BRITISH STANDARD

BS 1796-1: 1989
ISO 2591-1: 1988

Test sieving —

Part 1: Methods using test sieves of woven wire cloth and perforated metal plate

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the General Mechanical Engineering Standards Policy Committee (GME/-) to Technical Committee GME/29, upon which the following bodies were represented:

BCIRA
British Cement Association
British Ceramic Society
British Coal Corporation
British Laboratory Ware Association
Coated Abrasives Manufacturers' Association
Department of Transport
Guild of Metal Perforators
Institution of Chemical Engineers
Institution of Mining and Metallurgy
Mechanical Handling Engineers' Association
Ministry of Defence
NABIM
Society of Chemical Industry
Society of Cosmetic Scientists
Woven Wire Association

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Aluminium Federation
British Ceramic Research Ltd.
Chemical Industries Association
Department of Trade and Industry (Warren Spring Laboratory)
English Metal Powder Co. Ltd.
Institute of Physics
Institution of Mining Engineers
Oil and Colour Chemists' Association
Royal Society of Chemistry
University of Bradford

This British Standard, having been prepared under the direction of the General Mechanical Engineering Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 29 September 1989

First published March 1952
First revision July 1976
Second revision September 1989

The following BSI references relate to the work on this standard:
Committee reference GME/29
Draft for comment 87/71699 DC

ISBN 0 580 17527 8

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

National foreword

This Part of BS 1796 has been prepared under the direction of the General Mechanical Engineering Standards Policy Committee. It is identical with ISO 2591-1:1988 "*Test sieving — Part 1: Methods using test sieves of woven wire cloth and perforated metal plate*", which is a revision of ISO 2591:1973, prepared by Technical Committee ISO/TC 24, Sieves, sieving and other sizing methods, of the International Organization for Standardization (ISO), and in the development of which the UK has played an active part. It supersedes BS 1796:1976, which is withdrawn.

Cross-references

The Technical Committee has reviewed the provisions of ISO 565:1983[1)], ISO 2395:1972[1)], ISO 3310-1:1982[1)], ISO 3310-2:1982[1)] and ISO 3310-3[2)], to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. A related British Standard to ISO 565:1983[1)], ISO 3310-1:1982[1)] and ISO 3310-2:1982[1)] is BS 410:1986 "*Specification for test sieves*".

ISO 565:1983[1)] is only referred to in clause **0** and in Figure 1, and ISO 2395:1972[1)] is only referred to in clause **2** for information.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

[1)] At present being revised by ISO.

[2)] At present at the stage of draft.

0 Introduction

0.1 General considerations

Test sieving is used in many industries on a wide variety of materials and for different purposes. No single method of test sieving can be specified to cover the many applications, and certain industries have already produced specifications for sieving procedures which are incorporated in the appropriate International Standard for a limited application. Standardized series of nominal openings of test sieve media are specified in ISO 565, and standardized technical requirements on test sieves are standardized in ISO 3310.

ISO 2591 is intended as a guide to all who are responsible for deciding on test sieving procedures, including those concerned with specific materials, and it formulates general principles of sieving which may be applied to many natural and artificial materials.

The procedures given depend on the predominant size range of the particles in a sample, and it is recognized in this part of ISO 2591 that some materials are difficult to sieve and require specially developed techniques (see clause 4).

Test sieving may be undertaken

a) as part of a research project involving an investigation of the particle size of a material;

b) as part of a control procedure for the production of material where the particle size distribution is important;

c) as the basis of a contract for the supply of material specified to be within stated grading limits.

The principles to be followed in the sieving procedure will be similar in each case but the actual detail may vary considerably according to the purpose for which the results are required. For example, the main criterion for a sieve analysis undertaken for research purposes may be consistency in one laboratory, whereas for a procedure which forms part of a specification in a contract it may well be maximum reproducibility between laboratories consistent with reasonable cost of testing.

The accuracy required for quality control purposes may well be relatively low and the predominant factors could be low cost, maximum mechanization and speed in obtaining the result. A simplified procedure with a given operator and particular apparatus in one set-up may be found adequate for control purposes, even though the reproducibility of the procedure as used between different laboratories may not be very good.

0.2 Principles of sieving

A single test sieve separates a particular material into two fractions, of which one is retained by the sieving medium and the other of which passes through its apertures. When applied to particles of non-spherical shape the procedure is complicated by the fact that a specific particle with a size close to that of the nominal aperture size of the test sieve may pass through the apertures only when presented in a favourable position, and will not pass through when presented in other positions. As there is inevitably a variation in the size of the sieve apertures, prolonged sieving will cause the larger apertures to exert an unduly significant effect on the sieve analysis: the proportion of oversize apertures is limited by the specifications for test sieves. The procedure is also complicated in many cases by the presence of so-called "near aperture size" particles which cause blinding of the sieve apertures and reduce the effective area of the sieving medium.

