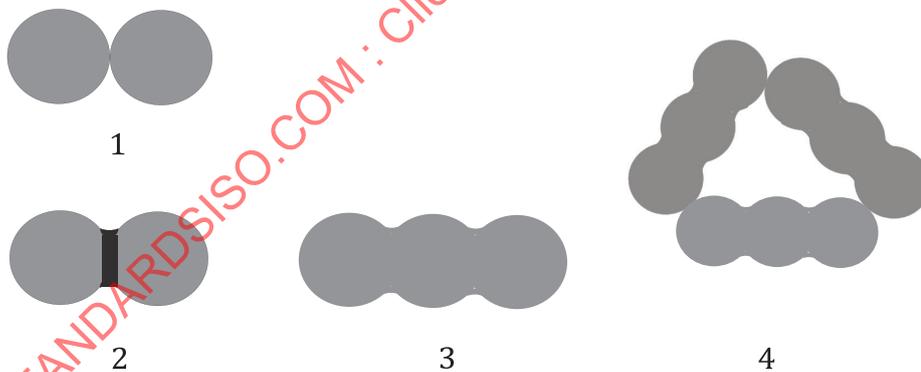
**constituent particle**

identifiable, integral component of a larger *particle* (3.1.1)

Note 1 to entry: The constituent particle structures may be *primary particles* (3.1.4) or *aggregates* (3.1.3).

Note 2 to entry: See [Figure 1](#).

Note 3 to entry: Constituent particles are considered as the smallest dispersible units of a large particle.



**Key**

- 1 agglomerate - constituent particles are identical to primary particles
- 2 aggregate with covalent bond - constituent particles are identical to primary particles
- 3 aggregate, produced from initially formed, primary particles (of approximately 10 or more times smaller size than the widths of the aggregate) which coalesce during the pyrogenic process and sinter into long chains (the visible large circle-like parts never existed as isolated particles before)
- 4 example of an agglomerate, formed from aggregates (key 3), which are the constituent particles-

**Figure 1 — Examples for agglomerates and aggregates of constituent particles and primary particles (not identifiable as such in all cases)**

[SOURCE: ISO/TS 80004-2:2015, 3.3, modified — Figure 1 has been added, Note 1 has been modified, Note 2 and 3 have been added]

**3.1.6****nanoscale**

length range approximately from 1 nm to 100 nm

Note 1 to entry: Properties that are not extrapolations from larger sizes are predominantly exhibited in this length range.

[SOURCE: ISO/TS 80004-1:2015, 2.1]

**3.1.7****nano-object**

discrete piece of material with one, two or three external dimensions in the *nanoscale* (3.1.6)

Note 1 to entry: The second and third external dimensions are orthogonal to the first dimension and to each other.

[SOURCE: ISO/TS 80004-1:2015, 2.5]

**3.1.8****nanomaterial**

material with any external dimension in the *nanoscale* (3.1.6) or having internal structure or surface structure in the nanoscale

[SOURCE: ISO/TS 80004-1:2015, 2.4]

**3.1.9****particle size**

$x$

$d$

linear dimension of a *particle* (3.1.1) 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* (3.1.10).

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 the symbol ' $x$ ' is used to denote the particle size. However, it is recognised that the symbol ' $d$ ' is also widely used to designate these values. Therefore the symbol ' $x$ ' may be replaced by ' $d$ '. [ISO 9276-1:1998, 3.1]

[SOURCE: ISO 9276-1:1998, 4.2, modified – text reformatted]

**3.1.10****equivalent diameter****equivalent spherical diameter**

diameter of a sphere that produces a response by a given particle-sizing method, that is equivalent to the response produced by the *particle* (3.1.1) being measured

Note 1 to entry: The physical property to which the equivalent diameter refers is indicated using a suitable subscript [ISO 9276-1:1998].

Note 2 to entry: For discrete-particle-counting, light-scattering instruments, an equivalent optical diameter is used.

Note 3 to entry: Other material constants like density of the particle are used for the calculation of the equivalent diameter like Stokes diameter or sedimentation equivalent diameter. The material constants, used for the calculation, should be reported additionally.

Note 4 to entry: For inertial instruments, the aerodynamic diameter is used. Aerodynamic diameter is the diameter of a sphere of density  $1\,000\text{ kg m}^{-3}$  that has the same settling velocity as the irregular particle.

[SOURCE: ISO/TS 80004-6:2021, 4.1.5]

**3.1.11**  
**type of quantity**

$r$   
specification of the quantity of a distribution, a *cumulative* (3.1.13) or a *density* measure (3.1.14).

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]

**3.1.12**  
**particle size distribution**

distribution of *particles* (3.1.1) as a function of *particle size* (3.1.9)

Note 1 to entry: Particle size distribution may be expressed as *cumulative distribution* (3.1.13) or a *distribution density* (3.1.14) (distribution of the fraction of material in a size class, divided by the width of that class).

[SOURCE: ISO/TS 80004-6:2013, 3.1.2]

**3.1.13**  
**cumulative distribution**

$Q_r(x)$   
distribution of the fraction of material smaller (undersize) than given *particle sizes* (3.1.9)

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 %.

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

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 equation holds:

$$Q_r(x) = Q_r(\ln x)$$

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

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

### 3.1.14 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* (3.1.13),  $Q_r(x)$ , is differentiable, the continuous distribution density,  $q_r(x)$ , is obtained from

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

Conversely, the *cumulative distribution* (3.1.13),  $Q_r(x)$ , 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: The more common term “density distribution” can be misunderstood in the context of sedimentation methods, so an alternative has been adopted.

Note 3 to entry: Differential distribution is also called in statistics “density of a probability or frequency”

[SOURCE: ISO 9276-1:1998, 5.3, modified – “density distribution” replaced with “distribution density”]

### 3.1.15 distribution density on a logarithmic abscissa

$q_r^*(x)$

*distribution density* (3.1.14), transformed for a logarithmic abscissa

Note 1 to entry: The density values of a histogram:  $q_{r,i}^* = q_r^*(x_{i-1}, x_i)$ , can be recalculated using the following equation 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.

$$q_r^*(\xi_{i-1}, \xi_i) \Delta \xi_i = \bar{q}_r(x_{i-1}, x_i) \Delta x_i \text{ where } \xi \text{ is any function of } x.$$

Thus the following transformation can be carried out to obtain the distribution density on a logarithmic abscissa

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

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

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

### 3.1.16 histogram

graphical representation of a *distribution density*  $q_r(x)$  (3.1.14), comprising a successive series of rectangular columns with the height of mean distribution density,  $\bar{q}_{r,i}(x)$ , and the width of  $\Delta x_i$ , the area of each represents the relative quantity  $\Delta Q_{r,i}(x)$ , where

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

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

### 3.1.17

#### 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* (3.1.14) function of the *particle size* (3.1.9) by multiplication with the overall sizes measured concentration.

### 3.1.18

#### 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]

### 3.1.19

#### equiprobable cut size

$x_e$   
cut size, which represents the median of the *grade efficiency* (3.1.20) 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* (3.1.9), particles of this size have the equal probability to be classified into the fine and into the coarse fraction.

[SOURCE: ISO 9276-4:2001, 3.3.2]

### 3.1.20

#### grade efficiency

$T(x)$   
grade efficiency (Tromp's curve, Partial classification efficiency) represents for a certain *particle size* (3.1.9)  $x$  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.

[SOURCE: ISO 9276-4:2001, 4.4]

Note 1 to entry: In the dust collection field this efficiency is called as Partial separation efficiency.

### 3.1.21

#### reference material

##### RM

material, sufficiently homogeneous and stable with respect to one or more specified properties, which has been established to be fit for its intended use in a measurement process

Note 1 to entry: RM is a generic term.

Note 2 to entry: Properties can be quantitative or qualitative, e.g. identity of substances or species.

Note 3 to entry: Uses may include the calibration of a measurement system, assessment of a measurement procedure, assigning values to other materials, and quality control.

Note 4 to entry: ISO/IEC Guide 99:2007 has an analogous definition but restricts the term “measurement” to apply to quantitative values. However, ISO/IEC Guide 99:2007, 5.13, Note 3 (VIM), specifically includes qualitative properties, called “nominal properties”.

[SOURCE: ISO Guide 35:2017, 3.1]

### 3.1.22 certified reference material CRM

*reference material* (3.1.21) characterised by a metrologically valid procedure for one or more specified properties, accompanied by an RM certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability

Note 1 to entry: The concept of value includes a nominal property or a qualitative attribute such as identity or sequence. Uncertainties for such attributes may be expressed as probabilities or levels of confidence.

Note 2 to entry: Metrologically valid procedures for the production and certification of RMs are given in, among others, ISO 17034 and ISO Guide 35.

Note 3 to entry: ISO Guide 31 gives guidance on the contents of RM certificates.

Note 4 to entry: ISO/IEC Guide 99:2007, 5.14 has an analogous definition.

[SOURCE: ISO Guide 35:2017, 3.2]

### 3.1.23 accuracy

closeness of agreement between a test result or measurement result and the *true value* (3.1.26)

Note 1 to entry: In practice, the accepted reference value is substituted for the *true value* (3.1.26).

