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BSI Standards Publication

Solid biofuels — Determination of particle size distribution

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

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

Biocombustibles solides - Détermination de la distribution granulométrique - Partie 2: Méthode au tamis vibrant d'ouverture de maille inférieure ou égale à 3,15 mm

Feste Biobrennstoffe - Bestimmung der Partikelgrößenverteilung - Teil 2: Rüttelsiebverfahren mit Sieb-Lochgrößen von 3,15 mm und darunter

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Foreword

This document (EN 15149-2:2010) 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of an identical text or by endorsement, at the latest by April 2011, and conflicting national standards shall be withdrawn at the latest by April 2011.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 supersedes CEN/TS 15149-2:2006.

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.

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 support 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 vibrating screen method. The method described is meant for particulate biofuels only, namely materials that either have been reduced in size, such as most wood fuels, or are physically in a particulate form. This document applies to particulate uncompressed fuels with a nominal top size of 3,5 mm and below (e.g. sawdust).

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*

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

4 Principle

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

NOTE A manual sieving is excluded due to the fact that small sieve holes can easily be clogged by particles.

5 Apparatus

5.1 Sieves.

For the test an appropriate number of either circular or rectangular sieves with a minimum effective sieve area of 250 cm^2 is required. The geometry of the apertures, the thickness of the sieves, the hole distances and the diameter of the holes shall be in accordance with the requirements of ISO 3310-1 and -2. The frame of the sieves shall have a height that enables the sieves to contain the samples and allows a free movement of the sample during the sieving process.

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 also EN 14961-1. For sawdust and similar fine grade materials it is recommended to use the following set of sieves:

— 3,15 mm round holes;

— 2,8 mm mesh wire cloth;

— 2,0 mm mesh wire cloth;

— 1,4 mm mesh wire cloth;

— 1,0 mm mesh wire cloth;

— 0,5 mm mesh wire cloth;

— 0,25 mm mesh wire cloth.

5.2 Collecting pans.

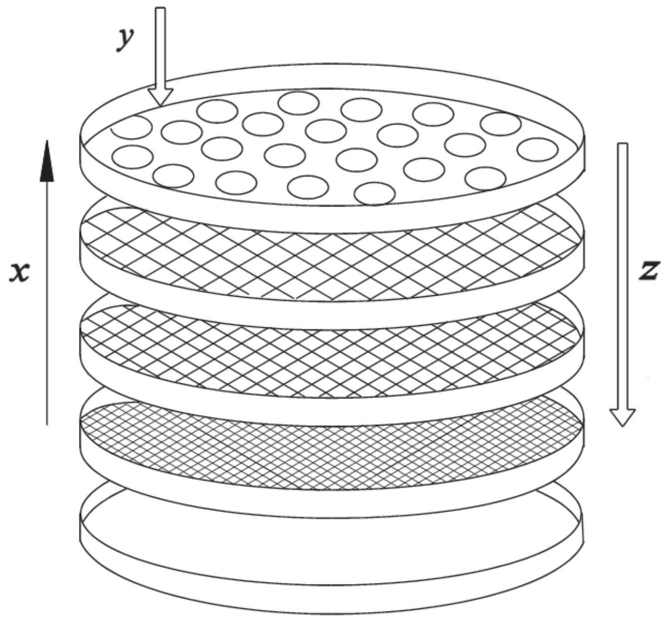
For weighing of the size classes an adequate number of collecting pans is required.

5.3 Flat brush.

For cleaning the sieves a flat brush is required.

5.4 Mechanical sieving equipment.

The mechanical device shall apply a vibrating operation. For principle drawing of the sieving operation, see Figure 1.



Key

x Increasing hole diameters

y Material addition

z Material flow direction

Figure 1 — Principle of the sieving operation

5.5 Balance, capable of measuring the mass of the sample to be sieved to the nearest 0,01 g.

6 Sample preparation

6.1 Sample size

The minimum size of the test sample for the determination of the size distribution shall be 50 g and shall be sampled according to prEN 14778. To prevent overloading of the screens the layer height on the upper sieve shall never exceed 2 cm. In such a case the test portion is divided into two or more subsamples which are to be processed subsequently, the results of the separate determinations are combined according to Clause 8.

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

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 0,01 g. If the size of the test sample is significantly larger than the minimum 50 g stated in 6.1, the test portion shall be divided into two or more sub-portions which are to be processed subsequently.

Spread the sample in an even layer on the top sieve and start the sieving operation. The sieving operation shall be continued until the mass changes between two sequential sieves do not exceed a maximum of 0,3 % of the total sample mass per 1 min time of sieving operation. This pre-testing requirement can be avoided by applying the sieving operation for the fixed duration of 30 min.

