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BSI Standards Publication

Solid biofuels — Determination of particle size distribution

Part1: Oscillating screen method using sieve apertures of 1 mm and above

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee PTI/17, Solid biofuels.

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

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English Version

Solid biofuels - Determination of particle size distribution - Part 1: Oscillating screen method using sieve apertures of 1 mm and above

Biocombustibles solides - Détermination de la distribution granulométrique - Partie 1: Méthode au tamis oscillant d'ouverture de maille égale ou supérieure à 1 mm

Feste Biobrennstoffe - Bestimmung der Partikelgrößenverteilung - Teil 1: Rüttelsiebverfahren mit Sieb-Lochgrößen von 1 mm und darüber

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Foreword

This document (EN 15149-1:2010) has been prepared by Technical Committee CEN/TC 335 “Solid biofuels”, the secretariat of which is held by SIS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2011, and conflicting national standards shall be withdrawn at the latest by April 2011.

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This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

EN 15149, *Solid biofuels — Determination of particle size distribution*, consists of the following parts:

— *Part 1: Oscillating screen method using sieve apertures of 1 mm and above*;

— *Part 2: Vibrating screen method using sieve apertures of 3,15 mm and below*.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

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Introduction

Part 1 describes the reference method for size classification of samples with a nominal top size of 1 mm and above.

Part 2 describes the reference method for size classification of samples with a nominal top size below 3,15 mm.

Manual sieving is not included in this standard, as no data is available which supports that manual sieving operations are comparable to the here described mechanical sieving operations.

1 Scope

This European Standard specifies a method for the determination of the size distribution of particulate biofuels by the horizontally oscillating screen method. It applies to particulate uncompressed fuels with a nominal top size of 1 mm and above as e.g. wood chips, hog fuel, olive stones, etc.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 14588:2010, *Solid biofuels — Terminology, definitions and descriptions*

EN 14774-1:2009, *Solid biofuels — Determination of moisture content — Oven dry method — Part 1: Total moisture — Reference method*

EN 14774-2:2009, *Solid biofuels — Determination of moisture content — Oven dry method — Part 2: Total moisture — Simplified method*

prEN 14778, *Solid biofuels — Sampling*

prEN 14780, *Solid biofuels — Sample preparation*

EN 14961-1, *Solid biofuels — Fuel specifications and classes — Part 1: General requirements*

EN 15149-2, *Solid biofuels — Determination of particle size distribution — Part 2: Vibrating screen method using sieve apertures of 3,15 mm and below*

ISO 3310-1, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth*

ISO 3310-2, *Test sieves — Technical requirements and testing — Part 2: Test sieves of perforated metal plate*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14588:2010 and the following apply.

3.1
median value of the size distribution
value [d50] that separates a distribution into two equal parts and that is graphically the intercept point of the cumulative size distribution curve with the 50 %-horizontal line

4 Principle

A sample is subjected to sieving through horizontally oscillating sieves, sorting the particles in decreasing size classes by mechanical means.

5 Apparatus

5.1 Sieves.

For the test an appropriate number of either circular or rectangular sieves with a minimum effective sieve area of 1 200 cm^2 is required. The geometry of the apertures shall be in accordance with the requirements of ISO 3310-1 and -2, respectively. The frame of the sieves shall have a height that enables the sieves to contain the sample and allows a free movement of the sample during the sieving process.

NOTE 1 For materials with a nominal top size of less than 10 mm, an effective sieve area of less than 1 200 cm^2 is adequate.

The number of sieves and the aperture sizes of the sieves shall be chosen according to the size specification of the actual sample material, see EN 14961-1. Sieves should correspond to ISO 3310-1 (1 mm) and ISO 3310-2 (all aperture sizes above 1 mm).

NOTE 2 For samples of wood chips e.g. the following set of sieves may apply: 3,15 mm, 8,0 mm, 16 mm, 31,5 mm, 45 mm, 63 mm. If experience shows that no particles are caught by the larger sieves, these can be omitted from the set. For further size distribution determination of the fraction that passes the 3,15 mm sieve, see EN 15149-2.

