



**BSI Standards Publication**

# **Representation of results of particle size analysis**

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Part 1: Graphical representation

## National foreword

This British Standard is the UK implementation of ISO 9276-1:2025. It supersedes BS ISO 9276-1:1998, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee LBI/37, Particle characterization including sieving.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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**International  
Standard**

**ISO 9276-1**

# **Representation of results of particle size analysis —**

## **Part 1: Graphical representation**

*Représentation de données obtenues par analyse  
granulométrique —*

*Partie 1: Représentation graphique*

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# Contents

Page

|                                                                                                                 |           |
|-----------------------------------------------------------------------------------------------------------------|-----------|
| <b>Foreword</b>                                                                                                 | <b>iv</b> |
| <b>Introduction</b>                                                                                             | <b>v</b>  |
| <b>1 Scope</b>                                                                                                  | <b>1</b>  |
| <b>2 Normative references</b>                                                                                   | <b>1</b>  |
| <b>3 Terms and definitions</b>                                                                                  | <b>1</b>  |
| <b>4 Symbols</b>                                                                                                | <b>5</b>  |
| 4.1 General                                                                                                     | 5         |
| 4.2 Symbols                                                                                                     | 5         |
| <b>5 Particle size, measures and types</b>                                                                      | <b>6</b>  |
| 5.1 General                                                                                                     | 6         |
| 5.2 Particle size, $x$                                                                                          | 6         |
| 5.3 Measures and types of quantity                                                                              | 7         |
| <b>6 Graphical representation of PSDs</b>                                                                       | <b>7</b>  |
| 6.1 Cumulative distribution, $Q_r(x)$                                                                           | 7         |
| 6.2 Representation in discrete classes as histogram, $\bar{q}_{r,i}$                                            | 9         |
| 6.3 Distribution density, $q_r(x)$                                                                              | 10        |
| <b>7 Graphical representation of cumulative distribution and distribution density on a logarithmic abscissa</b> | <b>11</b> |
| 7.1 Cumulative distribution on a logarithmic abscissa                                                           | 11        |
| 7.2 Distribution density on a logarithmic abscissa                                                              | 12        |
| <b>8 Graphical representation of non-normalized distributions</b>                                               | <b>12</b> |
| 8.1 Graphical representation of concentration distribution                                                      | 12        |
| 8.2 Graphical representation of separated particle distributions                                                | 13        |
| <b>9 Graphical representation of two-dimensional distribution</b>                                               | <b>13</b> |
| 9.1 Graphical representation of two-dimensional PSD                                                             | 13        |
| 9.2 Graphical representation of shape and size distribution data                                                | 16        |
| <b>Annex A (informative) Example of graphical representation of particle size analysis results of sieving</b>   | <b>19</b> |
| <b>Annex B (informative) Example of number concentration size distribution as result of aerosol measurement</b> | <b>22</b> |
| <b>Annex C (informative) Example of graphical representation of two-dimensional PSD</b>                         | <b>24</b> |
| <b>Bibliography</b>                                                                                             | <b>27</b> |

## 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 document 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)).

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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 third edition cancels and replaces the second edition (ISO 9276-1:1998), which has been technically revised. It also incorporates the Technical Corrigendum ISO 9276-1:1998/Cor 1:2004.

The main changes are as follows:

- [Clause 3](#) has been added;
- [Formulae \(9\)](#) and [\(10\)](#) have been added in [7.2](#);
- [Clauses 8](#) and [9](#) have been added;
- [Annex B](#) and [Annex C](#) have been added.

A list of all parts in the ISO 9276 series can be found on the ISO website.

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

The characterization of a dispersed phase with respect to its particle size distribution (PSD) is a major task, whenever the generation, emission, transport, application or consumption of particulate matter is monitored or investigated. The spectrum of relevant materials is very broad and "particle" can refer to grains, flakes, fibres, droplets, bubbles, micelles or pores. Within a particulate material, particles typically vary with regard to their size. The distribution of this measurand is characterized by the relative quantity of particles belonging to a specific size class.

There are a wide range of methods for the size analysis of particulate matter. For many reasons, the results will, in general, not be the same. One of the main problems still encountered with most methods in use is their unknown absolute accuracy. Apart from this, there are two principal origins of the differences among measured PSDs.

