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Test sieving

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FOREWORD

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Australia	Germany	Switzerland
Belgium	India	Turkey
Chile	Ireland	United Kingdom
Czechoslovakia	Romania	U.S.A.
Egypt, Arab Rep. of	South Africa, Rep. of	
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The Member Body of the following country expressed disapproval of the document on technical grounds :

Canada

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Test sieving

1 SCOPE AND FIELD OF APPLICATION

This International Standard discusses the main factors affecting test sieving and the results obtained, and specifies general principles to be followed concerning apparatus, procedure and presentation of results.

2 MATERIAL TO BE SIEVED

Materials to be test sieved range from very coarse lumps such as stone and coal to very fine materials such as pigments and clay, and vary in their physical and chemical properties. Information about the properties of a material is helpful in judging its sieving characteristics, and as far as possible these properties should be ascertained and noted in the test report. The more important properties affecting sieving are discussed below.

Because of the considerable variety of the 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 the ISO document or national standard dealing with that material.

2.1 Physical and chemical properties

2.1.1 Density

The following kinds of density are important in test sieving:

- Effective particle density: Mass of a particle divided by the volume of the particle including open and closed pores.
- Apparent bulk density: The mass of the charge divided by its volume at the moment when it is placed on the sieving medium.

The effective particle density can affect the duration of sieving, whilst the apparent bulk density can influence the quantity of material to be taken for sieving.

2.1.2 Friable nature

Some materials are liable to size reduction during sieving due to their friable nature. This property should be taken

into account in the handling of the material during sampling and test sieving.

2.1.3 Abrasive properties

Some materials, for example emery powders, are abrasive and wear out the sieves and change 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 permitted tolerances.

2.1.4 Moisture

The following points are of importance:

2.1.4.1 Surface moisture

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

2.1.4.2 Internal moisture

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

2.1.4.3 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.

2.1.4.4 Changes on drying

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

2.1.5 Particle shape

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

2.1.6 Size distribution

The range of particle size of the material is important in deciding the sieving procedure to be used (see section 4).

2.1.7 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 friction and increases with the fineness of the powder.

2.1.8 Magnetic properties

Magnetic properties of materials may affect the results on account of the reactions of the particles with each other (tending to agglomeration) and with the sieve (tending to adhesion).

2.1.9 Electrostatic properties

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

2.1.10 Chemical reactivity

Certain materials may react with the atmosphere or with the material of the sieves. This aspect should be considered in choosing the sieve and in conducting the test.

2.1.11 Production of material

The source of the material and method of preparation may provide information on the properties discussed above. This information should be included in the test report.

2.2 Sampling method

2.2.1 Method of taking samples

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

The method of sampling 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, for example 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, and precise sampling methods should be specified for particular materials and circumstances.

The method of sampling shall follow the specifications laid down for individual products in ISO documents for these products; otherwise the methods laid down in national standards shall be followed.

2.2.2 Division of the sample

The original sample is often too large for direct use in a sieve test. It must 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.

As in the case of original sampling, the division of samples of particular materials shall follow the ISO documents for the material, or, in the absence of such documents, the appropriate national standards.

2.2.3 Storage of samples and test samples

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

3 APPARATUS

3.1 Test sieves

Test sieving is carried out with a single test sieve or with a series of test sieves with different nominal aperture sizes. A lid and a receiver pan shall 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.

3.1.1 Test sieving media

Wire cloth or perforated plate shall be used as the sieving media in test sieves. These shall conform to the relevant ISO documents.

The choice of the material of the test sieving medium is left to the user. It is, however, recommended that the same type of sieving medium (wire cloth or perforated plate) and the same geometrical form of the apertures be used for all the test sieves used in any one analysis.

3.1.1.1 Wire cloth

Woven wire cloth in test sieves shall be of plain weave with the exception of aperture sizes $63 \mu\text{m}$ and less where the weave may be twilled. The sieving medium must not have any weaving faults. It shall be mounted in the frame without distortion or creases.