The process of sieving may be divided into two stages: firstly, the elimination of particles considerably smaller than the sieve apertures, which could occur fairly rapidly, and secondly, the separation of "near aperture size" particles, which is a gradual process rarely reaching completion. Both stages require all particles put on the sieving medium to have the opportunity of passing through an aperture. Ideally, each particle should be presented individually to an aperture, as is permitted for the largest aperture sizes, but for most sizes this is impracticable. The effectiveness of a sieving technique depends on the amount of material (charge) put on a sieve and the type of movement imparted to the charge on the sieve.

If the charge is too large, the bed of material on the sieving medium will be too many particles deep to allow each one the opportunity of being presented to an aperture in the most favourable position in order for gauging to be completed in a reasonable time. The charge, therefore, is limited by a requirement on the maximum amount of material retained at the end of sieving appropriate to the aperture size of the test sieve. However, the sample to be sieved has to contain enough particles to be representative of the consignment, so a minimum size of sample is specified. In some cases, the sample will have to be subdivided into a number of charges if the requirement for preventing overloading of the sieves is to be satisfied.

The movement imparted to a sieve by hand can be adapted, by experience, to meet the needs of the material and the sieving medium; different techniques are required for particles of quite different size. A machine, however, is usually designed to impart a particular combination of movements, irrespective of the aperture size of the test sieve or the characteristics of the material, and may not be readily adaptable to be equally effective for different materials. Nevertheless, a machine does not get tired and moderate effectiveness may often be acceptable providing that sieving continues long enough.

When this part of ISO 2591 was being prepared, the alternatives of shaking the sieve by hand and by means of a machine were considered. Hand shaking by an experienced operator is generally more effective when sieving relatively coarse particles. For fine powders, however, the end point may be approached more rapidly, and certainly with less effort, by using one of the many mechanical and other sieving techniques now commercially available. Hand sieving and machine sieving are not mutually exclusive; machine sieving followed by a final brief hand sieving to ensure that the end point has been reached (see **7.2.7**) may achieve the best results.

0.3 Correlation of results from different methods of size analysis

It may be necessary to combine size distributions determined by different methods, e.g. sieving, sedimentation, elutriation or microscopy. It is preferable to cover the range of a single distribution using a single method, but this is not always possible. A simple, but admittedly not a particularly accurate, procedure for establishing correlation factors for two different sizing techniques is to overlap the methods of size determination so that one or more size classes are assessed by both methods.

1 Scope and field of application

This part of ISO 2591 draws attention to and describes the main factors affecting test sieving and the results obtained; it also specifies general principles to be followed concerning apparatus, procedure and presentation of results.

It applies to methods in which test sieves of woven wire cloth or perforated metal plate are used. Test sieving methods using test sieves of electroformed sheet will form the subject of ISO 2591-2.

2 References

ISO 565, *Test sieves — Woven metal wire cloth, perforated plate and electroformed sheet — Nominal sizes of openings.*

ISO 2395, *Test sieves and test sieving — Vocabulary.*

ISO 3310, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth — Part 2: Test sieves of perforated metal plate — Part 3: Test sieves of electroformed sheets*[3)].

3 Definitions

For the purposes of this part of ISO 2591, the definitions given in ISO 2395 apply.

4 Material to be sieved

4.1 General

Materials to be test sieved range from very coarse lumps, such as coal and stone, to very fine materials, such as pigments and clay; they differ in their physical and chemical properties. Information about the properties of a material is helpful in judging its sieving characteristics, and should be noted in the test report. The more important properties affecting sieving are dealt with in **4.2**.

Because of the considerable variety of material properties encountered, it is not possible to specify a single method of test sieving which applies to all materials. The sieving method appropriate to a material should be stated in an International Standard or national standard, or in other specifications dealing with that material.

4.2 Physical and chemical properties

4.2.1 *Density*

The following kinds of density are important in test sieving:

a) effective particle density, which can affect the duration of sieving;

b) apparent bulk density, which can influence the quantity of material to be taken for sieving.

4.2.2 *Friable nature*

Some materials are liable to reduce in size during sieving because of their friable nature. This property should be taken into account in the handling of the material during sampling and test sieving.

[3)] At present at the stage of draft.

4.2.3 ***Abrasive properties***

Some materials, e.g. emery powders, are abrasive; these wear out the sieves and modify the apertures in the course of a prolonged sieving operation. It is desirable to ascertain whether or not the material is abrasive before commencing the test and to check the conformity of the apertures of the sieving medium against the specified tolerances.

4.2.4 ***Surface moisture***

Surface moisture is important because it affects the way in which a material will flow on a sieve.

4.2.5 ***Internal moisture***

If there is a change in internal moisture during sieving, the masses of the fractions will be affected.