NOTE 1 The required minimum sieving time should be determined for each equipment and type of fuel in separate pre tests.

Avoid losing any particles when determining individual weight differences during such pre tests.

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

NOTE 3 After approximately half of the sieving operation, check if the sample is even distributed on the sieves. If not, turn each of the sieves approximately 180° and complete the sieving operation.

Weigh the retained net material on each sieve and in the collecting pan to an accuracy of 0,01 g and record each net mass in a scheme equal to Table 1. In case that a particle sticks in a sieving hole, it shall be removed with the brush and added to the fraction, which remained on the sieve (as if it did not pass the hole).

NOTE 4 During the sieving operation particles can stick on the edge of the sieves due to static electricity. Since this problem mostly is connected to the intensity of the mechanical shaking operation it should be taken into consideration in separate pre test for each equipment and biofuel sample materials. Grounding the sieves using a copper wire can reduce the problem with static electricity.

NOTE 5 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.

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.

Table 1 — Results of the size distribution analysis

Sieve name	**Fraction** mm	**(1)** **Mass of fraction in subsample 1** g	**(2)** **Mass of fraction in subsample 2** g	**(3)** **Mass of fraction in subsample 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 in column 4)**
1st Sieve (3,15 mm)	above 3,15					
2nd Sieve (2,8 mm)	2,8 to 3,15					
3rd Sieve (2,0mm)	2,0 to 2,8					
4th Sieve (1,4 mm)	1,4 to 2,0					
5th Sieve (1,0 mm)	1,0 to 1,4					
6th Sieve (0,5 mm)	0,5 to 1,0					
7th Sieve (0,25 mm)	0,25 to 0,5					
Collecting pan	below 0,25					
Total mass of all fractions	all					100 w-%

Other recordings:

Total mass of test portion (g)	
Difference between the total mass of the 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 causes for the deviation should be investigated and the measurement to be repeated. In case this is impossible or the result still deviates more than 2 w-% the actual deviation shall be reported.

If an evaluation of the precision is required then the sieving operation is to be repeated using another test portion of the sample material. If sufficient material is not available the fractions from the first determination may be combined and used for the second determination. For comparison with the research data in Annex B, the cumulative particle size distribution shall be calculated; see Annex A.

9 Performance characteristics

No general precision data can be given for the method. For guidance research data are presented in Annex B.

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;

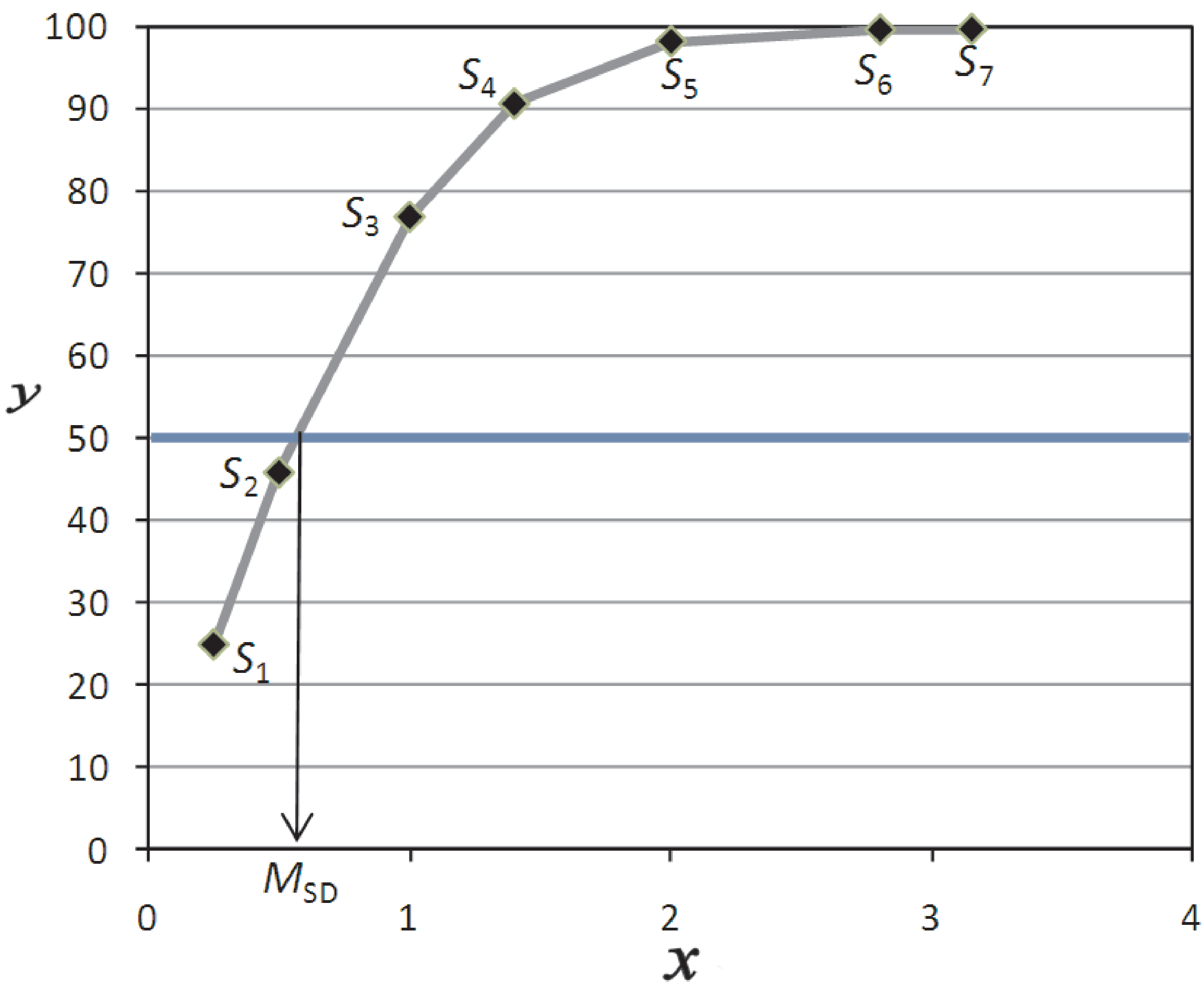
— if the 2 w-% difference between the total mass of test portion and the total mass of all fractions in percent of the total test portion as given in Table 1, column (4), has been exceeded it shall be clearly stated.

