DD CEN/TS 15405:2010

BSI Standards Publication

Solid recovered fuels — Determination of density of pellets and briquettes

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National foreword

This Draft for Development is the UK implementation of CEN/TS 15405:2010. It supersedes DD CEN/TS 15405:2006 which is withdrawn.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature. It should be applied on this provisional basis, so that information and experience of its practical application can be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the international organization responsible for its conversion to an international standard. A review of this publication will be initiated not later than 3 years after its publication by the international organization so that a decision can be taken on its status. Notification of the start of the review period will be made in an announcement in the appropriate issue of *Update Standards.*

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into an international Standard, to extend the life of the Technical Specification or to withdraw it. Comments should be sent to the Secretary of the responsible BSI Technical Committee at British Standards House, 389 Chiswick High Road, London W4 4AL.

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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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ICS 75.160.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This Draft for Development was published under the authority of the Standards Policy and Strategy Committee on 31 October 2010.

Amendments issued since publication

Date	Text affected

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CEN/TS 15405

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ICS 75.160.10

Supersedes CEN/TS 15405:2006

English Version

Solid recovered fuels - Determination of density of pellets and briquettes

Combustibles solides de récupération - Méthode de détermination de la densité des granulés et des briquettes

Feste Sekundärbrennstoffe - Bestimmung der Dichte von Pellets und Briketts

This Technical Specification (CEN/TS) was approved by CEN on 12 June 2010 for provisional application.

The period of validity of this CEN/TS is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the CEN/TS can be converted into a European Standard.

CEN members are required to announce the existence of this CEN/TS in the same way as for an EN and to make the CEN/TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the CEN/TS) until the final decision about the possible conversion of the CEN/TS into an EN is reached.

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Contents

Foreword

This document (CEN/TS 15405:2010) has been prepared by Technical Committee CEN/TC 343 “Solid recovered fuels”, the secretariat of which is held by SFS.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes CEN/TS 15405:2006.

CEN/TS 15405:2006 is not be converted into a European Standard as the test method specified in this document was not validated (see [1], [2]).

This document differs from CEN/TS 15405:2006 mainly as follows:

a) number of replicate tests changed to two replications;

b) whole document editorially revised.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this Technical Specification: 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

This Technical Specification specifies a method for the determination of particle density where the required volume is measured by the buoyancy in a liquid. The parameter particle density is not an absolute value, therefore conditions for its determination should be standardised in order to gain comparative measuring results. Practical experience shows that for briquettes, the method specified is also replaceable by a similar measurement applying a gravimetrical determination of the volume via the displaced liquid. In this case, the container with the liquid is not positioned underneath the balance as specified in this Technical Specification but is placed onto the balance which would then have to carry a higher total mass (at the same accuracy requirements). For all other requirements (e.g. for the wetting agent), the procedure as outlined in this Technical Specification should be followed, except, that the Equation for density calculation shall be modified accordingly.

This Technical Specification is based on CEN/TS 15150.

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1 Scope

This Technical Specification specifies a method for the determination of particle density of irregularly shaped pieces of compressed fuels such as pellets or briquettes. It is not applicable to soft or semi-soft pellets.

NOTE 1 The term soft pellet is defined in CEN/TS 15639.

NOTE 2 Particle density is subject to variation due to the susceptibility of organic material to environmental or technical impacts such as air humidity, vibration, abrasion or biodegradation. Therefore, particle density can vary during time thus the measured values should be regarded as a momentary fuel property.

NOTE 3 At the time of preparing this document, the production of briquettes of solid recovered fuels could not be identified in the European market.

2 Normative references

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

prEN 15357:2008, *Solid recovered fuels — Terminology, definitions and descriptions*

prEN 15442, *Solid recovered fuels — Methods for sampling*

prEN 15443, *Solid recovered fuels — Methods for the preparation of the laboratory sample*

CEN/TS 15359, *Solid recovered fuels — Specifications and classes*

CEN/TS 15414-1, *Solid recovered fuels — Determination of moisture content using the oven dry method — Part 1: Determination of total moisture by a reference method*

CEN/TS 15414-2, *Solid recovered fuels — Determination of moisture content using the oven dry method — Part 2: Determination of total moisture by a simplified procedure*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in prEN 15357:2008 apply.

4 Principle

Both mass and volume of an individual particle or a group of particles are determined. The volume is measured by determining the buoyancy in a liquid. This procedure follows the physical principle that the buoyancy of a body is equal to the mass of the displaced volume of a liquid. The apparent loss in mass between a measurement in air and a subsequent measurement in liquid marks its buoyancy. The volume of the sample body is calculated via the density of the applied liquid.