NOTE 3 Sieve sizes above 63 mm are not useful as the shaking operation will not force the particles to orientate vertically to the plane of the sieves. Furthermore the vertical distance to the following sieve will have to be longer than the usual 80 mm in order to allow the long and slim particles to pass through the holes.

In the case of checking the fulfilment of particle size demands of a certain quality class given in EN 14961-1, only those sieve sizes which have limit values are necessary to be chosen.

5.2 Collecting pan.

For collecting of material passing through the sieves a collecting pan of adequate size is required.

5.3 Mechanical sieving equipment.

The sieving operation shall be horizontally oscillating (one or two dimensional), using an appropriate stroke-frequency according to the type of material. For principle drawing of the sieving operation, see Figure 1.

NOTE Be aware that too low a shaking frequency may lead to incomplete particle separation. The minimum shaking frequency can be determined by pre-tests.

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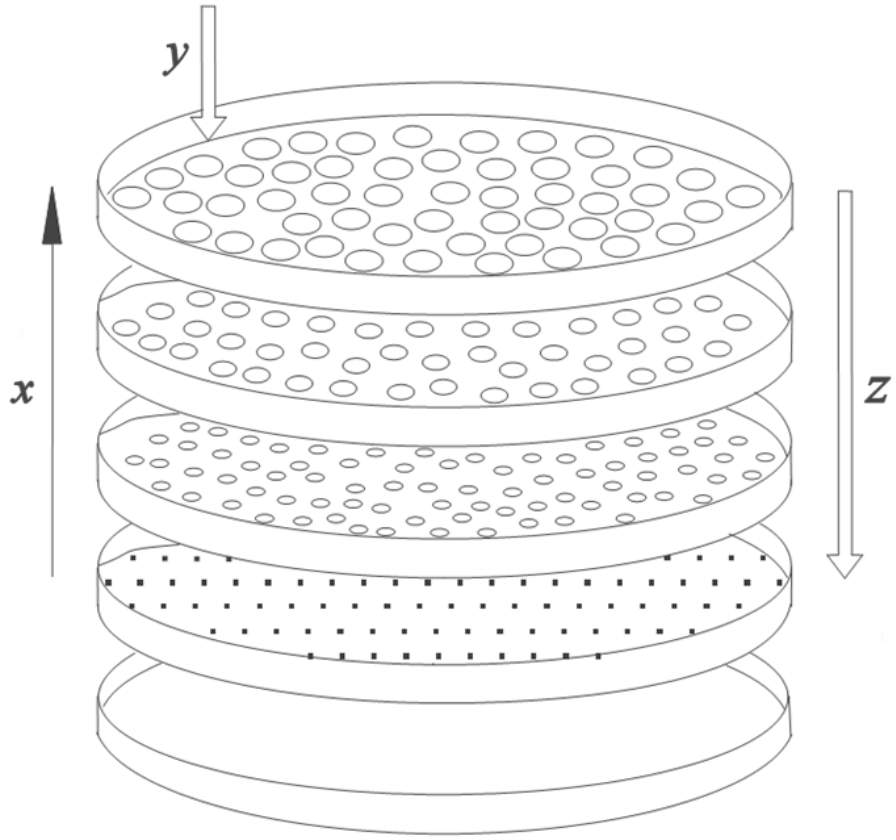

Key

x Increasing hole diameters

y Material addition

z Material flow direction

Figure 1 — Principle of the sieving operation

5.4 Balance, capable of measuring the mass of the sample to be sieved to the nearest 0,1 g.

6 Sample preparation

6.1 Sample size

The minimum size of the test sample for the determination of the size distribution shall be 8 l and shall be sampled according to prEN 14778. For biofuels, where 100 % of the particles will pass the holes of a 45 mm aperture size sieve, a smaller sample size of minimum 4 l can be used.