Warp and weft wires shall be seen by visual inspection to be perpendicular to each other after mounting.

NOTE — A commonly accepted criterion is a maximum deviation of 3° from perpendicularity. Measurements shall be based on the mean direction of wires over several meshes.

3.1.1.2 Perforated plates

Holes in perforated plates shall be cleanly formed. The plates shall be mounted punch side uppermost.

3.1.2 Test sieve frame

3.1.2.1 Shape and size of the test sieve frame

The types given in Table 1 are recommended.

TABLE 1 — Frame sizes

Dimensions in millimetres

Nominal shape and size of test sieve	Width of effective sieving surface		Approximate depth
	min.	max.	
Round, diameter 200	185	200	50
Round, diameter 300	275	310	75
Square, 300	275	310	75

It is recommended that the 200 mm round frame should be used as far as possible, especially for wire cloth up to 1 mm nominal aperture size. A smaller round frame may be appropriate for very fine sieves and for very small quantities of material. For large aperture sizes the 300 mm round or square sieve may be required, or even larger sieves for aperture sizes greater than 25 mm and large sample quantities. The shape and size of the sieve have little effect on the results of the sieving operation.

The choice of the shape and of the size shall be stated in the test report.

3.1.2.2 Construction of the test sieve frame, lid and receiver

The test sieve frames shall nest snugly with each other and with the lid and the receiver of the same type. The frame shall be smooth and the seal of the sieve so constructed as to prevent lodging of the material to be sieved.

3.1.2.3 Marking of the frame

The label attached to the sieve shall give the following details :

- the nominal aperture size;
- a reference to the standard(s) with which the test sieve is claimed to comply;
- the material of the sieving medium and the material of the frame;
- the name of the firm (manufacturer or vendor) taking responsibility for the sieve;
- an identification number.

3.1.3 Preparation and maintenance of the test sieve

Before use, the sieving medium and frame shall be degreased and cleaned. The cleaning of the sieve should be carried out with great care so that the sieving medium is not damaged. (Cleaning by ultrasonics, for example.)

The accuracy of the sieving medium in the test sieve shall be verified initially, and subsequently reverified in course of use. Factors such as the frequency of use and type of material sieved will influence the frequency of the verifications. It is desirable, therefore, to have a record card for each test sieve.

Verification and reverification may be made by the procedure described in ISO . . .¹⁾.

Another method is to compare the performance of the sieve with the performance of a reference sieve, using a sample material similar to the one for which the test sieve is to be used.

Another method is available for a sieve which has been tested with calibrated glass spheres. It may be retested at any time to verify that its condition is maintained.

When a sieving medium no longer complies with the tolerances specified, the marking on the label shall be cancelled and the sieve discarded.

3.2 Accessories

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

- for dry sieving : a soft brush, for example a paint brush, to clean the underside of the sieving medium from time to time.
- for wet sieving : an installation with liquid reservoir, regulating valve and collecting tank.

For test sieving purposes the use of devices such as balls and chains added to the material is not permissible.

4 PROCEDURE

4.1 General considerations

Test sieving can be carried out by hand or with the aid of test sieving machines. If test sieving machines are used, they shall be so constructed and operated that the sieving results conform within agreed tolerances to those obtained by hand sieving. The reference method shall always be hand sieving, performed under specified conditions.

The following conditions should be laid down beforehand :

- method of sieving, dry, wet or a combination of both;
- number of sieves to be used and their aperture sizes;
- sequence of the sieves to be used (usually coarse to fine, more rarely fine to coarse).

For special cases when only machine test sieving is carried out, the machine and method of operation shall be stated in the test report.

1) In preparation.

Test sieving by hand should normally be performed on the whole test sample with sieves up to 25 mm aperture size. 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 :

- larger than 25 mm
- 25 to 4 mm
- 4 to 1 mm
- smaller than 1 mm

The test sieving procedures for materials within these different size ranges are given in 4.6.