4.2.6 ***Hygroscopic properties***

Some materials readily absorb moisture and cannot safely be allowed to come into equilibrium with the laboratory atmosphere. In such cases they should be handled and sieved in such a way as to reduce their contact with the atmosphere to a minimum.

4.2.7 ***Change of property on drying***

It is important to know whether the properties of a material are changed by any proposed drying process, e.g. whether the material is liable to break or to cake.

4.2.8 ***Particle shape***

The duration and results of sieving can be considerably affected by the shape of the particles.

4.2.9 ***Size distribution***

The range of particle size of the material is important in deciding the sieving procedure to be used (see clause **7**).

4.2.10 ***Cohesive property***

The spreading of the particles on the sieving medium depends on the cohesive nature of the material; this, in turn, depends on the inter-particle forces and increases with the fineness of the powder.

4.2.11 ***Magnetic properties***

Magnetic properties of materials may affect the results on account of the reaction of the particles with each other (tending to agglomerate) and with the sieve (tending to adhere).

4.2.12 ***Electrostatic properties***

Some powders may become charged with static electricity during the sieving operation and adhere to the sieve frame, thereby affecting the results.

4.2.13 ***Chemical reactivity***

Certain materials to be sieved may react with the atmosphere or with the materials of the sieve. Consequently, it is necessary that all component parts of the sieve be inert. Furthermore, the test may have to be conducted in an inert atmosphere.

4.2.14 ***Production of material***

The source of the material and method of preparation may provide information on the properties dealt with in **4.2.1** to **4.2.13**; such information should be included in the test report.

5 Sampling

5.1 Sampling method

Precise sampling is a necessary condition for obtaining accurate results for sieve tests. Just as much care should, therefore, be taken with the sampling as with the actual sieving.

The sampling method used should be such that the sample taken for sieving is truly representative of the material from which it has been drawn. The most suitable method will depend both on the material and on the form in which it is presented, e.g. whether it is in bags, in a heap or flowing as a continuous stream. It is not possible to specify one method that is applicable to all materials; precise sampling methods should be specified for particular materials and circumstances.

The sampling method shall comply with the requirements specified for individual products in the relevant International Standards concerned with those products; otherwise, the methods specified in national standards shall be complied with.

5.2 Division of the sample

The original sample is often too large for direct use in a sieve test: it shall therefore be reduced. In reducing the sample, it is just as important to ensure that the final quantity (test sample) taken for sieving is truly representative of the original sample as it is to ensure that the original sample was representative of the material (see **5.1**).

As in the case of the original sampling, the division of samples of particular material shall comply with the relevant International Standards concerned with that material, or, in the absence of any International Standards, the appropriate national standards.

5.3 Storage of samples and test samples

Samples and test samples shall be stored in such a way that they are not liable to be contaminated or changed in any other way.

6 Apparatus

6.1 *Test sieves*

Test sieves shall comply with the relevant part of ISO 3310 or with International Standards based on ISO 3310.

Test sieving shall be carried out with a single test sieve or with a series of test sieves with different nominal aperture sizes. A lid and receiver pan should be included in both cases, where appropriate. The number of sieves used in the test should be sufficient to give the requisite information about the material and to avoid excessive wear or blinding.

The same type of sieving medium (i.e. wire cloth or perforated plate) and the same geometrical form of the apertures shall be used for all the test sieves used in any one nest.

If more than one nest of sieves has to be used in series, the results shall be combined.

6.2 *Preparation and maintenance of test sieves*

Before each use, the sieving medium and frame should be scrutinized against an illuminated background for defects, blinding or contamination. If it is necessary to clean the sieve, cleaning should be carried out with great care to avoid damage to the sieving medium.

Sieves may be washed in warm water containing a liquid synthetic detergent. The sieve should afterwards be rinsed thoroughly in clean water and dried in a warm atmosphere. The test sieves should not be heated to high temperature; heating above 80 °C is liable to cause permanent damage.

Other useful methods for removing entrapped material from the sieving medium, particularly from the finer apertures, include shaking the sieve upside down on a sieving machine or immersing the sieve in a bath of water agitated by an ultrasonic transducer, provided that the sieving medium will withstand such a process.

The accuracy of the sieving medium in the test sieve shall be verified at the outset and shall subsequently be re-verified in the course of use. Factors such as the frequency of use and type of material sieved will influence how often such verifications are carried out. It is desirable, therefore, to have a record card for each test sieve. Verification and re-verification shall be carried out according to the procedure described in ISO 3310. If a sieving medium no longer complies with the tolerances specified, the marking of the label shall be obliterated and the sieve discarded.

Test sieves of the same nominal aperture size may not give identical results with the same product. A method for checking the effective sieving size (cut size) of a test sieve is to calibrate it with a certified reference material, glass spheres, quartz particles, etc., and to retest it from time to time to verify that the effective sieving size has not changed.