Note 2 to entry: The term “accuracy”, when applied to a set of test or measurement results, involves a combination of random components and a common systematic error or bias component.

Note 3 to entry: Accuracy refers to a combination of *trueness* (3.1.25) and *precision* (3.1.24).

[SOURCE: ISO 3534-2:2006, 3.3.1]

### 3.1.24 precision

closeness of agreement between independent test/measurement results obtained under stipulated conditions

Note 1 to entry: Precision depends only on the distribution of random errors and does not relate to the *true value* (3.1.26) or the specified value.

Note 2 to entry: The measure of precision is usually expressed in terms of imprecision and computed as a standard deviation of the test results or measurement results. Less precision is reflected by a larger standard deviation.

Note 3 to entry: Quantitative measures of precision depend critically on the stipulated conditions. *Repeatability conditions* (3.1.28) and reproducibility conditions are particular sets of extreme stipulated conditions.

[SOURCE: ISO 3534-2:2006, 3.3.4]

### 3.1.25 trueness

closeness of agreement between the expectation of a test result or a measurement result and a *true value* (3.1.26)

Note 1 to entry: The measure of trueness is usually expressed in terms of bias.

Note 2 to entry: Trueness is sometimes referred to as “accuracy of the mean”. This usage is not recommended.

Note 3 to entry: In practice, the accepted reference value is substituted for the true value.

[SOURCE: ISO 3534-2:2006, 3.3.3]

### 3.1.26

#### **true value**

value which characterizes a quantity or quantitative characteristic perfectly defined in the conditions which exist when that quantity or quantitative characteristic is considered

Note 1 to entry: The true value of a quantity or quantitative characteristic is a theoretical concept and, in general, cannot be known exactly.

Note 2 to entry: For an explanation of the term "quantity", refer to ISO 3534-2:2006, Note 1 of [3.2.1](#).

[SOURCE: ISO 3534-2:2006, 3.2.5]

### 3.1.27

#### **repeatability**

precision under *repeatability conditions* ([3.1.28](#))

Note 1 to entry: Repeatability can be expressed quantitatively in terms of the dispersion characteristics of the results.

[SOURCE: ISO 13320:2020, 3.1.20]

### 3.1.28

#### **repeatability conditions**

observation conditions where independent test/measurement results are obtained with the same method on identical test/measurement items in the same test or measuring facility by the same operator using the same equipment within short intervals of time

Note 1 to entry: Repeatability conditions include the following:

- the same measurement procedure or test procedure;
- the same operator;
- the same measuring or test equipment used under the same conditions;
- the same location;
- repetition over a short period of time.

[SOURCE: ISO 3534-2:2006, 3.3.6]

### 3.1.29

#### **method repeatability**

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

Note 1 to entry: The variability includes the variabilities of sub sampling technique, of the sampled material together and of the instrument.

[SOURCE: ISO 13320:2020, 3.1.22]

## 3.2 Terms related to representation of particle shape

### 3.2.1

#### particle shape

external geometric form of a *particle* (3.1.1)

Note 1 to entry: Macroshape is a description of the overall form of a *particle* (3.1.1) 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/TS 80004-6: 2021, 4.1.3, modified — Notes 1 to 3 have been added from ISO 9276-6:2008, 5.2]

### 3.2.2

#### 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]

### 3.2.3

#### geodesic length and thickness

$x_{LG}$  and  $x_E$

approximations for very long and concave *particles* (3.1.1), 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]

### 3.2.4

#### ellipse ratio

ratio of the lengths of the axes of the *Legendre ellipse of inertia* (3.2.3)

Note 1 to entry: Macroshape descriptor, proportion descriptor

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

### 3.2.5

#### Feret diameter

$x_F$

distance between two parallel tangents on opposite sides of the image of a *particle* (3.1.1)

[SOURCE: ISO 13322-1:2014, 3.1.5]

### 3.2.6

#### aspect ratio

ratio of the minimum *Feret diameter* to the maximum *Feret diameter* (3.2.5)

Note 1 to entry: For not very elongated particles (approximately smaller than 1:3)

Note 2 to entry: Macroshape descriptor, proportion descriptor

[SOURCE: ISO 9276-6:2008, 8.1.3, modified — 'Ferret diameter' is inserted after 'minimum.']

### 3.2.7

#### **elongation**

ratio of the geodesic thickness to the *geodesic length* (3.2.3)

Note 1 to entry: For very elongated particles (approximately greater than 1:3), such as fibres

Note 2 to entry: Macroshape descriptor, proportion descriptor

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

### 3.2.8

#### **straightness**

ratio of the maximum *Feret diameter* (3.2.5) to the *geodesic length* (3.2.3)

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]

### 3.2.9

#### **irregularity**

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

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

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

### 3.2.10

#### **compactness**

$s$

degree to which the projection area  $A$  of the *particle* (3.1.1) is similar to a circle, considering the overall form of the *particle* (3.1.1) with the maximum *Feret diameter* (3.2.5)  $x_{\text{Fmax}}$  :

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

Note 1 to entry: Macroshape descriptor, proportion descriptor

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

### 3.2.11

#### **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]

### 3.2.12

#### **sphericity**

$\Psi$

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  $\Psi$ , also derived from surface area  $S$

Note 2 to entry: Mesoshape descriptor

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

### 3.2.13 circularity

$C$

degree to which the projection area of the *particle* (3.1.1)  $A$  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]

### 3.2.14 solidity

$S_1$

ratio of the projected area  $A$  to the the area of the convex hull  $A_C$  (envelope)

$$S_1 = A / A_C$$

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]

## 3.3 Terms related to pore size distribution, porosity and surface area analysis

### 3.3.1 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]

### 3.3.2 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]

### 3.3.3 specific surface area

absolute surface area of the sample divided by sample mass

[SOURCE: ISO 9277:2010, 3.15]

### 3.3.4 blind pore

dead end pore

open pore having a single connection with an external surface

Note 1 to entry: also called dead-end-pore

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

### 3.3.5

#### **closed pore**

pore totally enclosed by its walls and hence not interconnecting with other pores and not accessible to fluids

[SOURCE: ISO 15901-1:2016, 3.10]

### 3.3.6

#### **open pore**

pore not totally enclosed by its walls and open to the surface either directly or by interconnecting with other pores and therefore accessible to fluid

[SOURCE: ISO 15901-1:2016, 3.11]

### 3.3.7

#### **open porosity**

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

[SOURCE: ISO 15901-2:2006, 3.17]

### 3.3.8

#### **contact angle**

angle at which a liquid/vapour interface meets the surface of a solid material

[SOURCE: ISO 15901-1:2016, 3.32]

### 3.3.9

#### **ink bottle pore**

narrow necked open pore

[SOURCE: ISO 15901-1:2016, 3.12]

### 3.3.10

#### **interconnected pore**

pore which communicates with one or more other pores

[SOURCE: ISO 15901-2:2006, 3.9]

### 3.3.11

#### **intraparticle porosity**

ratio of the volume of open pores inside the individual particles of a particulate or divided solid sample to the bulk volume occupied by the sample

[SOURCE: ISO 15901-1:2016, 3.29]

### 3.3.12

#### **interparticle porosity**

ratio of the volume of void space between the individual particles to the bulk volume of the particles or powder

[SOURCE: ISO 15901-1:2016, 3.28]

### 3.3.13

#### **macropore**

pore of internal width greater than 50 nm

[SOURCE: ISO 15901-1:2016, 3.7]

**3.3.14****mesopore**

pore of internal width between 2 nm and 50 nm

[SOURCE: ISO 15901-1:2016, 3.8]

**3.3.15****micropore**

pore of internal width less than 2 nm

[SOURCE: ISO 15901-1:2016, 3.9]

**3.3.16****supermicropore**

pore with width of approximately 0,7 nm – 2 nm

[SOURCE: ISO 15901-2:2022, 3.14]

**3.3.17****ultramicro-pore**

pore with width of approximately < 0,7 nm

[SOURCE: ISO 15901-2:2022, 3.15]

**3.3.18****nanopore**

pore with width of 100 nm or less

Note 1 to entry: The concept of nanopore overlaps all three traditionally defined major pore size ranges with micropore (pore with width of about 2 nm or less), mesopore (pore with width between approximately 2 nm and 50 nm), and macropore (pore with width greater than about 50 nm) and therefore is not based on sorption behavior or principles. See also Reference [16].