The charges (see 4.4) should be taken by sub-dividing the fractions obtained by the preliminary sieving. If, however, the charges do not ensure a representative sample, the whole fraction in the size range under consideration shall be tested.

If test sieving over more than one of the above size ranges is required, the individual fractions shall be recorded in mass percentages of these ranges, and in the final evaluation converted to mass percentages of the sum of all the fractions collected (see 4.9.2).

The procedure consists in gently placing the material to be sieved on the test sieve with a 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 sizes the test sample is separated into size fractions designated by the aperture sizes of the test sieves used (see 5.1.1).

For hand test sieving the following procedures are known :

- dry sieving : by shaking and tapping (the procedure suitable for most materials).
- wet sieving : by 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 these alternatives.

The sieving of particles smaller than 1 mm may be facilitated by starting with the finest test sieve, so that the coarse particles in the charge may aid the sieving process. As is well known, the sieving of fine particles on a fine test sieve can be difficult owing to the tendency of the apertures to blind. Care shall be taken, however, to avoid the presence of excessively coarse particles as these may easily damage the sieve (see 4.5).

Extremely fine particles (such as those encountered in the determination of the grit content in soot) or particles which charge themselves with static electricity (for example, some plastics powders), or damp dust which cannot be dispersed, shall be sieved wet.

The effectiveness of dry test sieving depends on

- the duration of sieving;
- the tapping force;
- the number of taps per minute (frequency);
- the tapping direction;
- the amplitude of shaking;
- the inclination of the sieve surface.

The effectiveness of wet test sieving depends on

- the duration of sieving;
- the liquid;
- the wetting agent used (if any);
- the intensity of the washing action;
- the intensity and nature of the movement of the sieve if sieving is carried out by moving the sieve in the liquid.

4.2 Weighing precision for the material to be sieved

It is recommended that the masses of the charge and the fractions should be determined to a precision of at least $\pm 0.1\%$ of the mass of the charge.

4.3 Influence of the humidity of the air

Samples to be dry-sieved, other than those mentioned in 2.1.4.3, shall be in a state of equilibrium with the laboratory atmosphere. This is achieved by the method best suited to the product. If there is a change of humidity during the test, the masses of the charges and fractions shall be corrected to their dry masses.

4.4 Test sample and charge

4.4.1 Test sample

The recommended quantity of material to be sieved on a 200 mm round sieve is given for guidance in Table 2, column 2 for R 20/3 sizes between 22,4 mm and 45 μm .

The quantity should be that indicated 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 3.

The values given in Table 2 apply equally to single sieves and nests of sieves, and to hand sieving and machine sieving.

4.4.2 Charge

The quantity of material to be placed on the sieve depends on

- the sieve aperture size;
- the apparent bulk density of the material;

- the cross-sectional area of the sieve;
- the proportion of oversize material (determined if necessary by preliminary sieving).

The proportion of oversize material shall be such that the volume retained on the sieve after completion of sieving is not greater than that recorded in Table 2, column 3. It may be necessary, therefore, to sieve a test sample in two or more charges to avoid exceeding the volume. The results shall be combined.

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

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

4.5 Largest particle permitted on a test sieve

To avoid damage to the sieve, the size of the largest particle in the charge shall not exceed

$$10 w^{0,7} \text{ mm}$$

where *w* is the nominal aperture size.

Examples

Nominal aperture size <i>w</i>	Approximate size of largest particle
25 mm	95 mm
11,2 mm	55 mm
4 mm	26 mm
1 mm	10 mm
250 μm	3,8 mm
45 μm	1,2 mm

4.6 Methods and sequences of operation

4.6.1 Particles larger than 25 mm

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

A charge appropriate to the sieve may first be screened by gentle shaking. The particles remaining on the sieve are then checked one by one in all positions without applying force. Those that pass are included in the passing fraction. Those that do not pass become the residue.