6.3 *Accessories*

Depending on the material characteristics and the particle size distribution of the sample to be tested, the following auxiliary apparatus may be useful:

a) for dry sieving: a soft brush, e.g. a paint brush, to clean the underside of the sieving medium from time to time;

b) for wet sieving: an installation with a reservoir of liquid, regulating valve and collecting tank.

For test sieving purposes, the use of mechanical accessories, such as rubber cubes or balls, is not permitted since these may damage both the material to be sieved and the sieving medium.

7 Test sieving methods

7.1 General

7.1.1 *Principle*

Test sieving consists in gently placing the material to be sieved on the test sieve having the specified nominal aperture size and separating the material, by shaking, tapping or washing, into oversize and undersize. In sieving successively with test sieves of different aperture size, the test sample is separated into size fractions designated by the aperture sizes of the test sieves used.

Before test sieving is begun, the following conditions should be stipulated:

a) the sieving method, i.e. dry, wet, or a combination of both;

b) the number of sieves to be used and their nominal aperture sizes;

c) the size and shape of the frame;

d) the type of sieving medium (i.e. woven wire cloth, perforated plate or electroformed sheet), square or round holes, material of frame and sieving medium.

7.1.2 *Hand sieving and machine sieving*

Test sieving can be carried out by hand and/or on test-sieving machines. If test-sieving machines are used, the sieving results shall conform, within agreed tolerances, to those obtained by hand sieving. The reference method shall always include final hand sieving, performed under specified conditions (see **7.2.7**). If machine test sieving alone is carried out, the machine and the method of operation shall be stated in the test report.

7.1.3 *Dry sieving and wet sieving*

For test sieving by hand, the following procedures are commonly used:

a) for dry sieving: shaking and tapping (the procedure suitable for most materials);

b) for wet sieving: washing (for materials which tend to agglomerate).

The hand-sieving process may be adapted to the sieving characteristics of the sample concerned by choosing from the alternatives given above.

7.1.4 *Weighing accuracy*

It is recommended that the masses of the charge and the fractions should be determined by weighing to an accuracy of better than 0,1 % of the mass of the charge.

7.1.5 *Influence of the humidity of the air*

Samples which are not hygroscopic or chemically reactive and which are to be dry sieved shall be in equilibrium with the laboratory atmosphere; this is achieved by adopting the method best suited to the product. If there is a change in humidity during the test, the masses of the charges and fractions shall be corrected to their dry masses or to an agreed basis.

7.1.6 *Test sample*

The quantity of material (charge) to be placed on a sieve depends on

a) the sieve nominal aperture size;

b) the apparent bulk density of the material;

c) the cross-sectional area of the sieve;

d) the proportion of oversize material (determined if necessary by preliminary sieving).

The recommended quantity of material to be sieved on a 200 mm diameter round sieve is given, for guidance, in the Table (column 2 gives the quantity for sizes in the R 20/3 series between 22,4 mm and 25 μm). The quantity should be that specified for the sieve corresponding to the dominant size fraction of the sample, providing that the size distribution does not cause excess volume on any of the sieves in the set as indicated in column 2 of the Table.

The values given in the Table apply both to single sieves and to sieves in nests, and both to hand sieving and to machine sieving.

However, the incidence of blinding if there is a large proportion of near aperture size particles on any sieve may necessitate a reduction of the charge.

The proportion of oversize material should be such that the volume retained on the sieve after sieving has been completed is not greater than the volume specified in column 3 of the Table. It may be necessary, therefore, to sieve a test sample in two or more charges to avoid exceeding the maximum permissible volume of residue. The results shall be combined.

To obtain the best results, it is always preferable to place a reduced charge on the coarsest aperture sieve to avoid overloading any of the finer aperture sieves in the set.

If any of the fractions of particular interest do not contain a sufficient number of particles to be representative of the bulk material, the sieving shall be repeated with further charges until this fraction is sufficient.

7.1.7 *Largest particle to be permitted on a test sieve*

To avoid damage to the sieve, the size of the largest particle in the charge should not exceed $10w^{0,7}$ mm, where w is the nominal aperture size in millimetres.

Examples:

Nominal aperture size, w	Approximate size of largest particle
4 mm	25 mm
1 mm	10 mm
0,25 mm	4 mm
0,045 mm	1 mm

7.2 Dry sieving

7.2.1 *Effectiveness of dry test sieving*

The effectiveness of dry test sieving depends on

a) the duration of sieving;

b) the tapping force, frequency and direction;

c) the amplitude of shaking;

d) the inclination of the sieve surface;

e) the nature of the material.

7.2.2 *Preliminary sieving into particle size ranges*

Test sieving by hand should normally be performed on the whole test sample with sieves having an aperture size up to 25 mm. Above 25 mm, the particles can be presented individually by hand to the apertures.

The test sample may be divided into fractions by a preliminary sieving into the following particle size ranges:

a) larger than 25 mm;

b) 25 mm to 4 mm;

c) smaller than 4 mm to 1 mm;

d) smaller than 1 mm.