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5 Apparatus

5.1 General apparatus requirements

5.1.1 **Thermometer** for liquids, with an accuracy of 1 °C.

5.1.2 **Facilities** for the determination of moisture content in accordance with CEN/TS 15414-2.

5.2 Apparatus for pellet testing

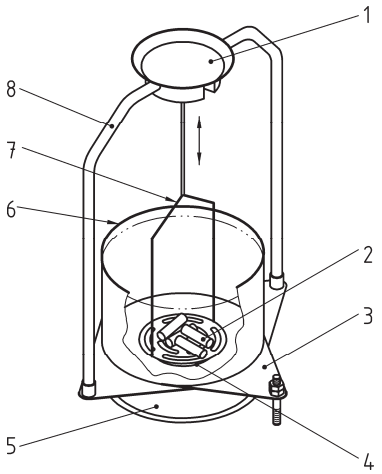
5.2.1 **Balance**, readable to 0,001 g. Due to the high sensitivity of the balance, the test rig shall be placed into a wind protection cabinet to allow undisturbed and immediate reading of the displayed values.

5.2.2 **Beaker glass**, transparent, with a filling volume of about 200 ml.

5.2.3 **Thermometer** for liquids, with an accuracy of 1 °C.

5.2.4 **Rig** for the determination of density, capable of being placed on the balance.

The rig shall be consisted of a bridge which overstretches the weighing plate of the balance in order to prevent the balance from being loaded. The bridge shall be capable of carrying the beaker glass (5.2.2). Through a supporting frame with suspension rods, a weighing dish („submergence dish“) shall be hung into the beaker glass (see Figure 1) which is filled with liquid. The dish shall be able to accommodate four pellets at once. Both the supporting frame and the submergence dish shall be directly loaded on the balance plate. The submergence apparatus (the dish and the suspension) shall be able to be removed for being loaded with pellets. The submergence depth shall always be kept constant through the dish suspension. The bottom of the submergence dish shall be perforated by openings which are smaller in diameter than the diameter of the pellets. This perforation allows the liquid to fill the dish from underneath if it is submerged. If sample material of low density shall be applied (< 1,0 g/cm^3), a modified suspension with an inverted submergence dish is required; this is to prevent pellets from floating atop of the liquid. For the determination of the mass in air, it is advantageous to use a combined test rig where an additional upper weighing dish is fixed (see Figure 1).



Key

1	weighing dish, for weighing in air	5	weighing plate
2	pellets	6	beaker glass
3	bridge	7	dish suspension
4	perforated submergence dish, for weighing in water	8	supporting frame

Figure 1 — Buoyancy determination rig on a balance (method for pellets)

5.3 Apparatus for briquette testing

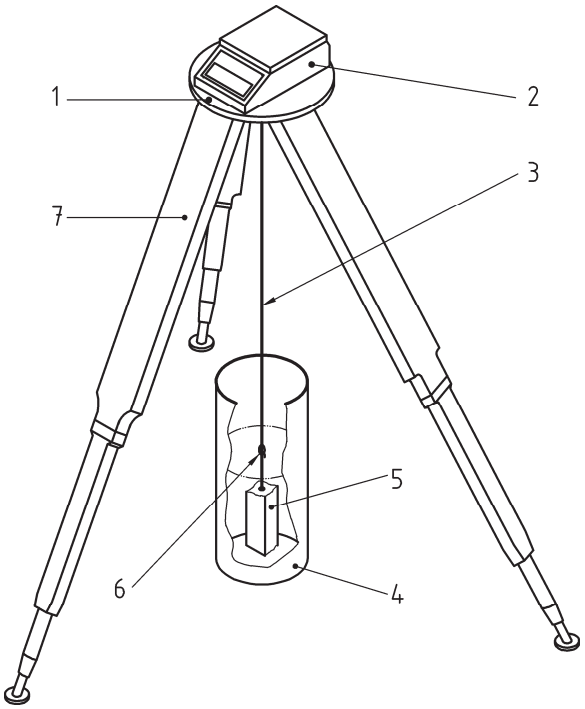
5.3.1 Balance, readable to 0,01 g. If briquettes of more than 500 g each shall be tested, the readability of the balance may be reduced to 0,1 g. The balance shall have a connecting point for hanging a weight to its load cell.

5.3.2 Container, transparent, for liquids, with a sufficient filling volume to accommodate the liquid and the submerged briquette.

NOTE A sufficient filling volume is usually achieved when the cross section of the container is about eight times larger than the cross section of the briquette. In this case, any effects by level changes of the liquid caused by submersion of the briquette are negligible. Such deviation would arise due to a larger part of the holding steel string being submerged.