NOTE The sample should include material for determination of size distribution and moisture content.

Depending on the size of the sieves the test sample may have to be divided into several sub-samples, which are processed in sequential sieving operations. This is to ensure that the filling height on the upper sieve shall never exceed 5 cm. This procedure of sequential processing also applies, if a larger sample than the above given 8 l is processed.

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6.2 Moisture conditions

The sample shall be sieved at a moisture content below 20 w-% wet basis, thus preventing the particles from sticking together or loosing moisture during the sieving process. If necessary the sample has to be pre-dried. Drying is done according to prEN 14780.

NOTE By pre-drying, as described in prEN 14780, the sample is brought into equilibrium with the humidity of the surrounding atmosphere.

Determine the moisture content of the material to be sieved on a separate sub-sample following the procedure given in EN 14774-1:2009, Clause 7 or EN 14774-2:2009, Clause 7. The moisture content shall be determined and reported concurrently with the particle size distribution determination.

7 Procedure

Assemble and operate the mechanical shaking device with the appropriate sieve sizes with decreasing aperture size ending with the collecting pan. Weigh the sample to the nearest 0,1 g. Spread the sample (sub-sample) in an even layer on the top sieve and start the sieving operation. The screening operation shall be continued for 15 min.

NOTE 1 The 15 min duration is chosen to ensure complete sieving. When lower sieving time is applied, deviations due to instrumental and operational effects may be increased.

NOTE 2 Be aware that an excessive sieving time, which is significantly longer than the required sieving time, may cause abrasion and a higher portion of the fine fraction.

Weigh the retained net material on each sieve and in the collecting pan to an accuracy of 0,1 g and record the masses in a scheme equal to Table 1. In case that a particle sticks in a sieving hole, it shall be removed and added to the fraction, which remained on the sieve (as if it did not pass the hole).

NOTE 3 Loosing particles from the screens should be avoided. This can be done by proper sealing between the trays and by the use of top cover.

All particles larger than 100 mm (maximum dimension) shall be hand-sorted into one or more fractions regardless from which sieve or collecting pan they are collected.

NOTE 4 In many cases it is useful to identify the largest particle (maximum dimension) and record it in a scheme equal to Table 1. The information on the longest particle may be required for computing the median particle size or for illustrating the results in a cumulative size distribution curve.

In size classification by sieving, some of the thin particles, which are longer than the hole diameter, will pass the sieve and mix with the particles in the smaller size fractions. Most of these particles shall remain in that fraction. Only particles, which are over 100 mm (maximum dimension), have to be sorted by hand, regardless from which collecting pan they are collected.

If fractionation of the particles passing the 1 mm or the 3,15 mm sieve is required, proceed as described in EN 15149-2.

8 Calculation

The result is expressed as a percentage of the total mass of all fractions. If the test sample has been divided into two or more sub-samples the mass of the respective fractions shall be added up before calculating the overall percentage of each class. This procedure is demonstrated in Table 1.

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Table 1 — Results of the size distribution analysis

Sieve name	**Fraction (to be specified)** mm	**(1) Mass of fraction in sub-sample 1** g	**(2) Mass of fraction in sub-sample 2** g	**(3) Mass of fraction in sub-sample 3** g *(add more columns if necessary)*	**(4) Total mass of fractions in columns 1, 2 and 3 (or more)** g	**(5) Percentage of fraction (by mass), in w-% (based on total mass of test portion in column 4)**
Hand sorting (...mm)						
Hand sorting (...mm)						
1st Sieve (…mm)						
2nd Sieve (… mm)						
3rd Sieve (…mm)						
4th Sieve (…mm)						
5th Sieve (…mm)						
6th Sieve (…mm)						
Collecting pan	Below:					
Total mass of all fractions	All					100 w-%

Other recordings:

Total mass of test portion (g)	
Number of Overlong (specify fraction in millimetres)	
Length of longest particle overall, in millimetres (if required)	
Difference between the total mass of test portion and the total mass of all fractions (column (4)) in percent of the total test portion	
Moisture content of the sieved sample, in w-%	

The difference between the total mass of test portion and the total mass of all fractions as indicated in Table 1 shall be smaller than 2 w-%. Larger differences may occur due to lost or retained particles or due to changes in moisture content. In this case the cause(s) for the deviation should be investigated and the measurement repeated. In case this is impossible or the result still deviates more than the 2 w-%, the actual deviation shall be reported.