Table — Guide to quantity of material for test sieving on a 200 mm diameter round sieve[a]

1	2	3
	Bulk volume of material[b]	
Nominal aperture size, *w*	Approximate volume of charge	Maximum volume of residue[c]
mm	cm^3	cm^3
22,4	1 600	800
16	1 000	500
11,2	800	400
8	500	250
5,6	400	200
4	350	175
2,8	240	120
2	200	100
1,4	160	80
1	140	70

1	2	3
	Bulk volume of material[b]	
Nominal aperture size, *w*	Approximate volume of charge	Maximum volume of residue[c]
µm	cm^3	cm^3
710	120	60
500	100	50
355	80	40
250	70	35
180	60	30
125	50	25
90	42	21
63	35	17
45	30	15
32	26	13
25	22	11

[a] When using test sieves of different shapes and sizes, the values should be modified in proportion to the sieving area.

[b] Masses of materials can be determined by multiplying the values specified in columns 2 and 3 by the apparent bulk density, in grams per cubic centimetre, of the material to be sieved.

[c] Maximum volume permitted on the sieve after sieving has been completed.

The test sieving procedures for materials within these different size ranges are given in **7.2.3** to **7.2.5**.

Each fraction obtained by preliminary sieving should be tested, if necessary by subdividing it into a number of charges, in accordance with the values specified in the Table. The results shall be combined.

If test sieving over more than one of the above size ranges is required, the individual fractions shall be recorded as mass percentages of these ranges and, in the final evaluation, converted to mass percentages of the sum of all the fractions collected (see **7.5.2**).

7.2.3 ***Procedure for particles larger than 25 mm***

For particles larger than 25 mm, the test sieve serves essentially as a gauge on which the particles are individually presented to one of the apertures.

A charge appropriate to the sieve may first be screened by gentle shaking. Then check the particles remaining on the sieve one by one in all positions without applying force. Those that pass through shall be included in the passing fraction; those that do not pass through shall become the residue.

7.2.4 ***Procedure for particles 25 mm to 1 mm***

Particles of sizes from 25 mm to 4 mm should, preferably, be tested on each individual sieve and not with a nest. Below 4 mm, the sieves may be nested.

The following two procedures are permissible.

a) Sieve a fresh charge through each sieve in turn (see the Table for recommended sample quantities).

b) Use a fresh charge only on the sieve with the largest nominal aperture size. Use the material which passes through this sieve as the charge for the test sieve with the next smallest nominal aperture size, and so on. This is a similar sieving process to that with a test sieve nest.

Take the test sieve, or the test sieve nest (sieve apertures from below 4 mm to 1 mm), with both hands and move to and fro horizontally about 120 times per minute at an amplitude of about 70 mm.

If the material is difficult to sieve, especially in the particle size range from below 4 mm to 1 mm, the to-and-fro movement should be interrupted three times per minute by a circular motion.

7.2.5 *Procedure for particles smaller than 1 mm*

7.2.5.1 *General*

The following procedures apply when test sieves in accordance with ISO 3310-1 are used. Electroformed sheet test sieves in accordance with ISO 3310-3 may require other procedures (see clause **1**).

a) Use a test sieve nest with a receiver pan and lid. Place the charge on the top sieve with the largest aperture size. In some cases it may be expedient to use a smaller charge than that specified in the Table to ensure that the finer material passes quickly to the sieves of smaller apertures. If preferred, the test sieving can also be performed with individual sieves one after the other in a manner similar to sieving with a nest of test sieves.

b) Use a test sieve nest with a receiver pan and lid. Place the charge on the sieve with the smallest aperture size in the nest, bearing in mind the limitation given in **7.1.7**, and hand-sieve until most of the undersize has passed through the sieve into the receiver. By removing most of the undersize fraction in this manner beforehand both the subsequent sieving time and the dust loss are reduced, as otherwise this undersize fraction would have to pass through all the sieves in the nest. Then place the residue from this preliminary sieving on the top sieve with the largest aperture size in the nest and follow the procedure outlined in a) above.

7.2.5.2 *Sieving technique*

Take the test sieve, or nest of test sieves, in one hand or, if it is too heavy, cradle it loosely in the crook of the arm; incline the sieve (or nest) at an angle of about 20° with the point at which the sieve is held in the lower position. Tap the sieve (or nest) approximately 120 times a minute with the other hand. After 30 taps put the test sieve into the horizontal position, turn through 90° and give a hard tap by hand against the sieve frame. From time to time the sieve may also be shaken vertically.

If particles are difficult to sieve, or when using fine test sieves, the underside of the sieving medium may be cleaned gently with a soft brush (see **6.3**), when necessary. The resulting dust shall be added to the undersize material.