Firstly, the measurand "particle size" is an ambiguous property being specified by the measurement principle of the instrumentation and the way of signal analysis. Both specifications define the type of particles which are intrinsically measured: agglomerates or their constituent particles; Pickering emulsion droplets or the nanoparticles at their surface; complete core-shell particles or the core of the particles only. Therefore, "size" can refer to a variety of physical and geometric properties.

Secondly, the distribution of size can be measured and expressed by different types (and measures) of quantity.<sup>[1]</sup>

A disperse system can be described by different types of PSD, which supplement each other in providing a comprehensive view on the granulometric state of the particulate material. Moreover, each type of PSD can be represented in various manners.

Beside numerical and mathematical representations, graphical ones are particularly popular and useful because they allow for a quick comprehension of the main PSD features or a fast evaluation of differences among product lots. There are various ways of plotting a PSD, which emphasize different details though communicating the same information. This requires explanation, especially when a PSD is described by discrete data.

A harmonized view on terms and a common understanding of how to graphically plot and interpret PSDs support the communication between suppliers and clients and improve the comparability of measurement data from different instruments.



# Representation of results of particle size analysis —

## Part 1: Graphical representation

### 1 Scope

This document specifies guidelines and instructions for the graphical representation of particle size analysis data in histograms, distribution densities and cumulative distributions. It also establishes a standard nomenclature to obtain the histograms, distribution densities and cumulative distributions from measured particle size data.

This document applies to the graphical representation of particle size distributions (PSDs) of solid particles, droplets or gas bubbles covering all size ranges.

### 2 Normative references

There are no normative references in this document.

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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 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 26824:2022 3.1.1]

#### 3.2 particle size

$x$   
 $d$   
linear dimension of a *particle* (3.1) 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 diameter.

Note 2 to entry: Possible types of particle size values are equivalent diameters from physical measurement or equivalent circular diameters from image analysis as well as linear dimensions, e.g. sieve size of a particle, the smallest aperture size through which a particle will pass if presented in the most favourable orientation.

Note 3 to entry: In this document and all other parts of the ISO 9276 series, the symbol  $x$  is used to denote the particle size. However, it is recognized that the symbol  $d$  is also used to designate these values. Therefore the symbol  $x$  may be replaced by  $d$ .

### 3.3 equivalent diameter

equivalent spherical diameter

$x_j$   
 $d_j$   
diameter of a sphere that produces a response by a given particle-sizing method, that is equivalent to the response produced by the particle being measured

Note 1 to entry: The physical property to which the equivalent diameter refers is indicated using a suitable subscript.

Note 2 to entry: For discrete-particle-counting in light-scattering instruments, a scattering intensity equivalent diameter is used, in extinction measurement a light extinction equivalent 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. In some instances, refractive index and the spectral function should be reported as well.

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 26824:2022 3.1.10, modified — Notes 2 and 3 to entry have been expanded.]

### 3.4 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:  $r = 3$

Note 2 to entry: To include frequently used non-geometrical quantities, the specification of the quantity has been extended to the following subscripts, replacing  $r$ :

- light extinction: subscript “ext”;
- light intensity: subscript “int”.

### 3.5 particle size distribution PSD

distribution of particles as a function of *particle size* (3.2)

Note 1 to entry: Particle size distribution may be expressed as *cumulative distribution* (3.6) or a *distribution density* (3.8) (distribution of the fraction of material in a size class, divided by the width of that class).

[SOURCE: ISO 26824:2022, 3.1.12]

### 3.6

#### cumulative distribution

cumulative distribution function

$Q_r(x)$

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

Note 1 to entry: If the cumulative distribution,  $Q_r(x)$ , is calculated from *histogram* (3.10) 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 quantity 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

- $r$  is the (subscript) type of quantity;
- $i$  is the (subscript) number of the size class with upper limit  $x_i$ ;
- $v$  is the (subscript) number of the size class with upper limit  $x_v$ ;
- $n$  is the total number of size classes;
- $Q_{r,v}$  is the relative quantity 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 quantities 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  $1 - Q_r(x)$ .

### 3.7

#### cumulative oversize distribution

cumulative oversize distribution function

$1 - Q_r(x)$

distribution of the fraction of material larger (oversize) than given particle sizes

Note 1 to entry: Each individual point of the distribution defines the relative quantity of particles larger than the particle size. Therefore, the abscissa value of each point is  $x_{i-1}$ , the lower size of the particle size class,  $i$ .

### 3.8

#### distribution density

distribution density function

$q_r(x)$

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*,  $Q_r(x)$  (3.6), 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: 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”.