If an assessment of the precision is required (see Clause 9), then the sieving operation is to be repeated using another test portion of the sample material. If sufficient sample material is not available the fractions from the first determination may be combined and used for the second determination.

If the median value of a size distribution is required, see the calculation in normative Annex A.

9 Precision

9.1 Repeatability

The results of duplicate determinations of the individual mass fractions, performed within a short period of time in the same laboratory, by the same operator, using the same apparatus on two representative test portions taken from the same sample, shall not differ by more than 2 w-%. See Bibliography [1].

9.2 Reproducibility

The means of the results of duplicate determinations of the individual mass fractions, performed in each of two different laboratories on representative test portions taken from the same sample, shall not differ by more than 10 w-%. See Bibliography [1].

10 Test report

The test report shall include at least the following information:

— identification of the laboratory and the testing date;

— identification of the product or sample tested (see prEN 14778);

— a reference to this document;

— any deviation from this document;

— conditions and observations, e.g. unusual occurrences during the test procedure, which may affect the result;

— the test results as demonstrated in Table 1;

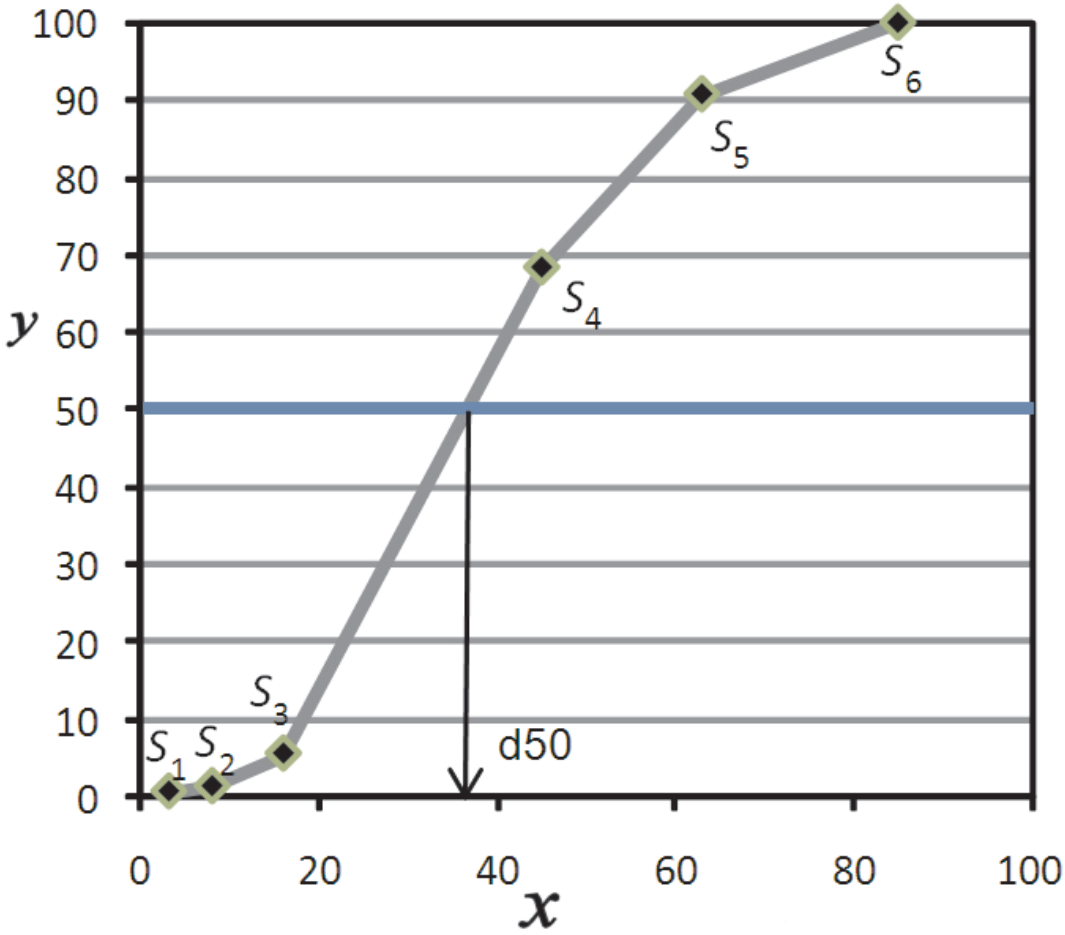
— if the 2 w-% difference between the total mass of test portion and the total mass of all fractions in percent of the total test portion as given in Table 1, column (4), has been exceeded, it shall be clearly stated.