7.2.6 *Factors affecting sieving time*

Sieving, like any other particle separation process, does not produce an ideal separation. A few particles which are smaller than the nominal aperture size always remain in the sieve residue, e.g. because they stick to larger particles, have not found a free aperture or have only encountered undersize apertures. Similarly, owing to the presence of oversize apertures, particles which are larger than the nominal aperture size will be found in the passing fraction.

Because of this inaccuracy, no fixed time by which the sieving process will be completed can be defined. The sieving time is dependent on

a) the characteristics of the material, e.g. fineness, particle shape, size distribution, density;

b) the volume of the initial charge;

c) the sieving intensity;

d) the nominal aperture size of the test sieve;

e) the characteristics of the sieving medium;

f) the humidity of the air.

7.2.7 *Dry sieving end point*

If the end point is decided by sieving rate, it is important to ensure that the rate is not being significantly reduced by blinding.

For most non-friable materials, it may be considered that the end point of the sieving process has been reached when the quantity passing through the sieve, or through any one sieve of a nest, in 1 min is less than 0,1 % of the mass of the charge, if no other instructions are given.

For friable materials and certain special cases, the end point of the sieving process shall be determined by trial. The interested parties should agree to use a specified sieving time, as only in this way will their results be comparable.

7.3 Wet sieving

7.3.1 *Application*

Extremely fine particles, such as those encountered in the determination of the grit content in soot, or particles which become electrically charged, e.g. plastic powders, damp dust which cannot be dispersed or materials in liquid suspension, should be sieved wet, to facilitate dispersion of the primary particles.

7.3.2 *Effectiveness of wet sieving*

The effectiveness of wet test sieving depends on

a) the duration of sieving;

b) the liquid;

c) the wetting agent used, if any;

d) the intensity and nature of the movement of the sieve if sieving is carried out by moving the sieve in the liquid.

7.3.3 *Liquids*

The liquid shall not affect the particles in any way other than by dispersion. Non-foaming wetting and dispersing agents may be added.

7.3.4 *Procedures for wet sieving*

Before wet sieving, wet the test sample by mixing with a small quantity of the liquid to avoid loss of dust; also wet the sieve. Carefully transfer all the slurry onto the sieve.

Add liquids slowly, regularly and at a very low pressure to avoid loss of material and damage to the sieving medium. For this purpose, the accessories specified in **6.3** may be used.

Several procedures are permissible; some examples are given below.

a) If the test sample is sufficiently large, a number of individual samples may be produced by subdivision so that a fresh charge can be used on each test sieve in the chosen range.

b) If only a limited quantity of material is available, the test sample may be washed successively through a nest of test sieves with the finest at the bottom of the nest. The suspension which washes through the coarser test sieves is placed directly on the next sieve.

c) If only a limited quantity of liquid is available, a well-dispersed suspension should be prepared for analysis.

7.3.5 *Final drying and weighing*

When the test has been completed, dry the test sieves together with the oversize material retained at a suitable low temperature, and weigh after allowing the sieve and its contents to attain room temperature, if necessary in a desiccator. Alternatively, the material retained and the undersize fraction may be recovered, dried and weighed.

When the material to be sieved requires a prolonged wet-sieving operation, it is often difficult to collect all the undersize fraction dispersed in a large volume of liquid. In such cases, it is permitted to determine the undersize fraction by subtracting the mass of the oversize from the mass of the test sample.

7.3.6 *Wet-sieving end point*

A wet-sieving operation on an individual sieve is considered to be complete when the liquid used is practically clear when it flows through.

7.4 Combined wet and dry sieving

7.4.1 *Application*

Samples should be submitted to the combined sieving procedure if they contain significant amounts of very fine particles, which may cause coarser particles to agglomerate or which may be difficult to disperse but which may present difficulties in wet sieving in accordance with **7.3**.

NOTE Samples containing significant amounts of very fine particles may take an unacceptably long time to reach an end point when dry sieved because of blinding of the sieve apertures by the fines, but they may, when wet sieved, produce unacceptably large volumes of suspension passing the finest sieve. The procedure described in **7.4.2** may be used to reduce the time taken for test sieving.

7.4.2 *Procedure*

7.4.2.1 *Wet sieving or washing*

Follow the principles outlined in **7.3** in order to wash the fine particles through the finest sieve in the chosen set. Protect this sieve by placing one or more guard sieves before it, e.g. a 45 μm sieve might be protected by a 500 μm sieve.

Determine the mass of material passing through the finest sieve by one of the following procedures.

a) Collect the washings passing through the finest sieve and separate the suspended solids by filtration followed by drying. Flocculation of the suspended particles may assist filtration.

b) Use a weighed and dried initial charge; dry and weigh the combined oversize from the washing stage and determine the mass of undersize as the difference between the initial and the final masses.

7.4.2.2 *Dry sieving*

Dry the combined oversize from the washing stage and sieve it according to the procedure described in **7.2** using the chosen set of sieves. The finest sieve in the set should have the same apertures as that used in the washing stage.