[SOURCE: ISO 15901-2:2022, 3.10, modified — Note 1 has been added]

**3.3.19****pore size**

internal pore width (e.g. the diameter of a cylindrical pore or the distance between the opposite walls of a slit) which is a representative value of various sizes of vacant space inside a porous material

[SOURCE: ISO 15901-1:2016, 3.13]

**3.3.20****pore volume**

volume of open pores unless otherwise stated

[SOURCE: ISO 15901-1:2016, 3.14]

**3.3.21****porosimeter**

instrument for measuring pore volume and pore size distribution

[SOURCE: ISO 15901-1:2016, 3.1]

**3.3.22****porosimetry**

methods for the estimation of pore volume, pore size distribution, and porosity

[SOURCE: ISO 15901-1:2016, 3.2]

**3.3.23**

**porosity**

ratio of the volume of the accessible pores and voids to the bulk volume occupied by an amount of the solid

[SOURCE: ISO 15901-1:2016, 3.27]

**3.3.24**

**porous solid**

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

[SOURCE: ISO 15901-1:2016, 3.3]

**3.3.25**

**surface area**

extent of accessible surface area as determined by a given method under stated conditions

[SOURCE: ISO 15901-1:2016, 3.30]

**3.3.26**

**surface tension**

work required to increase a surface area divided by that area.

[SOURCE: ISO 15901-1:2016, 3.31]

**3.3.27**

**through pore**

pore which passes all the way through the sample

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

**3.3.28**

**void**

interstice

space between particles, i.e. an interparticle pore

[SOURCE: ISO 15901-1:2016, 3.6]

**3.3.29**

**adsorbate**

adsorbed gas

[SOURCE: ISO 15901-2:2022, 3.1]

**3.3.30**

**adsorbed amount**

amount of gas adsorbed at a given pressure,  $p$ , and temperature,  $T$

[SOURCE: ISO 15901-2:2022, 3.6]

**3.3.31**

**adsorbent**

solid material on which adsorption occurs

[SOURCE: ISO 15901-2:2022, 3.4]

**3.3.32**

**adsorption**

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

[SOURCE: ISO 15901-2:2022, 3.2]

**3.3.33****adsorptive**

gas or vapour to be adsorbed

[SOURCE: ISO 15901-2:2022, 3.3]

**3.3.34****equilibrium adsorption pressure**

pressure of the adsorptive gas in equilibrium with the adsorbate

[SOURCE: ISO 15901-2:2022, 3.7]

**3.3.35****adsorption isotherm**

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

[SOURCE: ISO 15901-2:2022, 3.5]

**3.3.36****monolayer amount**

amount of the adsorbate that forms a monomolecular layer over the surface of the adsorbent

[SOURCE: ISO 15901-2:2022, 3.8]

**3.3.37****monolayer capacity**

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

[SOURCE: ISO 15901-2:2022, 3.9]

**3.3.38****relative pressure**

ratio of the equilibrium adsorption pressure,  $p$ , to the saturation vapour pressure,  $p_0$ , at analysis temperature

[SOURCE: ISO 15901-2:2022, 3.19]

**3.3.39****right cylindrical pore**

cylindrical pore perpendicular to the surface

[SOURCE: ISO 15901-2:2022, 3.19]

**3.3.40****saturation vapour pressure**

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

[SOURCE: ISO 15901-2:2022, 3.20]

**3.3.41****volume adsorbed**

volumetric equivalent of the amount adsorbed, expressed as gas at standard conditions of temperature and pressure (STP), or expressed as the adsorbed liquid volume of the adsorbate

[SOURCE: ISO 15901-2:2022, 3.21]

**3.3.42****physisorption**

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

[SOURCE: ISO 15901-2:2022, 3.16]

**3.3.43**

**powder**

porous or nonporous solid composed of discrete particles with maximum dimension less than about 1 mm, powders with a particle size below about 1  $\mu\text{m}$  are often referred to as fine powders

[SOURCE: ISO 15901-1:2016, 3.4]

**3.3.44**

**pore**

cavity or channel which is deeper than it is wide, otherwise it is part of the material's roughness

[SOURCE: ISO 15901-1:2016, 3.5]

**3.3.45**

**pore diameter**

diameter of a pore in a model in which the pores typically are assumed to be cylindrical in shape and which is calculated from data obtained by a specified procedure

[SOURCE: ISO 15901-1:2016, 3.15]

**3.3.46**

**median pore diameter**

diameter that corresponds to the 50th percentile of pore volume, i.e. the diameter for which one half of the pore volume is found to be in larger pores and one half is found to be in smaller pores

[SOURCE: ISO 15901-1:2016, 3.16]

**3.3.47**

**modal pore diameter**

mode

pore diameter of the maximum in a differential pore size distribution curve

[SOURCE: ISO 15901-1:2016, 3.17]

**3.3.48**

**hydraulic pore diameter**

average pore diameter, calculated as the ratio of pore volume multiplied by four to pore area

[SOURCE: ISO 15901-1:2016, 3.18]

**3.3.49**

**density**

ratio of the mass of a certain amount of a sample to the volume occupied by that mass

[SOURCE: ISO 12154:2014, 3.1]

**3.3.50**

**true solid state density**

ratio of the sample mass to the volume of the compact solid skeleton of the sample which excludes the volume of open and closed pores or internal voids and also interparticle voids as in the case of granulated or highly dispersed samples

[SOURCE: ISO 12154:2014, 3.2]

**3.3.51**

**bulk volume**

volume of powder or solids, including all pores (open and closed) and interstitial spaces between particles

[SOURCE: ISO 15901-1:2016, 3.19]

**3.3.52****bulk density**

ratio of sample mass to bulk volume

[SOURCE: ISO 15901-1:2016, 3.20]

**3.3.53****skeleton volume**

volume of the sample including the volume of closed pores (if present) but excluding the volumes of open pores as well as that of void spaces between particles within the bulk sample

[SOURCE: ISO 15901-1:2016, 3.21]

**3.3.54****skeleton density**

ratio of sample mass to *skeleton volume* ([3.3.53](#))

[SOURCE: ISO 15901-1:2016, 3.22; ISO 12154:2014, 3.3]

**3.3.55****apparent volume**

total volume of the solid constituents of the sample including closed pores and pores inaccessible or not detectable by the stated method

[SOURCE: ISO 15901-1:2016, 3.23]

**3.3.56****apparent density**

ratio of sample mass to apparent volume

[SOURCE: ISO 15901-1:2016, 3.24]

**3.3.57****envelope volume**

total volume of the particle, including closed and open pores, but excluding void space between the individual particles

[SOURCE: ISO 15901-1:2016, 3.25]

**3.3.58****envelope density**

ratio of sample mass to *envelope volume* ([3.3.57](#))

[SOURCE: ISO 15901-1:2016, 3.26]

**3.4 Terms related to gravity or centrifugal sedimentation methods****3.4.1****sedimentation**

directional motion of particles in a viscous liquid under the action of gravity or centrifugal fields

Note 1 to entry: For a positive density contrast, sedimentation occurs in the direction of gravitational acceleration; it is counter directed to this acceleration for a negative density contrast.

Note 2 to entry: A downward motion under gravity is also called settling or falling.

Note 3 to entry: An upward motion under gravity is also called creaming (for liquid particles) or more general rising and floating.

[SOURCE: ISO 13317-1:—<sup>1</sup>), 3.1]

1) Under preparation. Stage at the time of publication: ISO/DIS 13317-1:2022.

### 3.4.2

#### **migration**

directional motion of particles in a viscous liquid under the action of a force field

Note 1 to entry: For a positive density contrast, migration occurs in the direction of gravity or centrifugal acceleration; it is counter directed to this acceleration for a negative density contrast.

[SOURCE: ISO 13317-1:—, 3.2]

### 3.4.3

#### **terminal sedimentation velocity**

sedimentation velocity in case that gravity or centrifugal force is completely balanced by buoyancy and drag force

[SOURCE: ISO 13317-1:—, 3.3]

### 3.4.4

#### **Stokes diameter**

equivalent diameter of a sphere that has the same *buoyant density* (3.4.12) and *terminal sedimentation velocity* (3.4.3) as the real particle in the same liquid under *creeping flow* (3.4.15) conditions

Note 1 to entry: The general rule that the *buoyant density* (3.4.12) is used for calculating the Stokes diameter applies also to coated particles or multiconstituent particles (such as droplets in multiple emulsion). The *buoyant density* (3.4.12) can be approximated with the *skeletal density* (3.4.10) for monoconstituent particles.

Note 2 to entry: For porous particles, it is common use to compute particle size based on the *apparent particle density* (3.4.11). This approach considers the stagnant liquid in the open pores as intrinsic constituent of the dispersed phase. Thus obtained size values are hydrodynamic equivalent diameters.

Note 3 to entry: For closed-packed agglomerates or aggregates, the *buoyant density* (3.4.12) can be replaced by the *apparent particle density* (3.4.11) – with particle referring to the agglomerate/aggregate – in order to get the hydrodynamic equivalent diameter.