Annex A
(normative)

Determination of the median value of a particle size distribution

A.1 Definition

The median value of a particle size distribution [d50] as determined by screening operation is defined as the calculated particle size of a sample where 50 % of the particle mass is below and 50 % is above. Therefore the cumulative size distribution is separated into two halves. Graphically the median value is established by the intersection of the cumulative distribution curve with the 50-%-line (see example in Figure A.1).



Key

x Particle/hole size (mm)

y Cumulative particle share (%)

Figure A.1 — Median value of the size distribution of a wood chip sample (sample data from example below)

A.2 Procedure (example)

Record the determined mass shares from each screen as shown in Table A.1. Calculate the cumulated particle share as shown in Column 5 of Table A.1. Identify the screen sizes which are below and above the 50 % cumulative share. In the example below the median value will be found between S_3 and S_4, as shown in Column (5) (see also Figure A.1). These are the size boundaries from which the median value can be calculated by linear interpolation.

Table A.1 — Example of wood chip sample after size classification

(1)	(2)	(3)	(4)	(5)
Sieve class	Sieve/Class size C (mm)	Sample mass (g)	Fraction (%)	Cumulated share S (%)
0 - 3,15	C_1: 3,15	10,5	0,7	S_1: 0,7
> 3,15 - 8	C_2: 8	9,9	0,7	S_2: 1,4
> 8 - 16	C_3: 16	61,7	4,2	S_3: 5,6
> 16 - 45	C_4: 45	917,4	62,8	S_4: 68,4
> 45 - 63	C_5: 63	327,1	22,4	S_5: 90,8
> 63 - longest	C_6: 85 [a]	134,7	9,2	S_6:100,0
Total		*1 461,3*	*100*	

[a] Particle length as determined manually by hand-sorting.

A.3 Calculation

For the above-given example the linear interpolation can be made according to the following formula:

$$\text{d50} = C_3 + (50 - S_3) \times \frac{C_4 - C_3}{S_4 - S_3} = 16 + (50 - 5{,}6) \times \frac{45 - 16}{68{,}4 - 5{,}6} = 36{,}5 \text{ mm}$$

where

d50 is them edian value of the size distribution (in millimetres);

C_3 is the hole diameter of sieve C_3 (in millimetres);

C_4 is the hole diameter of sieve C_4 (in millimetres);

S_3 is the cumulative particle share at size class C_3 (in mass %);

S_4 is the cumulative particle share at size class C_4 (in mass %).

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[1] HARTMANN H., BÖHM T., DAUGBJERG JENSEN P., TEMMERMAN M., RABIER F., GOLSER M. [2006], *Methods for Size Classification of Wood Chips*, Biomass and Bioenergy, Vol. 30 no. 11 (2006), pp. 944-953, Pergamon

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