NOTE Because of the imperfection of separation by washing, a further quantity of material may pass through this finest sieve and the mass of such material should be added to the mass of undersize found from the washing stage to give the total mass of undersize from the charge.

7.5 Evaluation of results

7.5.1 *Single charge*

The fraction quantities retained on the sieves and the final undersize, if collected, should be weighed to an accuracy of 0,1 % of the mass of the charge. The sum of these masses should not differ by more than – 2 % from the mass of the charge.

The fraction masses shall be converted into percentages of the sum of the fractions collected and the losses shall be recorded separately (see example in Figure 1).

If, as in some sieving techniques, the undersize fraction is irretrievably lost, this fact shall be clearly stated in the report; in such cases, the fractions collected shall be related to the charge mass.

7.5.2 *Multiple charges*

The results of sieving each charge individually are evaluated as in **7.5.1**. In the final evaluation, these fractions shall be converted to percentages of the sum of the fractions collected.

7.5.3 *Reproducibility*

The reproducibility of results, i.e. permissible differences between two independent analyses, shall be specified in the relevant standard or as specified by the interested parties.

8 Presentation of results

8.1 Tabular presentation

8.1.1 *General presentation*

An example of the method for recording results of a test sieving analysis in Table form is shown in Figure 1.

The following information shall be included in the top section of the test results form:

a) the material to be sieved and its conditions;

b) the method of sieving;

c) the size and shape of sieve frame;

d) the type of sieving medium;

e) the shape of the apertures;

f) the sieve marking, e.g. national standard and identification marks;

g) the duration of sieving.

The Table in the bottom section of the test results form shall include the following information:

a) the test sieves, designated by their nominal aperture size, in millimetres or in micrometres;

b) the sieve fractions, as a mass and as a percentage of the sum of the fractions plus the final undersize;

c) the cumulative percentage undersize; alternatively, the percentage oversize could be recorded;

d) the original mass and the total of fraction masses.

8.1.2 *Use of a single sieve or two sieves*

Analyses requiring the use of one sieve or two sieves may be presented in the following simplified manner.

a) **Using one sieve**

The oversize or undersize shall be recorded as a mass percentage of the sum of the two fractions, oversize and undersize.

b) **Using two sieves**

The oversize may be used either to determine the proportions of material coarser and finer than the two sieves, or to determine the proportion falling between the two limits.

The proportions shall be recorded as mass percentages.

Example:

Particle size mm	**Mass in fraction** (as a percentage of the sum of the masses of the fractions)
Larger than 2 (oversize)	5
Between 2 and 1 (oversize)	75
Smaller than 1 (final undersize)	20

8.2 Graphical presentation

When the test sieving results are presented graphically, two axes at right angles should be used as follows:

a) horizontal axis: the nominal aperture size, beginning with the smallest size;

b) vertical axis: the cumulative percentage undersize or oversize, in increasing values from the origin.

The results may be plotted, for example, on linear coordinates (see Figure 2), linear/logarithmic coordinates (see Figure 3) or probability/logarithmic coordinates (see Figure 4); other functional scales may be used but their application is outside the scope of this part of ISO 2591.

Material: Quartz sand, dry — **Sieve marked**: ISO 565

Method of sieving: dry [x] — by hand [ ]

wet [ ] — by machine [x] Type: xyz

Size and shape of test sieve: 200 mm — round [x] square [ ]

Sieving medium: Woven wire cloth [x] — **Shape of apertures**: round [ ]

Perforated plate [ ] — square [x]

Electroformed sheet [ ]

Duration of sieving: 20 min in nest

1	2	3	4	5
Particle size, d	**Sieve fractions**		**Nominal aperture size**	**Cumulative undersize**
µm	g	%	µm	%
$d > 250$	0,04	0,1	250	99,9
$250 \geqslant d > 180$	1,3	2,9	180	97
$180 \geqslant d > 125$	4,23	9,5	125	87,5
$125 \geqslant d > 90$	9,44	21,2	90	66,3
$90 \geqslant d > 63$	13,1	29,4	63	36,9
$63 \geqslant d > 45$	11,56	26	45	10,9
$d \leqslant 45$	4,87	10,9	Final undersize	
Total	44,54	100		

Original mass: 44,70 g

Total of fraction masses: 44,54 g

Loss: 0,16 g = 0,36 %

NOTE The example given above is intended to illustrate a method for presenting results. It shall not be regarded in any sense as a guide to sieving time, etc.; such information should be determined in accordance with clause **7**.

