BRITISH STANDARD

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Solid biofuels — Determination of bulk density

ICS 75.160.10

BSI
British Standards

National foreword

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

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Feste Biobrennstoffe - Bestimmung der Schüttdichte

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Foreword

This document (EN 15103:2009) 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of an identical text or by endorsement, at the latest by June 2010, and conflicting national standards shall be withdrawn at the latest by June 2010.

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Introduction

Bulk density is an important parameter for fuel deliveries on volume basis and together with the net calorific value, it determines the energy density. It also facilitates the estimation of space requirements for transport and storage. This document describes the determination of the bulk density of pourable solid biofuels which can be conveyed in a continuous material flow.

For practical reasons two standard measuring containers with a volume of 5 l or 50 l were chosen for the determination. Due to the limited volume of these containers, some fuels are therefore excluded from the scope of this document. This, for example, applies for chunk wood, uncomminuted bark or baled material and larger briquettes. The bulk density of such fuels can be calculated from their mass and the volume of the container or lorry used to transport them.

To decide on the actual storage room requirement of a solid biofuel the different storage conditions (e.g. height of heap or moisture content), which usually differ largely from the sample volume of the standard measuring container, should also be taken into account.

The here described method includes a defined shock exposure to the bulk material. The decision for this procedure was based on several reasons. It leads to a certain volume reduction which accounts for compaction effects occurring during the production chain. These compaction effects are mainly due to the fact that the fuel is usually transported and/or stored in containers or silos that are much larger than the measuring container as chosen for the here described method. Thus, in practice the higher mass load leads to an increased load pressure and to fuel settling, which can also be additionally enhanced by the vibrations during transportation. Furthermore, filling or unloading operations in practise usually apply a higher falling depth than the one chosen for the here performed test. This will also result in a respectively higher compaction due to the increased kinetic energy of the particles falling. A procedure which applies a controlled shock to the sample was thus believed to reflect the practically prevailing bulk density in a better way than a method without shock. This is particularly true when the mass of a delivered fuel has to be estimated from the volume load of a transporting vehicle, which is a common procedure in many countries. For a rough estimation on how susceptible the different solid biofuels are towards the shock exposure some research data are given in Annex A. The data show a compaction effect between 6 % and 18 % for biomass fuels.

1 Scope

This European Standard describes a method of determining bulk density of solid biofuels by the use of a standard measuring container. This method is applicable to all solid biofuels with a nominal top size of maximum 100 mm.

Bulk density is not an absolute value, therefore conditions for its determination have to be standardised in order to gain comparative measuring results.

NOTE 1 The nominal top size is defined as the aperture size of the sieve where at least 95 % by mass of the material passes (see CEN/TS 15149-1).

NOTE 2 Bulk density of solid biofuels is subject to variation due to several factors such as vibration, shock, pressure, biodegradation, drying and wetting. Measured bulk density can therefore deviate from actual conditions during transportation, storage or transhipment.

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.

prEN 14588:2009, *Solid biofuels — Terminology, definitions and descriptions*

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

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

prEN 14778-1, *Solid biofuels — Methods for sampling*

CEN/TS 14778-2, *Solid biofuels — Sampling — Part 2: Method for sampling particulate material transported in lorries*

CEN/TS 14779, *Solid biofuels — Sampling — Methods for preparing sampling plans and sampling certificates*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in prEN 14588:2009 apply.

4 Symbols and abbreviations

Abbreviations used in this document:

BD_{ar}	bulk density as received in kg/m³
BD_{d}	bulk density of the sample on dry basis in kg/m³
M_{ar}	moisture content, as received, as percentage by mass (wet basis)
m_1	mass of the empty container in kg
m_2	mass of the filled container in kg
V	net volume of the measuring container in m³

5 Principle

The test portion is filled into a standard container of a given size and shape and is weighed afterwards. Bulk density is calculated from the net weight per standard volume and reported for the measured moisture content.

6 Apparatus

6.1 Measuring containers

6.1.1 General

The container shall be cylindrically shaped and manufactured of a shock resistant, smooth-surfaced material. The container shall be resistant to deformation in order to prevent any variation in shape and volume. The container has to be waterproof. For easier handling grips may be fixed externally. The height-diameter-ratio shall be within 1,25 and 1,50.

6.1.2 Large container

The large measuring container has a filling volume of 50 l (0,05 m³) volume. The volume may deviate by 1 l (= 2 %). It shall have an effective (inner) diameter of 360 mm and an effective (inner) height of 491 mm (see Figure 1). Deviations from these dimensions are tolerable, if the height-diameter-ratio remains as given in 6.1.1