4.6.2 Particles 25 to 1 mm

Particles above 4 mm are preferably tested on each sieve individually and not with a nest. Below 4 mm the sieves may be nested.

TABLE 2 – Quantity of material for test sieving on a 200 mm round sieve¹⁾

1	2	3
Nominal aperture size <i>w</i>	Bulk volume of material ²⁾	
	Recommended volume of charge	Maximum volume of residue permitted on the sieve at the completion of sieving
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	150
2,8	240	120
2	200	100
1,4	160	80
1	140	70
μm		
710	120	60
500	100	50
355	80	40
250	70	35
180	60	30
125	50	25
90	40	20
63	35	17
45	30	15

1) When using test sieves of different shapes and sizes, the values should be modified accordingly.

2) Masses of materials can be determined by multiplying the values in columns 2 and 3 by the apparent bulk density (g/cm³) of the material to be sieved.

Two procedures are permissible :

- A fresh charge is sieved through each sieve in turn. (See Table 2 for recommended sample quantities).
- A fresh charge is used only on the sieve with the largest nominal aperture size. The material which passes through this sieve is used 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.)

The test sieve, or the test sieve nest, (sieves 4 to 1 mm) is taken with both hands and moved 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 of 4 to 1 mm, the to and fro movement should be interrupted three times per minute by a circular motion.

Dry sieving, wet sieving, or a combination of wet and dry sieving may be employed.

4.6.3 Particles smaller than 1 mm

Two procedures are permissible :

- a) Use a test sieve nest with a receiver pan and lid. Place the charge on the top sieve having the largest aperture size. If preferred, 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) Place the charge on the sieve with the smallest aperture size in the chosen range. After sieving, place the oversize material on the next coarser sieve and repeat the process until all the sieves in the chosen range have been used. This sequence has the advantage that the coarser particles assist the sieving process on the finer test sieves.

The test sieve, or nest of test sieves, is taken in one hand or, if too heavy, cradled loosely in the crook of the arm and tapped approximately 120 times per minute with the other hand at an inclination of 10 to 20°, the grasped point having the lower position. After 30 taps, i.e. four times per minute, the test sieve is put into the horizontal position, turned through 90° and given a hard tap by hand against the sieve frame. A periodical vertical shake may also be given.

If particles are difficult to sieve, or when using fine test sieves, the underside part of the sieving medium may be cleaned gently with a soft brush (see 3.2) when necessary. The resulting dust is added to the undersize material.

4.7 Wet sieving

Materials which become electrostatically charged, or damp samples, are best sieved wet to facilitate dispersion of the primary particles.

The liquid shall not affect the particles in any other way. Wetting agents may be added.

Liquid should be added slowly, regularly and at a very low pressure to avoid loss of material and damage to the sieving medium. For this purpose the accessories listed in 3.2 may be used.

Before wet sieving, the test sample shall be wetted by mixing with a small quantity of the liquid to avoid loss of dust.

Two procedures are permissible :

- a) If the test sample is sufficiently large, a number of individual samples may be produced by sub-division so that a fresh charge can be used on each test sieve in the chosen range. At the completion of the test, the test sieves together with the retained oversize material are dried at a suitably low temperature.

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

4.8 End-point

4.8.1 Factors affecting sieving duration

Sieving, like any other 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, for example, by sticking to larger particles, because they 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 are to be found in the passing fraction.

Because of these imprecisions, no fixed time can be determined at which the sieving process would be completed. The end-point has to be based on experience.

The sieving time is dependent on

- the characteristics of the material, for example fineness, particle shape, size distribution, density;
- the volume of the initial charge;
- the sieving intensity;
- the nominal aperture size of the test sieve;
- the characteristics of the sieving medium;
- the humidity of the air.

4.8.1.1 Dry sieving end-point

For most non-friable materials, the end-point of the sieving process may be taken when the quantity passing through the sieve in 1 min is less than 0,1 % of the charge, if no other instructions are given.