[SOURCE: ISO 13317-1:—, 3.4]

### 3.4.5

#### **shape correction factor**

<sedimentation analysis> ratio of the sedimentation velocity of a non-spherical particle to the one of a spherical particle of the same volume and density

[SOURCE: ISO 13317-1:—, 3.5]

### 3.4.6

#### **hindrance function**

ratio of the *terminal sedimentation velocity* (3.4.3) of a particle placed in well-mixed dispersion divided by its sedimentation velocity in an infinite vessel for the absence of other particles

[SOURCE: ISO 13317-1:—, 3.6]

### 3.4.7

#### **dynamic viscosity**

characteristic of flow resistance for Newtonian liquids which is calculated as ratio of the shear stress to the rate of shear for laminar flow exposed to a pre-set shear stress or strain

[SOURCE: ISO 13317-1:—, 3.11]

### 3.4.8

#### **apparent viscosity**

viscosity value for non-Newtonian liquids under a defined shear stress or strain, calculated as ratio between the shear stress and the rate of shear

[SOURCE: ISO 13317-1:—, 3.12]

**3.4.9****true density of the dispersed phase**

ratio of mass to volume for a body solely consisting of the dispersed phase without pores, voids, inclusions or surface fissures

[SOURCE: ISO 13317-1:—, 3.13]

**3.4.10****skeletal density**

<sedimentation analysis> ratio of mass to volume for a monoconstituent body defined by its external surface

Note 1 to entry: The skeletal density of a monoconstituent particle refers to the volume occupied by the dispersed phase including internal voids (i.e. *closed pores* (3.3.5)), whereas *open pores* (3.3.6) and surface fissures are not counted.

[SOURCE: ISO 13317-1:—, 3.14, ISO 18747-1:2018, modified - to be applicable to non-solid particles]

**3.4.11****apparent particle density****effective particle density**

ratio of mass to volume for a particle including particulate inclusions, entrapped stagnant liquid and gas in pores, voids and surface fissures as well as surface layers and coatings

Note 1 to entry: The a. p. d. is the density of a migrating entity and is calculated as weighted average of its constituents.

Note 2 to entry: The a. p. d. depends on wettability of open pores and the kinetics of wetting or replacement of pore liquid. Therefore, it is affected by sample preparation.

Note 3 to entry: The a. p. d. is not identical with the *buoyant density* (3.4.12). They deviate from each other in particular for porous particles and particle agglomerates.

[SOURCE: ISO 13317-1:—, 3.15]

**3.4.12****buoyant density**

ratio of mass to volume for a particle including particulate inclusions, liquid and gas in closed pores and voids as well as surface layers and coatings but excluding the liquid continuous phase that penetrates open pores

Note 1 to entry: The buoyant density equals the (hypothetical) density of the continuous phase for which the gravitational force acting on the immersed particle is counterbalanced by buoyancy.

Note 2 to entry: The buoyant density of a particle can be experimentally determined (ISO 18747-1, ISO 18747-2)

Note 3 to entry: The buoyant density of monoconstituent particles can be approximated with their *skeletal density* (3.4.10).

Note 4 to entry: The buoyant density of multiconstituent particles (e.g. coated pigments, droplets of multiple emulsions) can be approximated with the averaged skeletal densities of the single constituents.

Note 5 to entry: The buoyant density is affected by the adsorption of dissolved species at the particle surface and therefore depends on the solvent and its composition.

Note 6 to entry: The buoyant density is not identical with the *apparent particle density* (3.4.11). This holds particularly true for porous particles and particle agglomerates.

[SOURCE: ISO 13317-1:—, 3.16]

### 3.4.13

#### **density contrast**

difference between the buoyant density of the dispersed phase and the density of the continuous phase

[SOURCE: ISO 13317-1:—, 3.17]

### 3.4.14

#### **particle Reynolds number**

dimensionless characteristic (number) for the flow behaviour of moving particles defined as the ratio of inertial force to viscous force

Note 1 to entry: The particle Reynolds number is based on the volume equivalent diameter.

Note 2 to entry: In other contexts, the definition of the p.R.n. may refer to different equivalent diameters or to the equivalent radii.

[SOURCE: ISO 13317-1:—, 3.18]

### 3.4.15

#### **creeping flow**

type of flow that is solely governed by viscous forces and not affected by inertial effects

Note 1 to entry: For moving particles or for the flow past a particle, the creeping flow condition holds approximately true if the *particle Reynolds number* (3.4.14) is well below 0,25.

[SOURCE: ISO 13317-1:—, 3.19]

### 3.4.16

#### **Brownian motion**

random motion of particles caused by collisions with the molecules or atoms of the surrounding continuous phase

Note 1 to entry: The trajectory of Brownian motion is not differentiable.

Note 2 to entry: Brownian motion results on a macroscopic level in mass transport of the dispersed phase; e. g. in case of diffusion, thermophoresis or photophoresis.

[SOURCE: ISO 13317-1:—, 3.20]

### 3.4.17

#### **sensitivity**

change of instrument response with respect to changes in concentration or absolute quantity of particles in a specified size class

Note 1 to entry: Concentration or quantity can be given in relative or absolute values in dependence on the detection aim.

Note 2 to entry: Sensitivity depends on the *type of quantity* (3.1.11).

Note 3 to entry: Sensitivity is a function of size.

[SOURCE: ISO 13317-1:—, 3.24]

### 3.4.18

#### **limit of quantity detection**

smallest quantity of specified particle size class, for which the instrument response can be distinguished from the background

Note 1 to entry: It depends on the size range, on precision, noise level, smoothing algorithms etc.

Note 2 to entry: It affects the lower and upper size limit.

[SOURCE: ISO 13317-1:—, 3.25]

### 3.5 Terms related to electrical sensing zone methods

#### 3.5.1

##### **dead time**

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

[SOURCE: ISO 13319-1:2021, 3.1]

#### 3.5.2

##### **aperture**

##### **orifice**

small-diameter hole through which suspension is drawn

[SOURCE: ISO 13319-1:2021, 3.2, modified – orifice has been added]

#### 3.5.3

##### **analysis volume**

volume of suspension that is analysed

[SOURCE: ISO 13319-1:2021, 3.4]

#### 3.5.4

##### **sensing zone**

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

[SOURCE: ISO 13319-1:2021, 3.3]

#### 3.5.5

##### **size bin**

size interval to distinguish particle size for size distribution measurement

[SOURCE: ISO 13319-1:2021, 3.5]

#### 3.5.6

##### **envelope size**

external size of a particle as seen in a microscope

[SOURCE: ISO 13319-1:2021, 3.6]

#### 3.5.7

##### **envelope volume**

<electrical sensing zone methods> volume of the envelope given by the three-dimensional boundary of the particle to the surrounding medium

[SOURCE: ISO 13319-1:2021, 3.7, modified — domain has been included before the definition.]

### 3.6 Terms related to laser diffraction methods

#### 3.6.1

##### **absorption**

<optics> reduction of intensity of a light beam not due to scattering

[SOURCE: ISO 13320:2020, 3.1.1]

#### 3.6.2

##### **complex refractive index**

$n_p$

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

$$\underline{n}_p = n_p - ik_p$$

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, this document follows the convention of adding a minus sign to the imaginary part of the refractive index.

Note 3 to entry: Imaginary (absorption) part can also represent conversion to other radiation loss of energy, see e.g. F A Jenkins H E White, Fundamentals of Optics, Third Edition; McGraw-Hill (1957), page 544

[SOURCE: ISO 13320:2020, 3.1.5, modified — note 3 has been added]

### 3.6.3

#### relative refractive index

$m_{\text{rel}}$   
ratio of the complex refractive index of a particle to the real part of the dispersion medium

[SOURCE: ISO 24235:2007, 3.3, modified — “absolute refractive index” has been replaced by “complex refractive index” and “the sample” has been replaced by “a particle”]

Note 1 to entry: In many applications, the medium is transparent and, thus, its refractive index has a negligible imaginary part.

Note 2 to entry: The relative refractive index can be expressed mathematically as

$$m_{\text{rel}} = \underline{n}_p / n_m$$

where

$n_m$  is the real part of the refractive index of the medium;

$\underline{n}_p$  is the complex refractive index of a particle.

See *single scattering* (3.6.17)

[SOURCE: ISO 13320:2020, 3.1.19]

### 3.6.4

#### deconvolution

<laser diffraction particle size analysis> mathematical procedure whereby the size distribution of an ensemble of particles is inferred from measurements of their scattering pattern

[SOURCE: ISO 13320:2020, 3.1.6]

### 3.6.5

#### diffraction

<laser diffraction particle size analysis> scattering of light around the contour of a particle, observed at a substantial distance (in the ‘far field’)

[SOURCE: ISO 13320:2020, 3.1.7]

**3.6.6****extinction**

<laser diffraction particle size analysis> attenuation of a light beam traversing a medium through absorption and scattering

[SOURCE: ISO 13320:2020, 3.1.9]

**3.6.7****intermediate precision**

<laser diffraction particle size analysis > accuracy and precision under *intermediate precision conditions* ([3.6.8](#))

[SOURCE: ISO 3534-2:2006, 3.3.15, modified — field of application <laser diffraction> has been added.]

**3.6.8****intermediate precision conditions**

<laser diffraction particle size analysis > conditions where test results or measurement results are obtained on different laser diffraction instruments and with different operators using the same prescribed method

Note 1 to entry: There are four elements to the operating condition: time, calibration, operator and equipment.

[SOURCE: ISO 13220:2020, 3.1.11]

**3.6.9****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

[SOURCE: ISO 13320:2020, 3.1.12]

**3.6.10****obscuration**

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

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

Note 2 to entry: When expressed as fractions, obscuration plus *transmission* ([3.6.19](#)) equal unity.