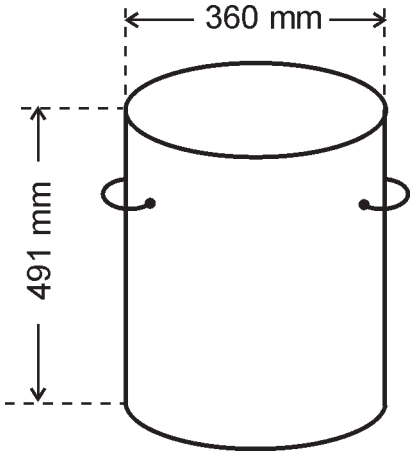

Figure 1 — measuring container, large

6.1.3 Small container

The small measuring container has a filling volume of 5 l (0,005 m³) volume. The volume may deviate by 0,1 l (= 2 %). It shall have an effective (inner) diameter of 167 mm and an effective (inner) height of 228 mm (see Figure 2). Deviations from these dimensions are tolerable, if the height-diameter-ratio remains as given in 6.1.1

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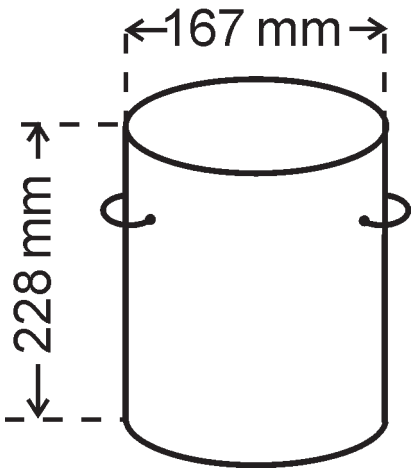

Figure 2 — measuring container, small

6.2 Balances

6.2.1 Balance 1

For measurements with the large container a balance having sufficient accuracy to enable the sample and container to be weighed to the nearest 10 g, shall be used.

6.2.2 Balance 2

For measurements with the small container a balance, having sufficient accuracy to enable the sample and container to be weighed to the nearest 1 g, shall be used.

6.3 Scantlings

A small scantling, preferably made of hard wood, approximately 600 mm long and having a cross section of about 50 mm x 50 mm should be used for the removal of surplus material.

Advisable: A strong scantling of 150 mm height is used to indicate the falling height in the shock exposure.

6.4 Wooden board

A flat wooden board (e.g. oriented strand board (OSB)) with a thickness of approximately 15 mm and sufficient in size for the container to be dropped onto for shock exposure should be used.

7 Sample preparation

Sampling shall be carried out in accordance with prEN 14778-1 and CEN/TS 14778-2. If necessary, the sample may be divided in mass in accordance with CEN/TS 14780. The sample volume should exceed the measuring container volume by maximum 30 %.

NOTE Precautions should be taken to ensure that the moisture is evenly distributed throughout the sample.

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8 Procedure

8.1 Determination of the container volume

Before use, the mass and filling volume of the container shall be determined. Weigh the empty, clean and dry container on the balance (6.2.1 or 6.2.2). Then fill the container with water and a few drops of wetting agent (e.g. liquid soap) until maximum capacity; then weigh it again. The water should be at a temperature between 10 °C and 20 °C. Calculate the volume (V) of the container from the net weight of water and the density of the water (1 kg/dm^3) and record the result rounded to the nearest 0,000 01 m^3 (for the large container) or 0,000 001 m³ (for the small container).

NOTE 1 The effect of temperature on the density of water is here neglected.

NOTE 2 The container volume should be checked regularly.

8.2 Container selection

All fuels that are within the scope of this document can be used in the large container (6.2.1). For fuels with a nominal top size up to 12 mm and for pellets with a diameter equal or below 12 mm the small container (6.2.2) can be used (optional).

8.3 Measurement procedure

a) Fill the container by pouring the sample material from a height of 200 mm to 300 mm above the upper rim until a cone of maximum possible height is formed.

NOTE 1 Make sure that the container is dry and clean before being (re)filled.

b) The filled container is then shock exposed to allow settling. This is done by dropping it freely from 150 mm height onto a wooden board (6.4). Before shock exposure remove particles from the wooden board within the dropping area. Make sure that the container hits the board in a vertical position. Repeat the shock exposure two more times. Then refill the resulting empty space in the container according to 8.3 a).

NOTE 2 In order to estimate the falling height correctly, it is useful to place the filled container on a strong scantling of 150 mm (6.3) before moving it to the side for dropping it freely. Other mechanisms to create a comparable shock impact are also suitable (e.g. a steel rig construction with vertical guidance devices).

c) Remove surplus material by using a small scantling (6.3), which is shuffled over the container's edge in oscillating movements. When the sample contains coarse material, all particles preventing the free passage of the scantling have to be removed by hand. If the removal of larger particles tears bigger holes into the levelled surface, the cavities are refilled and the removal procedure is repeated.

d) Weigh the container.

e) Unify the used sample with the unused sample material and repeat the procedure from 8.3 a) to 8.3 d) at least once in order to get two replications.

f) Determine moisture content of the sample as received according to EN 14774-1 or EN 14774-2 immediately after bulk density determination.

9 Calculation

9.1 Calculation of bulk density as received

Calculate the bulk density of the sample as received (BD_{ar}) according to the following equation:

$$BD_{ar} \text{ (at } M_{ar}) = \frac{(m_2 - m_1)}{V} \quad (1)$$

The result for each individual determination shall be calculated to 0,1 kg/m³, and for reporting purposes the mean value of the individual results shall be calculated and rounded to the nearest 10 kg/m^3.