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 saw dust 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_2 and S_3, 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 a saw dust sample after size classification

(1) Sieve class	(2) Sieve/Class size C (mm)	(3) Sample mass (g)	(4) Fraction (%)	(5) Cumulated share S (%)
0 – 0,25	C_1: 0,25	12,44	24,9	S_1: 24,9
> 0,25 – 0,5	C_2: 0,50	10,39	20,8	S_2: 45,8
> 0,5 – 1,0	C_3: 1,00	15,45	31,0	S_3: 76,8
> 1,0 – 1,4	C_4: 1,40	6,84	13,7	S_4: 90,5
> 1,4 – 2,0	C_5: 2,00	3,77	7,6	S_5: 98,0
> 2,0 – 2,8	C_6: 2,80	0,70	1,4	S_6: 99,4
> 2,8 – 3,15	C_7: 3,15	0,04	0,1	S_7: 99,5
> 3,15		0,24	0,5	100,0
Total		*49,87*	*100*	

A.3 Calculation

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

$$d50 = C_2 + (50 - S_2) \times \frac{C_3 - C_2}{S_3 - S_2} = 0{,}5 + (50 - 45{,}8) \times \frac{1{,}0 - 0{,}5}{76{,}8 - 45{,}8} = 0{,}568 \text{ mm}$$

where

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

C_2 is the hole diameter of sieve C_2 (in millimetres);

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

S_2 is the cumulative particle share at size class C_2 (in mass %);

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

Annex B
(informative)

Guidance data on performance characteristics

The performance data of the method stated in Table B.1 have been established in a Danish comparative study in 2007 (see Bibliography [1]) on two different samples of solid biofuels. For the obtained results in the study, the cumulative percentage of the material retained on each sieve was calculated for each set of results. For these obtained cumulative distributions the 25 %, 50 % and the 75 % quartiles were used for a statistical evaluation of the performance of the method. The results of this evaluation appear from Table B.1.

Table B.1 — Performance characteristics of the method

Sample	Quantile	N	X mm	s_r mm	S_r %	s_R mm	S_R %
Saw dust	25 %	72	0,24	0,019	0,12	3,8	24
	50 %	72	0,51	0,029	0,16	3,2	18
	75 %	72	0,83	0,032	0,091	2,4	6,7
Straw dust	25 %	40	0,50	0,020	0,032	8,3	13
	50 %	40	0,91	0,046	0,021	9,0	4,1
	75 %	40	1,35	0,051	0,042	6,1	5,1

N Number of values
X Mean value
s_r Estimate of the repeatability standard deviation
S_r Estimate of the relative repeatability standard deviation
s_R Estimate of the reproducibility standard deviation
S_R Estimate of the relative reproducibility standard deviation

Bibliography

[1] *Characterization of Solid Biofuels 2004 — Development of Methods. PSO project no. 5297*. October 2008

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