[SOURCE: ISO 13320:2020, 3.1.13]

**3.6.11****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 13320:2020, 3.1.14]

**3.6.12****reflection**

<laser diffraction particle size analysis> change of direction of a light wave at a surface without a change in wavelength or frequency

[SOURCE: ISO 13320:2020, 3.1.17]

**3.6.13  
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:

$$n_m \sin \theta_m = n_p \sin \theta_p$$

See ISO 13320:2020, 3.2 for symbol definitions.

[SOURCE: ISO 13320:2020, 3.1.18]

**3.6.14  
scattering**

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

[SOURCE: ISO 13320:2020, 3.1.23]

**3.6.15  
scattering angle**

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

[SOURCE: ISO 13320:2020, 3.1.24]

**3.6.16  
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 13320:2020, 3.1.25]

**3.6.17  
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 13320:2020, 3.1.26]

**3.6.18  
single shot**

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

[SOURCE: ISO 13320:2020, 3.1.27]

**3.6.19  
transmission**

<laser diffraction particle size analysis> fraction of incident light that remains un-attenuated by the particles

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

Note 2 to entry: When expressed as fractions, *obscuration* (3.6.10) plus transmission equal unity.

[SOURCE: ISO 13320:2020, 3.1.29]

### 3.7 Terms related to dynamic light scattering

#### 3.7.1

#### average hydrodynamic diameter

$\bar{x}_{DLS}$

*hydrodynamic diameter* (3.7.9) that reflects the central value of the underlying particle size distribution

Note 1 to entry: The average particle diameter is either directly determined without calculation of the particle size distribution, or calculated from the computed intensity-, volume- or number-weighted particle size distribution or from its fitted (transformed) density function. The exact nature of the average particle diameter depends on the evaluation algorithm.

Note 2 to entry: The cumulants method yields a scattered light intensity-weighted harmonic mean particle diameter, which is sometimes also referred to as the “z-average diameter.”

Note 3 to entry: Arithmetic, geometric and harmonic mean values can be calculated from the particle size distribution according to ISO 9276-2.

Note 4 to entry: Mean values calculated from density functions (linear abscissa) and transformed density functions (logarithmic abscissa) may significantly differ (ISO 9276-1).

Note 5 to entry:  $\bar{x}_{DLS}$  also depends on the particle shape and the scattering vector (and thus on the angle of observation, laser wavelength and refractive index of the suspension medium).

[SOURCE: ISO 22412:2017, 3.2]

#### 3.7.2

#### polydispersity index

PI

dimensionless measure of the broadness of the size distribution

Note 1 to entry: The PI typically has values less than 0,07 for a monodisperse test sample of spherical particles..

[SOURCE: ISO 22412:2017, 3.3]

#### 3.7.3

#### qualification

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

[SOURCE: ISO 22412:2017, 3.10]

#### 3.7.4

#### scattering volume

volume defined by the intersection of the incident laser beam and the scattered light intercepted by the detector

[SOURCE: ISO 22412:2017, 3.4]

#### 3.7.5

#### scattered intensity

intensity of the light scattered by the particles in the scattering volume

[SOURCE: ISO 22412:2017, 3.5]

#### 3.7.6

#### validation

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

Note 1 to entry: Evaluation of trueness requires a *certified reference material* (3.1.22).

[SOURCE: ISO 22412:2017, 3.7]

**3.7.7**

**count rate  
photocurrent**

$I_s$   
number of photon pulses per unit time

Note 1 to entry: It is also a photodetector current which is proportional to the scattered intensity as measured by a detector.

[SOURCE: ISO 22412:2017, 3.6]

**3.7.8**

**light scattering**

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

[SOURCE: ISO 13320:2009, 3.1.17]

**3.7.9**

**hydrodynamic diameter**

equivalent spherical diameter of a particle in a liquid having the same diffusion coefficient as the real particle in that liquid

[SOURCE: ISO/TS 80004-6:2013, 3.2.6]

**3.7.10**

**particle tracking analysis**

**PTA**

method in which *particles* (3.1.1) undergoing Brownian and/or gravitational motion in a suspension are illuminated by a laser and the change in position of individual particles is used to determine *particle size* (3.1.9)

Note 1 to entry: Analysis of the time-dependent particle position yields translational diffusion coefficient and hence the particle size as *hydrodynamic diameter* (3.7.9) using the Stokes-Einstein relationship.

Note 2 to entry: The analysis is applicable to nanoparticles as the size of particles detected is typically in the range 10 nm to 2 000 nm. The lower limit requires particles with high refractive index and the upper limit is due to limited Brownian motion and sedimentation.

Note 3 to entry: Nanoparticle tracking analysis NTA is often used to describe PTA. NTA is a subset of PTA since PTA covers larger range of particle sizes than *nanoscale* (3.1.6).

[SOURCE: ISO/TS 80004-6:2021, 4.2.8, modified — Nanoparticle tracking analysis has been removed from the term, and Note 3 has been modified]

**3.8 Terms related to image analysis methods**

**3.8.1**

**area equivalent diameter**

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 Heywood diameter or as the equivalent circular diameter.

[SOURCE: ISO 13322-1:2014, 3.1.1]

**3.8.2**

**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 13322-1:2014, 3.1.2]

**3.8.3****contrast (of an image)**

<image analysis particle size analysis> difference between the intensity of the particle image with respect to the background near to the particle

[SOURCE: ISO 13322-1:2014, 3.1.3]

**3.8.4****edge detection**

methods used to detect transition between objects and background

Note 1 to entry: See *segmentation method* (3.8.13)

[SOURCE: ISO 13322-1:2014, 3.1.4]

**3.8.5****frame coverage**

<dynamic image analysis> fraction of the image area that is obscured by the projection area of all segmented *particles* (3.1.1) counted in the image

Note 1 to entry: Frame coverage can be expressed as a part or percentage of image area.

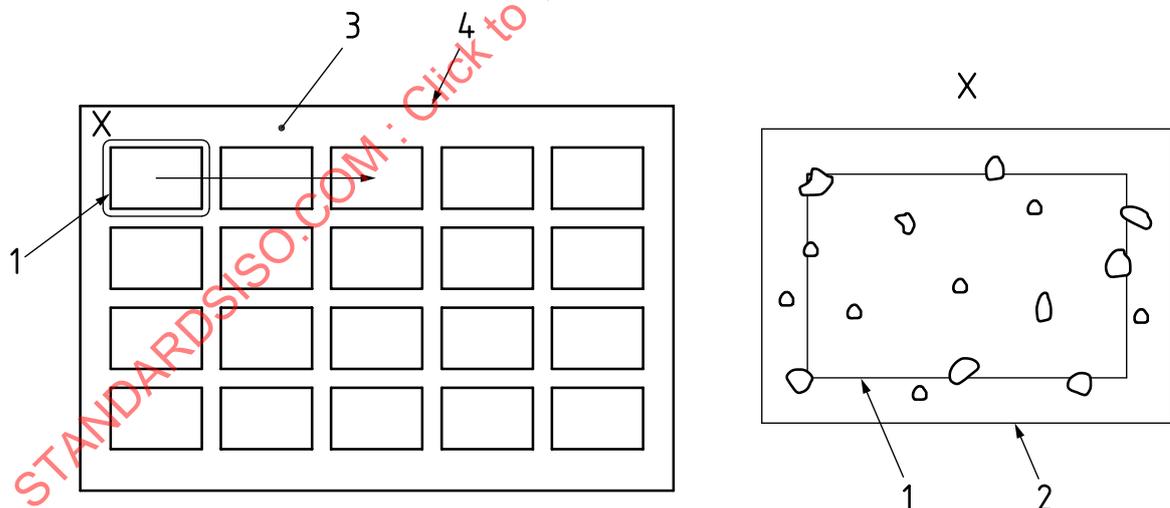
[SOURCE: ISO 13322-2:2021, 3.1.5]

**3.8.6****field of view**

field which is viewed by the viewing device

Note 1 to entry: The full image frame of a digital imaging device corresponds to its field of view.

Note 2 to entry: See [Figure 2](#).

**Key**

- X enlarged view of a field of view
- 1 measurement frame
- 2 field of view
- 3 raster pattern of measurement frames
- 4 measurement field

**Figure 2 — Relationship between the terms "field of view", "measurement frame", "raster pattern" and "measurement field"**

[SOURCE: ISO 13322-1:2014, 3.1.6]

**3.8.7**

**grey image**

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

[SOURCE: ISO 13322-1:2014, 3.1.7]

**3.8.8**

**image analysis**

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

[SOURCE: ISO 13322-1:2014, 3.1.8]

**3.8.9**

**measurement field**

field which is composed by the set of all measurement frames

Note 1 to entry: See [Figure 2](#).

[SOURCE: ISO 13322-1:2014, 3.1.9]

**3.8.10**

**measurement frame**

selected area from the field of view in which particles are sized and counted for image analysis

Note 1 to entry: See [Figure 2](#).