9.2 Calculation of bulk density on dry basis

Calculate the bulk density of the sample mass on dry basis (BD_d) according to the following equation:

$$BD_d = BD_{ar} \times \frac{(100 - M_{ar})}{100} \quad (2)$$

NOTE Equation (2) disregards shrinkage or expansion, which usually cause significant deviations when the sample is measured at different drying stages. For wood fuels, these phenomena usually occur at a moisture content below the fibre saturation point, which is at around 25 % moisture, depending on the wood species. A true comparison between fuel samples is therefore only possible when bulk density is measured at similar moisture contents. If sample materials of different moisture content shall be compared and at least one sample is below the fibre saturation point, the usual effect of swelling or shrinkage is in the order of around 0,7 % volume change per percentage point of moisture difference below the fibre saturation point [1]. For a comparison of measurements based on similar moisture content, the application of this correction factor can be useful.

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 CEN/TS 14779);

— reference to this European Standard;

— specification of the applied container size;

— any deviation from this standard;

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

— test result at moisture content as received according to 9.1 (required) or according to 9.2 (optional).

Test results shall be expressed with relevant symbols.

11 Precision

11.1 Repeatability

11.1.1 The maximum acceptable differences between the results obtained for bulk density as received (D_{ar}) are [2]:

— for samples with a bulk density below 300 kg/m³: 3,0 %;

— for samples with a bulk density equal or above 300 kg/m³: 2,0 %.

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11.1.2 The results of the duplicate determinations (performed within a short period of time, but not simultaneously) in the same laboratory by the same operator using the same apparatus on two representative test portions taken from the same sample material shall not differ by more than the values given in 11.1.1.

11.2 Reproducibility

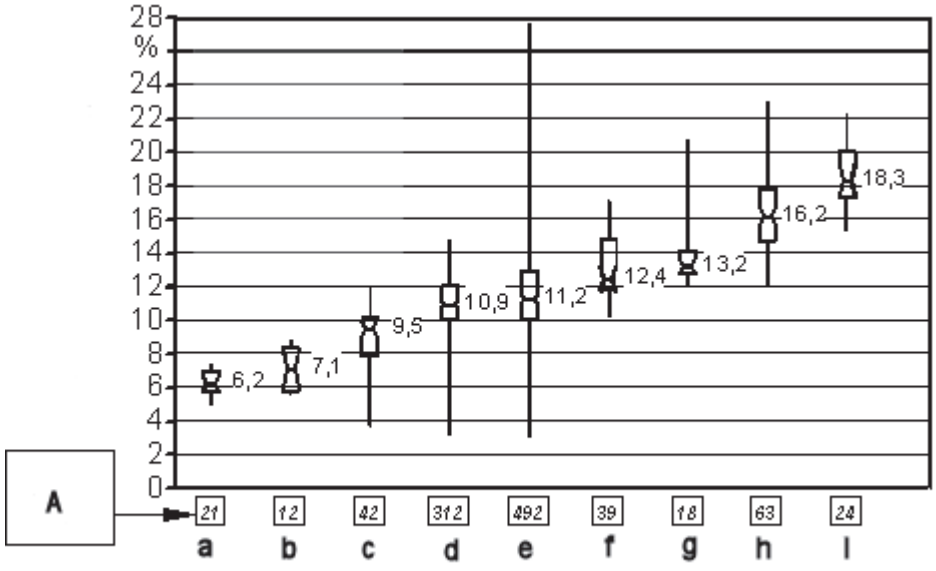
The means of the results of duplicate determinations for bulk density as received (D_{ar}), performed in each of two different laboratories on representative test portions taken from the same sample material shall not differ by more than the following values:

— for samples with a bulk density below 300 kg/m³: 6,0 %;

— for samples with a bulk density equal or above 300 kg/m³: 4,0 %.

Annex A
(informative)

Relative increase of bulk density determinations for solid biofuels: Application with shock impact versus application without shock impact



Key

	Maximum 75th Percentile Median 25th Percentile Minimum	d	High density wood chips
A	No. of replications	e	Low density wood chips
a	Wood pellets	f	Sawdust
b	Grain kernels	g	Peat
c	Herbaceous pellets	h	Bark
		i	Chopped miscanthus

Figure A.1 — Relative deviation to non-shock application

Relative effect of shock impact compared to a non-shock application in bulk density determination, here given for the 50-l container, which was dropped three times before refilling, surface levelling and weighing. The boundary value for high or low bulk density grouping was 180 kg/m³. Reference: [1].

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[2] Böhm, T.; Hartmann, H. *et al.* (2004): Guidelines for bulk density determination – European project "Pre-normative work on sampling and testing of solid biofuels for the development of quality assurance systems" (BioNorm) ENK6-CT-2001-00556, Deliverable D4 Part 2, Technology and Support Centre of Renewable Raw Materials (TFZ), Straubing, Germany.

[3] CEN/TS 14780, *Solid biofuels – Methods for sample preparation*

[4] CEN/TS 15149-1, *Solid biofuels – Methods for the determination of particle size distribution. Part 1: Oscillating screen method using sieve apertures of 3,15 mm and above*

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