

BRITISH STANDARD

Guide to particle sizing methods

ICS 17.040; 19.120



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ISBN 978 0 580 53047 0

The following BSI references relate to the work on this standard:

Committee reference LBI/37

Draft for comment 06/19987355 DC

Publication history

First published November 2007

Amendments issued since publication

Amd. no.	Date	Text affected
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Foreword

Publishing information

This British Standard was published by BSI and came into effect on 30 November 2007. It was prepared by Technical Committee LBI/37, Sieves, screens and particle sizing. A list of organizations represented on this committee can be obtained on request to its secretary.

Hazard warnings

The guidance contained in this British Standard is of a general nature. It cannot take account of hazards associated with specific materials which, when subjected to recommended treatments may be dangerous.

Information about this document

Users of this guide are directed to relevant Health and Safety (e.g. COSHH 2002 [1]) regulations, which require potential users of any procedure to assess hazards associated with it and to document the precautions appropriate to the risk.

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0 Introduction

This British Standard provides simple advice for those wishing to obtain particular information on the size distribution of particles in a sample of particulate material. Various methods of sizing exist which are based on several principles. The advice given is aimed at enabling users to select methods appropriate to their needs.

Particles exist as powders or as suspensions in solid, liquid or gaseous media. In the context of this document particles might also be in the form of liquid droplets or emulsions. Methods are available for sizing them in all these conditions. In some cases it might be desirable, or indeed essential, to examine them in their original condition. In other instances it can be advantageous to change the condition of suspension.

The standard provides a listing of the practical choices available and offers a logical approach to decision making. Principal features of each method are available at a glance in tabulated form.

Important criteria that should be borne in mind when an analysis is discussed and some variables that might influence the choice of approach are illustrated. Although many methods of particle sizing are ingenious, sensitive, reliable and repeatable, no method can be regarded as perfect and compromise is frequently necessary.

1 Scope

This British Standard guide discusses the techniques commonly used for particle sizing, in the context of the physical and chemical properties of the sample on which the information is required, and the purpose for which the information is to be used. This information is primarily relevant to particles in the sub-millimetre range.

2 Normative reference

The following referenced document is indispensable for the application of this document.

BS 2955:1993, *Glossary of terms relating to particle technology*

3 Definitions

For the purposes of this British Standard, the definitions given in BS 2955 apply.

4 General

Particle size is an important determinant in particle behaviour and its measurement can be achieved by many methods. The simplest involve determination of particle dimensions by comparison with a standard scale, calliper gap or two-dimensional figure, such as a circle. Single, two- and three-dimensional measurements can be of value on occasions and their usefulness might be enhanced by being complemented with shape descriptions.

Direct visual comparison of specific particles is not possible for particles the size of which is insufficient for resolution by the naked eye or with the aid of a microscope. To estimate the size of such particles, it is necessary to identify a property of the particle that varies as a function of size, and to determine that property for the particle concerned.

Measurement of a single particle is of limited value, as information is usually required on the size distribution of a population of particles. Obtaining this information by recording the dimensions of individual particles without the use of automation can be tedious and slow. Without automation, individual measurement is rarely the method of choice even with large sized particles.

A comparator method involves the segregation of particles through a mesh of finite size. Those particles that are small enough to pass through the holes in a uniform mesh are separated from those that are retained on the mesh. By use of a range of meshes appropriate to the sizes of the particles present, the population can be fractionated into classes whose contribution to the whole may be estimated by the weight of each fraction.

Detailed information, by assessing the proportions of the population falling within channels defined by a series of size limits or thresholds, can be achieved by other methods. The upper size limit of one channel forms the lower size limit of the next. Such methods depend upon each particle being measured and the distribution is thus derived from a process whereby individual particle data are sorted into size categories.

Some methods depend, not upon the measurement of individual particles, but upon the measurement of a characteristic of the entire particle assembly, for example the scattering of light by a dispersed cloud of particles.

5 Particle size distribution

A particle size distribution can be described as:

- a functional relationship between the quantity of particles and some measure of particle size, or
- a description of the size and frequency of particles in a population (BS 2955:1993, 6 **029**).

Particle size distributions can be expressed as a fraction, which indicates the proportion of the total population occurring in size channels defined by a continuous range of upper and lower limits. These limits are usually chosen between zero and a magnitude greater than the largest particle present, or an arbitrarily defined maximum.

In particle size distributions the quantity axis may be measured and expressed in terms of number, surface, volume or mass. Significant numerical differences occur when the quantity of particles in a particle size distribution are expressed on different quantity axes (e.g. number, surface, volume or mass).

A single 100 μm particle has the same volume as one thousand 10 μm particles. The volume of sample in a specific size class is related to the number of particles in that size class and by the cube of the particle diameter.

The sizing methods discussed in this British Standard depend upon some prior knowledge of the size and nature of the particles present in the sample to be measured. If such knowledge is not available when the sample is supplied, some might be revealed by microscopy. Both optical and electron microscopy, using calibrated measuring devices, constitute methods of particle sizing, and preliminary examination using a microscope is always recommended, even when it is not chosen as the final method of particle size analysis. Microscopy should also be used as a means to check the effectiveness of any pre-treatment of the sample prior to analysis.

Using appropriate techniques, it is possible to obtain size distributions of populations of particles that are solid, liquid or gaseous. It is necessary that, at the time of analysis, the boundaries of the particles should be distinguishable from the boundaries of the other particles and from the continuous phase in which they are dispersed. Physical and chemical knowledge is required of the particle population under consideration to select a suspending medium that allows this criterion to be met.

A general introduction to the techniques discussed in this standard can be found in [2] and [3].

6 Methods of particle size determination

6.1 General

Particle size analysis methods can be divided into three basic approaches: direct (6.2); classification (6.3) and indirect (6.4).

6.2 Direct methods

These examine and estimate the size of each particle separately and individually. These methods include:

- microscopy;
- electrical sensing zone;
- light blockage; and
- single particle light scattering.

6.3 Classification methods

With these methods, the assembly of particles is separated into size groups based upon a physical parameter of the particle.

Such methods include:

- sieving;
- sedimentation;
- field flow fractionation; and
- hydrodynamic chromatography.

6.4 Indirect methods

These are the methods that utilize a property of the particle. The particles are presented as an ensemble from which a size distribution is inferred from the measured property.

Such methods include:

- laser diffraction;
- dynamic light scattering;
- ultrasound; and
- specific surface.

7 Aggregation

It is important to determine whether the particle size distribution is to be obtained from examination of the fundamental particles or whether to measure them in their aggregated state. For example, a raspberry represents an aggregate of fleshy seeds. Do we wish to determine the size distribution of the fleshy seeds or the berry?

Aggregated particles can be reduced to individual particles by de-aggregation prior to analysis. Conversely, prior treatment can cause individual particles to aggregate into groups which are so stable that they are subsequently measured as individual particles. It is important that the potential for aggregation or de-aggregation occurring in particular samples is assessed. Examination by microscopy can be invaluable for determining changes in the degree of aggregation, even if alternative methods are to be used for the quantitative analysis.

8 Size and shape

The shape of particles is an extremely important factor in measuring particle size as it can influence the perception of size by the methods discussed in this guide.

In sieving, for example, the method discriminates the size of irregular particles according to the second largest dimension of the particle. Shape also influences the sedimentation of particles, causing them to appear smaller by mass than their actual mass.

Difficulties in interpretation of results are compounded when particles in a population to be measured have a range of both size and shape. Microscopic examination can provide an assessment of the shape or range of shapes present, allowing the choice of method or methods adopted to be matched to the predicted behaviour of particles under conditions of measurement.