[SOURCE: ISO 13322-1:2014, 3.1.10]

**3.8.11**

**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 13322-1:2014, 3.1.11]

**3.8.12**

**raster pattern**

scanning order of measurement frames in the total measurement field

[SOURCE: ISO 13322-1:2014, 3.1.12]

**3.8.13**

**segmentation method**

strategy employed to separate the objects of interest from their surroundings

Note 1 to entry: Method of dividing the particle image from the background.

Note 2 to entry: See *edge detection* ([3.8.4](#)).

[SOURCE: ISO 13322-1:2014, 3.1.13]

**3.8.14**

**threshold**

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

[SOURCE: ISO 13322-1:2014, 3.1.14]

**3.8.15****acceptable depth of field**

<dynamic image analysis> depth with respect to focal depth where the sharpness of the edges of the particle images is accepted for segmentation

Note 1 to entry: The acceptable depth of field is decided by the software based on the sharpness of the images and is also dependent on the particle size.

[SOURCE: ISO 13322-2:2021, 3.1.1]

**3.8.16****flow-cell**

measurement cell inside which the fluid-particle mixture flows

[SOURCE: ISO 13322-2:2021, 3.1.4]

**3.8.17****image capture device**

matrix camera or line scan camera for converting an optical image to digital image data

[SOURCE: ISO 13322-2:2021, 3.1.8]

**3.8.18****measurement zone**

volume in which particles are measured by an image analyser, formed by the measurement frame including a third dimension from the *acceptable depth of field* ([3.8.15](#))

Note 1 to entry: The measurement zone is defined by the software (see [3.8.15](#)).

[SOURCE: ISO 13322-2:2021, 3.1.9]

**3.8.19****orifice tube**

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

[SOURCE: ISO 13322-2:2021, 3.1.10]

**3.8.20****illumination**

continuous illumination for *image capture device* ([3.8.17](#)) with an electronic exposure time controller, or illumination of short duration for synchronised image capture device

[SOURCE: ISO 13322-2:2021, 3.1.11]

**3.8.21****sheath flow**

clean fluid flow surrounding particle-laden fluid for directing particles into a specific *measurement zone* ([3.8.18](#))

[SOURCE: ISO 13322-2:2021, 3.1.18]

**3.8.22****sampling volume**

volume in which the particles are within the field of view of the image analyser including a third dimension from the *sampling volume depth* ([3.8.23](#))

[SOURCE: ISO 13322-2:2021, 3.1.16]

**3.8.23****sampling volume depth**

length which describes the extent of the particle field in front of the camera

[SOURCE: ISO 13322-2:2021, 3.1.17]

### 3.9 Terms related to single particle light interaction methods

#### 3.9.1

##### **border zone error**

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

[SOURCE: ISO 21501-1:2009, 2.10]

#### 3.9.2

##### **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, flow velocity through the sensing zone and size of sensing zone.

[SOURCE: ISO 27891:2015, 3.9]

#### 3.9.3

##### **counting efficiency**

relation of the concentration determined from the counting rate of the measuring instrument and the real concentration of the aerosol at the inlet of the instrument

[SOURCE: ISO 21501-1:2009, 2.9]

#### 3.9.4

##### **light scattering equivalent particle diameter**

$x_{sca}$   
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, 2.5]

#### 3.9.5

##### **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, 2.6, modified — the entry 'number concentration density distribution' has been modified to 'number concentration distribution density. ]

#### 3.9.6

##### **particle concentration**

ratio of particle quantity to the volume of the carrier gas or liquid

Note 1 to entry: Quantities can be particle number, surface, volume or mass

Note 2 to entry: For the exact concentration measurement in aerosols, information on the gaseous condition (temperature and pressure) or the reference to a standard volume is necessary.

[SOURCE: ISO 21501-1:2009, 2.7, modified — 'indication' has been changed to 'ratio' and examples of quantity have been replaced by 'quantity' ]

#### 3.9.7

##### **calibration particles**

monodisperse spherical particles with a known mean particle size, e.g. polystyrene latex (PSL) particles, where the certified size is traceable to the International System of Units (IS), a relative standard uncertainty equals to or less than 2,5 %, and a refractive index that is approximately 1,59 at the wave length of 589 nm (sodium D line)

Note 1 to entry: For spherical particles, the particle size is equal to the diameter.

[SOURCE: ISO 21501-2:2019, 3.1; ISO 21501-3:2019, 3.1; ISO 21501-4:2018, 3.1]

**3.9.8****counting efficiency**

<LSLPC> ratio of the number concentration measured by a *light scattering liquid-borne particle counter* (3.9.10) to that measured by a reference instrument for the same sample

[SOURCE: ISO 21501-2:2019, 3.2, modified — <LSLPC> has been added to show the domain.]

**3.9.9****false count**

<LSLPC> apparent count per unit volume of sample liquid when a sample liquid containing no measurable particles is measured by the *light scattering liquid-borne particle counter* (3.9.10)

[SOURCE: ISO 21501-2:2019, 3.3, modified — <LSLPC> has been added to show the domain.]

**3.9.10****LSLPC****light scattering liquid-borne particle counter**

instrument that measures liquid-borne particle numbers by counting the pulses as the particles pass through the sensing volume, as well as particle size by scattered light intensity

Note 1 to entry: The optical particle size measured by the LSLPC is the light scattering equivalent particle size and not the geometrical size.

[SOURCE: ISO 21501-2:2019, 3.4]

**3.9.11****PHA****pulse height analyser**

instrument that analyses the distribution of pulse heights

[SOURCE: ISO 21501-2:2019, 3.5; ISO 21501-3:2019, 3.4; ISO 21501-4:2018, 3.5]

**3.9.12****size resolution**

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

[SOURCE: ISO 21501-2:2019, 3.6; ISO 21501-3:2019, 3.5; ISO 21501-4:2019, 3.6]

**3.9.13****coincidence loss**

reduction of particle count caused by multiple particles passing simultaneously through the sensing volume and/or by the finite processing time of the electronic system

[SOURCE: ISO 21501-2:2019, 3.7; ISO 21501-3:2019, 3.6; ISO 21501-4:2018, 3.7]

**3.9.14****MPE****maximum permissible error****limit of error**

extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system

Note 1 to entry: This document uses decimal numbers for the requirements to MPEs to avoid confusions that may arise when relative uncertainties of test results are reported in percent figures.

[SOURCE: ISO 21501-2:2019, 3.8; ISO 21501-3:2019, 3.8; ISO 21501-4:2018, 3.9]

### 3.9.15

#### **LELPC counting efficiency**

ratio of the particle number concentration measured by a light extinction *liquid-borne particle counter* (3.9.16) of a *certified reference material* (3.1.22) for particle number concentration to the certified value of the CRM

[SOURCE: ISO 21501-3:2019, 3.2, modified — <LELPC> has been added to show the domain.]

### 3.9.16

#### **LELPC**

#### **light extinction liquid-borne particle counter**

instrument that measures liquid-borne particle numbers by counting the pulses as the particles pass through the sensing volume, as well as particle size by the attenuation of light

Note 1 to entry: The optical particle size measured by the LELPC is the light extinction equivalent particle size and not the geometrical size.

[SOURCE: ISO 21501-3:2019, 3.3]

### 3.9.17

#### **false count**

<LSAPC> apparent count per unit volume when a sample air containing no measurable particles is measured by the *light scattering airborne particle counter (LSAPC)* (3.9.18)

[SOURCE: ISO 21501-4:2018, 3.3, modified — <LSAPC> has been added to show the domain.]

### 3.9.18

#### **LSAPC**

#### **light scattering airborne particle counter**

instrument that measures airborne particle numbers by counting the pulses as the particles pass through the sensing volume, and also particle size by scattered light intensity

Note 1 to entry: The optical particle size measured by the LSAPC is the light scattering equivalent particle size and not the geometrical size.

[SOURCE: ISO 21501-4:2018, 3.4]

### 3.9.19

#### **test aerosol**

aerosol to be used for calibration or testing of a *light scattering airborne particle counter (LSAPC)* (3.9.18) that is composed of *calibration particles* (3.9.7) suspended in clean air

[SOURCE: ISO 21501-4:2018, 3.8]

## 3.10 Terms related to small angle X-ray scattering

### 3.10.1

#### **small angle X-ray scattering**

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

Note 1 to entry: The scattering is typically measured in the angular range up to 5°. This provides structural information about inhomogeneities in materials with characteristic lengths typically ranging from 1 nm to 100 nm. Under certain conditions the limit of 100 nm can be significantly extended.

[SOURCE: ISO 18115-1:2013, 3.18, modified — Notes 2 and 3 to entry have been deleted.]