Figure 1 — Example of a completed test results form

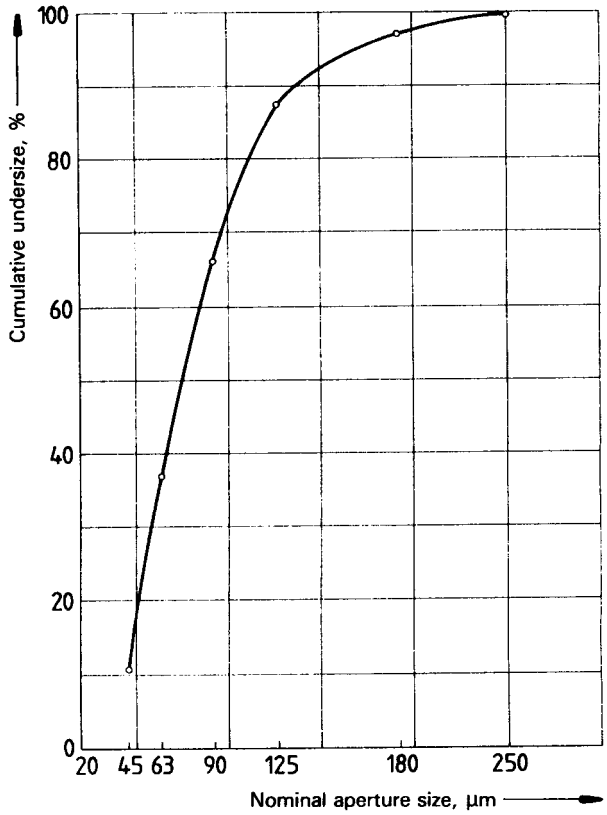

Figure 2 — Example of graphical presentation of test sieving results (cumulative undersize graph) on linear coordinates
(data taken from example of test results form shown in Figure 1)

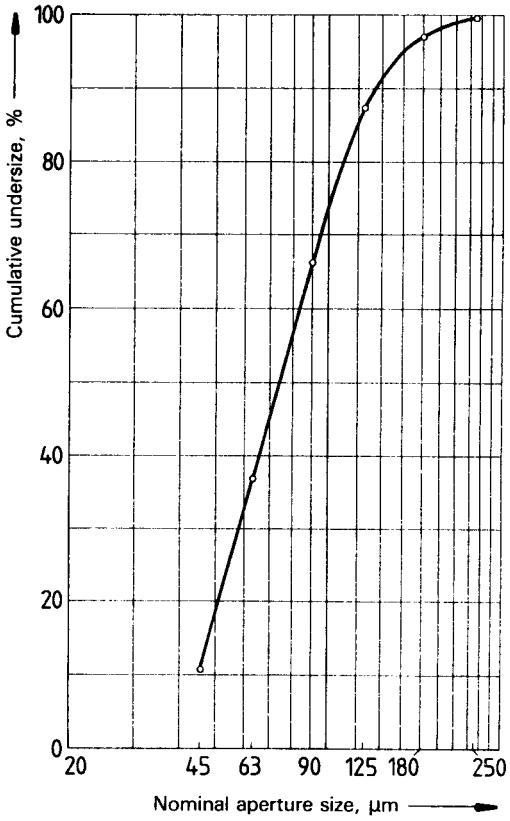

Figure 3 — Example of graphical presentation of test sieving results (cumulative undersize graph) on linear/logarithmic coordinates
(data taken from example of test results form shown in Figure 1)

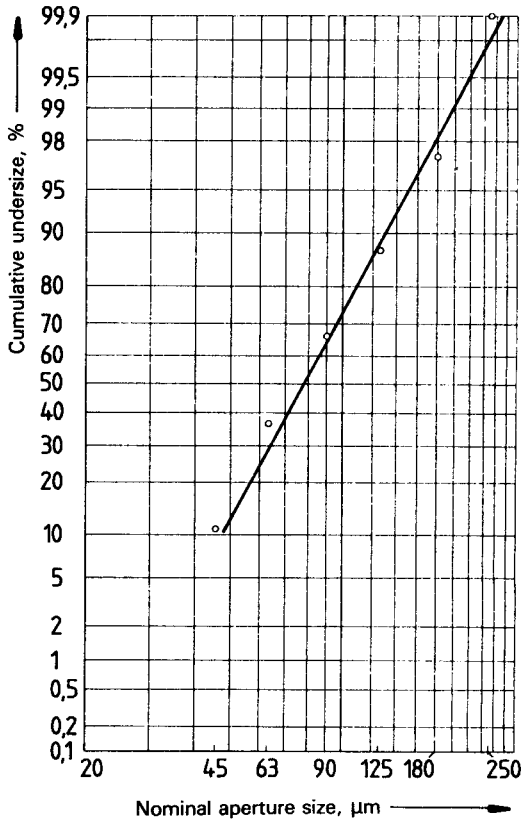

Figure 4 — Example of graphical presentation of test sieving results (cumulative undersize graph) on probability/logarithmic coordinates
(data taken from example of test results form shown in Figure 1)

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Publications referred to

See national foreword.

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