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

4.8.1.2 Wet sieving end-point

A wet sieving operation is considered completed when the liquid used flows off practically clear.

4.9 Evaluation of the results

4.9.1 Single charge

The fraction quantities retained on the sieves and the final undersize shall be weighed with a precision of 0,1 % of the charge. The sum of these masses must not differ by more than 2 % from that of the charge mass. The losses are recorded separately (see examples in 5.1.1).

The fraction masses shall be converted into percentages of the sum total of the fraction masses, not of the original mass of charge. See 5.1.1, examples 1 and 2, columns 2 and 3.

4.9.2 Test sample (or fractions according to 4.2) subdivided into multiple charges

The results of sieving each charge individually are evaluated as in 4.9.1. In the final evaluation these fractions shall be converted to percentages of the sum total of all the fraction masses, not of the original test sample mass.

4.9.3 Repeatability

At least two analyses are to be carried out. The corresponding fractions (F) should not differ by more than X % where :

$$X = Y \sqrt{F_{\min}}$$

with a maximum value of 2 %.

X is the maximum permissible difference between corresponding fraction masses of two analyses of samples of the same material, expressed as a percentage.

Y is the factor characterizing the precision attainable for different sieving methods.

F_{\min} is the smaller of the two corresponding fractions, F , expressed as a mass percentage.

In practice, the factor Y is found to vary according to the method of sieving and the physical characteristics of the material being sieved. The following values are typical :

Method of sieving	Factor Y
Dry hand sieving < 1 mm	0,5
Dry hand sieving > 1 mm	0,2
Wet hand sieving	0,1

Examples :

Mass percentage F_{\min}	≈ 0,5	1,0	10	50
Maximum permissible difference X for				
Dry hand sieving < 1 mm	≈ 0,35	0,5	1,5	2
Dry hand sieving > 1 mm	≈ 0,14	0,2	0,6	1,4
Wet hand sieving	≈ 0,07	0,1	0,3	0,7

If a fine sticky material is dry hand sieved and the above maximum permissible difference is exceeded, wet sieving should be attempted.

4.9.4 Reproducibility

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

5 PRESENTATION OF RESULTS

5.1 Tabular presentation

The method of recording results of a test sieving analysis in a tabular form is shown in the examples 1 and 2 below. At the head of the table is shown

- material to be sieved and its condition;
- method of sieving;
- size and shape of sieve frame;
- sieving medium (plate or woven wire);
- shape of the apertures;
- sieve marking, for example national standard and identification marks;
- duration of sieving.

The table itself shows

- the test sieves, designated by their aperture size in millimetres or in micrometres;
- the sieve fractions, in grams and as a percentage of the sum of the fractions plus the final undersize;
- the cumulative oversize, in per cent.

5.1.1 Examples

The following examples are intended only to illustrate presentation of results. They must not be regarded in any sense as a guide to the sieving time, etc. Such information should be determined by the considerations described in section 4.

Example 1 – Raw coal

Material : RAW COAL, DRY

Sieve marked : BS 410
(standard)

Method of sieving : by hand

~~by machine~~

dry

~~wet~~

Duration of sieving : 3 min

Shape and size of sieve : 200 mm – 300 mm

Sieving medium : plate – ~~woven wire~~

Shape of apertures :

1	2	3	4	5
Sieve size range	Sieve fractions		Nominal aperture size	Cumulative oversize
mm µm	g	% by mass	mm µm	% by mass
> 22,4	–	–	22,4	–
22,4 to 16	349,5	40,1	16	40,1
16 to 8	278,0	32,0	8	72,1
8 to 4	241,5*	27,8	4	99,9
< 4	(final undersize) 1,3	0,1		
Total	870,3	100,0		

Original sample mass 875,0 g

total of fraction masses 870,3 g

loss 4,7 g = 0,54 %

* To avoid excess volume on the 4 mm sieve (see Table 2) the test sample would have to be sieved in two portions.