### 3.10.2 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.

[SOURCE: ISO 17867:2020, 3.3]

## 3.11 Terms related to sample preparation and reference materials

### 3.11.1 clump

assemblage of particles which are either rigidly joined or loosely coherent

[SOURCE: ISO 14887:2000, 3.3]

### 3.11.2 critical micelle concentration CMC

concentration of dispersing agent above which micelles will form

[SOURCE: ISO 14887:2000, 3.4]

### 3.11.3 Tyndall effect

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

[SOURCE: ISO 14887:2000, 3.8]

### 3.11.4 bias

estimate of a systematic measurement error

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

### 3.11.5 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]

### 3.11.6 grab sample

sample that has not been taken under well-defined conditions

[SOURCE: ISO 14488:2007, 3.5]

### 3.11.7 gross sample

primary sample, composed of several sample increments

[SOURCE: ISO 14488:2007, 3.4]

### 3.11.8 primary sample

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

[SOURCE: ISO 14488:2007, 3.6]

**3.11.9**

**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]

**3.11.10**

**sample**

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

[SOURCE: ISO 14488:2007, 3.8]

**3.11.11**

**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]

**3.11.12**

**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]

**3.11.13**

**spot sample**

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

[SOURCE: ISO 14488:2007, 3.11]

**3.11.14**

**test sample**

sample that is entirely used for a property characterization

[SOURCE: ISO 14488:2007, 3.12]

**3.11.15**

**hydrostatic balance**

method to measure particle density based on particle dynamic sedimentation velocity with known fluid density and viscosity condition

[SOURCE: ISO/TS 14411-1:2017, 3.1.4]

**3.11.16**

**nominal value**

designated diameter in terms of a target value in a given specification

Note 1 to entry: The nominal value is the target diameter for an individual picket as calculated from the upper and lower size of the *picket fence distribution* (3.11.17), the number of pickets and the requirement of equal spacing of pickets on a lognormal scale. Actual values may differ from the nominal ones due to the availability of suitable material

[SOURCE: ISO/TS 14411-1:2017, 3.1.7]

**3.11.17**

**picket fence distribution**

mixture of several monodisperse particle fractions (pickets)

[SOURCE: ISO/TS 14411-1:2017, 3.1.8]

## 3.12 Terms related to electrical mobility and number concentration analysis for aerosol particles

### 3.12.1

#### **aerosol**

system of solid and/or liquid particles suspended in gas

[SOURCE: ISO 15900:2020, 3.1; ISO 27891:2015, 3.1]

### 3.12.2

#### **attachment coefficient**

attachment probability of ions and aerosol particles

[SOURCE: ISO 15900:2020, 3.2]

### 3.12.3

#### **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 15900:2020, 3.8]

### 3.12.4

#### **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 15900:2020, 3.10]

### 3.12.5

#### **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 15900:2020, 3.11]

### 3.12.6

#### **differential mobility analysing system**

##### **DMAS**

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

Note 1 to entry: Another common acronym for the DMAS is MPSS (mobility particle size spectrometer).

[SOURCE: ISO 15900:2020, 3.12]

### 3.12.7

#### **electrical mobility**

ratio of *migration velocity* (3.12.10) to electrical field for particles and ions in a gas

[SOURCE: ISO 15900:2020, 3.13]

### 3.12.8

#### **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 15900:2020, 3.16]

### 3.12.9

#### **laminar flow**

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

[SOURCE: ISO 15900:2020, 3.17; ISO 27891:2015, 3.20]

### 3.12.10

#### **migration velocity**

<aerosol particles> steady-state velocity of a charged airborne particle within an externally applied electric field

[SOURCE: ISO 15900:2020, 3.18]

### 3.12.11

#### **Reynolds number**

$Re$

dimensionless number expressed as the ratio of the inertial force to the viscous force

Note 1 to entry: For example, applied to an aerosol particle or a tube carrying aerosol particles

[SOURCE: ISO 15900:2020, 3.21]

### 3.12.12

#### **slip correction**

$S_c$

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 15900:2020, 3.22]

### 3.12.13

#### **Stokes' drag**

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

[SOURCE: ISO 15900:2020, 3.23]

### 3.12.14

#### **transfer function**

ratio of particle concentration at the outlet of a DEMC to the particle concentration at the inlet of the DEMC

Note 1 to entry: It is normally expressed as a function of electrical mobility.

[SOURCE: ISO 15900:2020, 3.24]

### 3.12.15 electrometer

device that measures electrical current of about 1 femtoampere (fA) and higher

[SOURCE: ISO 27891:2015, 3.15]

### 3.12.16 Faraday-cup aerosol electrometer FCAE

electrometer designed for the measurement of electrical charge concentration carried by an aerosol

Note 1 to entry: An FCAE 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. An FCAE measures electrical current ranging from about one femtoampere (fA) to about ten picoamperes (pA).

[SOURCE: ISO 15900:2020, 3.15]

### 3.12.17 calibration

operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

Note 1 to entry: A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

Note 2 to entry: Calibration should not be confused with adjustment of a measuring system, often mistakenly called "self-calibration", nor with verification of calibration.

Note 3 to entry: Often, the first step alone in the above definition is perceived as being calibration.

[SOURCE: ISO 27891:2015, 3.3]

### 3.12.18 calibration aerosol

charge conditioned and size classified primary aerosol with particle number concentration adjusted for the calibration measurement, as delivered by the flow splitter

[SOURCE: ISO 27891:2015, 3.4]

### 3.12.19 calibration particle material

material of the particles of the calibration aerosol

[SOURCE: ISO 27891:2015, 3.5]

### 3.12.20 detection efficiency

$\eta$

ratio of the concentration reported by an instrument to the actual concentration at the inlet of the instrument

[SOURCE: ISO 27891:2015, 3.11]

### 3.12.21 diffusion loss

reduction of particle number concentration due to thermal (or Brownian) and turbulent diffusion transport (e.g. to the walls of a transport tube)

[SOURCE: ISO 27891:2015, 3.14]

**3.12.22**

**flow rate**

quantity (volume or mass to be specified) of a fluid crossing the transverse plane of a flow path per unit time

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

[SOURCE: ISO 27891:2015, 3.18]

**3.12.23**

**GSD**

acronym used in this International Standard for geometric standard deviation

[SOURCE: ISO 27891:2015, 3.19]

**3.12.24**

**lower limit of the plateau efficiency**

$d_{\min, \text{ref}}$

lower size limit for which a reference CPC can be applied for the calibration of a test CPC

Note 1 to entry: This size limit depends on the CPC itself, but also to some extent on experimental conditions and on the particle type.

[SOURCE: ISO 27891:2015, 3.21]

**3.12.25**

**monodisperse aerosol**

aerosol with a narrow particle size distribution

Note 1 to entry: Monodispersity can be quantified by the geometric standard deviation (GSD) of the size distribution.

Note 2 to entry: In this International Standard, the term “monodisperse” is used for the GSD less than or equal to 1,15.

[SOURCE: ISO 27891:2015, 3.22]

**3.12.26**

**particle number concentration**

$C$

number of particles related to the unit volume of the carrier gas

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

[SOURCE: ISO 27891:2015, 3.25]

**3.12.27**

**particle type**

several particle properties like chemical composition of the particle material (especially chemical surface composition), physical particle shape and morphology (e.g. an agglomerate or aggregate)

Note 1 to entry: The CPC detection efficiency at low particle sizes will depend on the chemical affinity between the particle and the working fluid.

Note 2 to entry: Much of the underlying theory assumes that the particles are solid spheres. Non-sphericity can affect the size selection by the DEMC, the fraction of multiply charged particles, and the condensation of working fluid on the particle surface.

[SOURCE: ISO 27891:2015, 3.26]

**3.12.28****plateau detection efficiency**

mean detection efficiency of a CPC in the size range which is not biased by particle size

[SOURCE: ISO 15900:2020, 3.20]

**3.12.29****primary aerosol**

aerosol generated and conditioned in the primary aerosol source section of the calibration setup

[SOURCE: ISO 27891:2015, 3.28]

**3.12.30****single particle counting mode**

measurement mode of a particle number or number concentration measurement device (e.g. a CPC) in which every detected particle is counted to obtain the measurement result

[SOURCE: ISO 27891:2015, 3.29]

**3.12.31****size distribution**

distribution of particle concentration as a function of particle size

Note 1 to entry: In ISO 27891:2015, this term is used in the sense “particle number concentration represented as function of the particle diameter”.

Note 2 to entry: ISO 9276-1 can be applied for the representation of results of particle size distribution analysis.

[SOURCE: ISO 27891:2015, 3.30, modified — Note 1 has been adapted.]

**3.12.32****turbulent flow**

gas flow with temporally or spatially irregular activity or turbulent eddy flow

[SOURCE: ISO 27891:2015, 3.31]

**3.13 Terms related to electrical charge conditioning****3.13.1****charging**

processes that leave aerosol particles with size dependent specific distributions of unipolar or bipolar electrical charges

[SOURCE: ISO 15900:2020, 3.5]

**3.13.2****charge distribution function**

mathematical and/or empirical description of a conditioned particle size dependent charge distribution

[SOURCE: ISO 15900:2020, 3.7]

**3.13.3****conditioned charge distribution**

distribution of unipolar or bipolar electrical charges on aerosol particles defined by a charge distribution function, which is in a steady state for a sufficiently long period of time in an aerosol instrument downstream of a unipolar or bipolar charge conditioner

[SOURCE: ISO 15900:2020, 3.9]

### 3.13.4

#### **charge concentration**

concentration of the net electrical charges per unit volume

Note 1 to entry: Charge concentration is the measurand of the FCAE.

