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Particle characterization of particulate systems — Vocabulary

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National foreword

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INTERNATIONAL STANDARD

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Particle characterization of particulate systems — Vocabulary

Caractérisation des particules dans les systèmes particulaires — Vocabulaire

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Foreword

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

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Introduction

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

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

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

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INTERNATIONAL STANDARD ISO 26824:2013(E)

Particle characterization of particulate systems — Vocabulary

Scope

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

1 General terms, representation of particle size and classification analysis

1.1
particle
minute piece of matter with defined physical boundaries

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

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

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

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

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

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

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

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

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

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

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

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

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1.4
primary particle
original source particle of agglomerates or aggregates or mixtures of the two

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

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

1.5
particle size
x
d
linear dimension of a particle determined by a specified measurement method and under specified measurement conditions

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

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

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

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

1.6
equivalent spherical diameter
x
d
diameter of a sphere having the same physical properties as the particle in the measurement

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

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

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

1.7
type of quantity
r
specification of the quantity of a distribution, a cumulative or a density measure

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

— number: $r = 0$

— length: $r = 1$

— area: $r = 2$

— volume or mass: $r = 3$

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

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1.8
cumulative distribution
$Q_r(x)$
distribution of the fraction of material smaller (undersize) than given particle sizes

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

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

where

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

v (integer, see subscript i)

n total number of size classes

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

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

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

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

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

1.9
distribution density
$q_r(x)$
distribution of the fraction of material in a size class, divided by the width of that class

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

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

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

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

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

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

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

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1.10
distribution density on a logarithmic abscissa
$q_r^*(x)$
distribution density, transformed for a logarithmic abscissa

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

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

where ξ is any function of x.

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

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

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

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

1.11
histogram
$\bar{q}_r(x)$
normalized histogram, $\bar{q}_r(x)$, of a *distribution density* (1.9), $q_r(x)$, comprising a successive series of rectangular columns, the area of each of which represents the relative quantity $\Delta Q_{r,i}(x)$, where

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

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

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

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

1.12
concentration distribution density
distribution of the concentration of material in a size class, divided by the width of that class

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

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

1.13
analytical cut size
x_a
cut size with the coarse and the fine material containing equal quantities of misplaced material

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

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

1.14
equiprobable cut size
x_e
cut size, which represents the median of the grade efficiency curve $T(x_e) = 0,5$

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

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

1.15
grade efficiency
Tromp's curve
$T(x)$
representation, for a certain particle size x, of the ratio of the amount of material present in the coarse material to the amount of the same size initially present in the feed material

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

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

2 Sedimentation analysis

2.1
effective particle density
particle mass divided by the volume of liquid it displaces

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

2.2
true particle density
particle mass divided by the volume it would occupy excluding all pores, closed or open, and surface fissures

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

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

2.3
oversize
portion of the charge which has not passed through the apertures of a stated sieve

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

2.4
pycnometry
method wherein particle density is obtained from the measured mass of sample with a given calibrated volume

2.5
Stokes diameter
equivalent spherical diameter of the particle that has the same density and terminal settling velocity as the real particle in the same liquid under creeping flow conditions

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

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

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

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

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

3 Pore size distribution, porosity and surface area analysis

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

[SOURCE: ISO 9277:2010, 3.10.]

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

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

[SOURCE: ISO 9277:2010, 3.14.]

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

[SOURCE: ISO 9277:2010, 3.15.]

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

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

3.5
bulk density
powder density under defined conditions

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

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

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

3.7
closed pore
cavity not connected to the external surface

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

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

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

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

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

3.10
ink bottle pore
narrow necked open pore

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

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

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

3.12
internal surface area
area of internal pore walls

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

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

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

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

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

3.15
macropore
pore of internal width greater than 50 nm

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

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

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

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

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

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3.18
open pore
cavity or channel with access to an external surface

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

3.19
open porosity
ratio of the volume of open pores and voids to the total volume occupied by the solid

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

3.20
pore size
pore width, for example, the diameter of a cylindrical pore or the distance between the opposite walls of a slit

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

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

3.21
pore volume
volume of pores determined by stated method

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

3.22
porosimeter
instrument for measuring porosity and pore size distribution

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

3.23
porosimetry
methods for the estimation of porosity and pore size distribution

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

3.24
porosity
ratio of total pore volume to apparent volume of particle or powder

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

3.25
porous solid
solid with cavities or channels which are deeper than they are wide

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

3.26
powder density
mass of a powder divided by its apparent volume, which is taken to be the total volume of the solid material, open and closed pores and interstices

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

3.27
skeleton density
mass of a powder divided by the total volume of the sample, including closed pores but excluding open pores

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

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

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

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

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

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

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

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

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

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

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

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

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

3.34
adsorbate
adsorbed gas

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

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

3.36
adsorbent
solid material on which adsorption occurs

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

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

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

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3.38
adsorptive
gas or vapour to be adsorbed

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

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

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

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

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

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

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

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

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

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

3.44
right cylindrical pore
cylindrical pore perpendicular to the surface

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

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

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

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

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

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3.47
physisorption
weak bonding of the adsorbate, reversible by small changes in pressure or temperature

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

4 Representation of particle shape analysis

4.1
particle shape
external geometric form of a particle

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

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

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

[SOURCE: ISO 3252:1999, 1401.]

4.2
Legendre ellipse of inertia
ellipse with its centre at the particle's centroid and with the same geometrical moments of inertia, up to the second order, as the original particle area

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

Note 2 to entry: Macroshape descriptor, geometrical descriptor.

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

4.3
geodesic length and thickness
x_{LG} and x_E
approximations for very long and concave particles, such as fibres, calculated from the projection area A and perimeter P:

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

Note 1 to entry: Macroshape descriptor, geometrical descriptor.

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

4.4
ellipse ratio
ratio of the lengths of the axes of the Legendre ellipse of inertia)

Note 1 to entry: Macroshape descriptor, proportion descriptor.

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

4.5
aspect ratio
ratio of the minimum to the maximum Feret diameter

Note 1 to entry: For not very elongated particles.

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