Note 2 to entry: FCAE measurement can be displayed as charge concentration,  $C_Q$ , (e.g. in fC/cm<sup>3</sup>), charge number concentration,  $C_N^*$ , (e.g. in cm<sup>-3</sup>) or electrical current,  $I_{\text{FCAE}}$ , (e.g. in fA). Using the elementary charge,  $e$ , and the volumetric FCAE inlet flow rate,  $q_{\text{FCAE}}$ , these displayed values are related as follows:

$$C_N^* = C_Q / e = I_{\text{FCAE}} / (q_{\text{FCAE}} \times e)$$

EXAMPLE A charge concentration of 1 fC/cm<sup>3</sup> corresponds to a charge number concentration of 6 241 cm<sup>-3</sup>. When the volumetric FCAE inlet flow rate is 1 l/min, the resulting electrical current is 16,67 fA.

[SOURCE: ISO 27891:2015, 3.6]

### 3.13.5

#### **charge conditioning**

process that establishes a steady state charge distribution on the sampled aerosol

[SOURCE: ISO 27891:2015, 3.7]

### 3.13.6

#### **charge conditioner**

device (or component of a DMAS) which establishes a known conditioned size dependent charge distribution on aerosol particles which are passed through it

[SOURCE: ISO 15900:2020, 3.6]

### 3.13.7

#### **unipolar charger**

particle charge conditioner that expose aerosol particles to either positive or negative ions within the device

[SOURCE: ISO 27891:2015, 3.32]

### 3.13.8

#### **unipolar charge conditioner**

device which attains a conditioned charge distribution of either positive or negative charges on aerosol particles

[SOURCE: ISO 15900:2020, 3.25]

### 3.13.9

#### **unipolar charging**

process which attains a conditioned charge distribution of positive or negative charges on aerosol particles

[SOURCE: ISO 15900:2020, 3.26]

### 3.13.10

#### **bipolar charger**

particle charge conditioner to attain the equilibrium, known size-dependent charge distribution by exposing aerosol particles to both positive and negative ions within the device

Note 1 to entry: Exposing aerosol particles to an electrically neutral cloud of positive and negative gas charges with sufficiently high charge concentration and for a sufficiently long period of time leads to an equilibrium with the net charge of the aerosol nearly zero (also known as charge neutralization).

[SOURCE: ISO 27891:2015, 3.2]

**3.13.11****bipolar charging**

process which attains a conditioned charge distribution of both positive and negative charges on aerosol particles

[SOURCE: ISO 15900:2020, 3.3]

**3.13.12****bipolar charge conditioner**

device which attains a conditioned charge distribution of both positive and negative charges on aerosol particles

[SOURCE: ISO 15900:2020, 3.4]

**3.14 Terms related to acoustic methods****3.14.1****absorption**

<ultrasonic particle size analysis> direct reduction of incident ultrasonic energy by means other than scattering

[SOURCE: ISO 20998-1:2006, 2.1]

**3.14.2****attenuation****extinction**

<ultrasonic particle size analysis> 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  $1 \text{ Np} = 8,686 \text{ dB}$

[SOURCE: ISO 20998-1:2006, 2.2]

**3.14.3****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]

**3.14.4****attenuation spectrum**

attenuation coefficient measured as a function of frequency

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

**3.14.5****bandwidth**

range of frequencies contained in an ultrasonic signal, typically measured as the frequency difference between the -3 dB points on a spectrum analyzer

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

**3.14.6**

**broadband**

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

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

**3.14.7**

**digitisation**

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]

**3.14.8**

**excess attenuation**

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

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

**3.14.9**

**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]

**3.14.10**

**interference**

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

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

**3.14.11**

**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]

**3.14.12**

**path length**

distance traversed by the ultrasonic wave between the emitting transducer and the receiver

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

**3.14.13**

**pulse**

wave of sufficiently short duration to contain broadband Fourier components

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

**3.14.14**

**reflection**

<ultrasonic particle size analysis> return of an ultrasonic wave at an interface or surface

[SOURCE: ISO 20998-1:2006, 2.14]

**3.14.15****scattering**

<ultrasonic particle size analysis> removal of ultrasonic energy from the incident wave by redirection

[SOURCE: ISO 20998-1:2006, 2.15]

**3.14.16****spectrum**

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

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

**3.14.17****tone-burst**

short duration of a few cycles of a sinusoidal wave

Note 1 to entry: Typically, a tone burst consists of 5 to 10 cycles of a sinusoidal wave.

[SOURCE: ISO 20998-1:2006, 2.17]

**3.14.18****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]

**3.14.19****transmission**

<ultrasonic particle size analysis> passage of ultrasound through a sample

[SOURCE: ISO 20998-1:2006, 2.19]

**3.14.20****transmission spectrum**

the transmission value measured as a function of frequency

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

**3.14.21****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]

**3.14.22****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]

**3.14.23****wave**

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

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

**3.14.24**

**waveform**

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

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

**3.14.25**

**wavelength**

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

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

**3.14.26**

**dimensionless size parameter**

representation of particle size as the product of *wave number* (3.14.27) and particle radius

[SOURCE: ISO 20998-2:2013, 3.2]

**3.14.27**

**wave number**

ratio of  $2\pi$  to the wavelength

[SOURCE: ISO 20998-2:2013, 3.4]

**3.15 Terms related to focused beam method**

**3.15.1**

**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.

**3.16 Terms related to characterisation of particle dispersion in liquids**

**3.16.1**

**agglomerate**

<particle dispersion in liquids> loosely coherent assembly of *particles* (3.1.1) and/or *aggregates* (3.1.3) held together by weak physical interactions, with a total surface area virtually equal to the sum of the surface areas of the *constituent particles* (3.1.5)

Note 1 to entry: The transitive verb “agglomerate” means “to gather into a cluster”, and the process by which the cluster or assembly is formed is generally called “agglomeration”.

Note 2 to entry: Agglomeration can be a reversible process.

[SOURCE: ISO/TS 22107:2021, 3.1, modified — domain has been included before the definition]

**3.16.2**

**aggregate**

<particle dispersion in liquids> assemblage of *particles* (3.1.1) into rigidly joined structures

Note 1 to entry: Formation of aggregates is usually 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 aggregate and agglomerate (also aggregation and agglomeration) are sometimes applied interchangeably, but this practice is deprecated since the terms are not synonymous.

Note 4 to entry: The transitive verb “aggregate” means “to gather into a mass or whole”, and the process by which the structure is formed is generally called “aggregation”.

[SOURCE: ISO/TS 22107:2021, 3.2, modified — domain has been included before the definition]

### 3.16.3

#### **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, namely the formation of aggregates, may be followed by coalescence.

[SOURCE: IUPAC Gold Book<sup>[1]</sup>]

### 3.16.4

#### **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.

[SOURCE: ISO/TR 13097:2013, 2.4]

### 3.16.5

#### **dispersion**

multi-phase system in which discontinuities of any state (solid, liquid or gas) are homogeneously distributed in a continuous phase of a different composition or state

Note 1 to entry: This term can also refer to the act or process of producing a dispersion, but in this context the term “dispersion process” should be used.

Note 2 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 immiscible liquid phases, it is termed an emulsion.

[SOURCE: ISO/TS 22107:2021, 3.7]

### 3.16.6

#### **dispersion stability**

ability to resist change or variation in the initial properties (state) of a dispersion over time, in other words, the 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 segregation represents a loss of dispersion stability.

[SOURCE: ISO/TS 22107:2021, 3.8]

### 3.16.7

#### **flocculation**

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

Note 1 to entry: The term flocculation has been frequently used to denote agglomeration facilitated by addition of a flocculating agent (e.g., a polyelectrolyte).

Note 2 to entry: See *agglomeration* ([3.16.1](#)).

[SOURCE: ISO/TR 13097:2013, 2.7]

### 3.16.8

#### **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: It may be facilitated by adhering gas bubbles, for example dissolved air flotation, or the application of lipophilic surfactants (e.g., in ore processing).

[SOURCE: ISO/TR 13097:2013, 2.8]

### 3.16.9

#### **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.

[SOURCE: IUPAC Gold Book<sup>[1]</sup>]

### 3.16.10

#### **phase inversion**

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

[SOURCE: Yeo et al.<sup>[3]</sup>]

### 3.16.11

#### **phase separation**

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

[SOURCE: Yeo et al.<sup>[3]</sup>]

### 3.16.12

#### **shelf life**

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

[SOURCE: Gyeszly<sup>[4]</sup>]

### 3.16.13

#### **comminution**

operation of reducing particle size by crushing, grinding or pulverisation

[SOURCE: ISO/TS 22107:2021, 3.3]

### 3.16.14

#### **dispersant**

substance capable of promoting the formation of a dispersion

Note 1 to entry: Also called a dispersing agent (e.g. wetting agent or surfactant)

[SOURCE: ISO/TS 22107:2021, 3.4]

### 3.16.15

#### **disperse**

distribute particles homogeneously throughout a continuous phase, often by means of reducing the size of agglomerates

Note 1 to entry: Also called a dispersing agent (e.g. wetting agent or surfactant)