5.3.3 Thin steel string, non absorbent, able to be hung to the connecting point of the balance; the end of the string is equipped with a hook or a ring allowing an easy appending of the sample.

5.3.4 Tripod, for placing the balance on, having a plate with an opening allowing the string to pass through unhindered while hanging to the balance (see Figure 2).



Key

1 carrying plate with opening
2 balance
3 steel string
4 liquid container
5 test sample (briquette)
6 connecting ring or hook
7 tripod

Figure 2 — Buoyancy determination rig using a hanging load to a balance (method for briquettes)

5.3.5 Steel support device, e.g. a steel loop, allowing to fix the briquette to the lower connecting point of the string.

5.3.6 Removable weight, in the case of testing a sample material of low density (< 1,0 g/cm^3), placed onto the sample in a way which prevents the briquette from floating atop of the liquid.

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6 Sampling and sample preparation

The sample shall be taken and prepared in accordance with prEN 15442, prEN 15443, CEN/TS 15414-1 and CEN/TS 15414-2.

The sample size shall be at least 500 g for pellets and 15 pieces for briquettes, respectively.

A sub-sample of minimum 40 pellets or 10 briquettes shall be selected from the fuel and stored at room temperature before measuring.

7 Procedure

7.1 Procedure for pellets

This procedure shall be used up to a pellet diameter of 25 mm in accordance with CEN/TS 15359. The following steps shall be carried out:

a) fill the beaker glass (5.2.2) with water to a filling level which ensures that full submersion of all pellets on the submergence dish is achievable;

b) add a volume fraction of 2 % of liquid soap to the water in the beaker glass (5.2.2) and stir until full homogeneity of the liquid is achieved. Position the beaker glass with the liquid onto the bridge of the rig (5.2.4);

c) determine the temperature of the liquid using the thermometer (5.1.1). Wait until the liquid reaches constant room temperature and record the measurement to the nearest 1 °C;

d) determine the total mass of a group of four pellets in air and record the measurement to the nearest 0,001 g;

e) position the empty submergence apparatus onto the designated bracket of the supporting frame. The submergence apparatus shall not touch the bottom of the beaker glass (5.2.2);

f) tare the balance to zero while the empty submergence dish is below liquid surface at maximum depth;

g) remove the submergence apparatus and place the same four pellets as measured as specified in d) onto the submergence dish and carefully place it back onto the designated bracket of the supporting frame;

h) while the group of pellets is submerged in the liquid, read the total mass from the balance and record it to the nearest 0,001 g. Read it immediately after submersion of the pellets in order to prevent them from up taking any liquid or from decay. If proper balance reading due to water absorption cannot be achieved, samples may be treated with a suitable coating agent, e.g. paraffin oil, before the measurement;

NOTE The reading is usually to be conducted within the first 5 s to 8 s when the displayed value on the balance is about constant.

i) repeat the procedure from d) to h) to achieve two replications in total. Repetition shall be made with fresh samples;

j) determine the total moisture content of the sample by the oven dry method in accordance with CEN/TS 15414-2.

7.2 Procedure for briquettes

This procedure shall be used up to a briquette diameter ≥ 25 mm in accordance with CEN/TS 15359. The following steps shall be carried out:

a) fill the liquid container with water to a filling level which ensures that full submersion of all briquettes is achievable;

b) add a volume fraction of 2 % of liquid soap to the water in the container (5.3.2) and stir until full homogeneity of the liquid is achieved;

c) determine the temperature of the liquid using the thermometer (5.1.1). Wait until the liquid reaches constant room temperature and record the measurement to the nearest 1 °C;

d) determine the total mass of a sample briquette in air and record the measurement to the nearest 0,01 g. If briquettes each of more than 500 g are tested, record to the nearest 0,1 g;

e) fix the empty steel loop or any other briquette mounting armature to the connecting ring of the thin steel string (5.3.3) and submerge this (empty) armature to maximum depth. The armature shall not be in contact with either the walls or the bottom of the container (5.3.2);

f) tare the balance (5.3.1) to zero while the empty mounting armature is below liquid surface;

g) remove the mounting armature from the container (5.3.2) and fix the same sample briquette as measured in d) to the mounting equipment. Fix it to the connecting ring or hook and carefully submerge the total mass into the liquid;

h) while the briquette is submerged in the liquid, read the total mass from the balance (5.3.1) and record it to the nearest 0,01 g. If briquettes with a total mass each of more than 500 g are tested record to the nearest 0,1 g. If a sample of a lower density than 1,0 g/cm^3 is tested, an extra weight shall be fixed to the load which shall prevent it from floating atop of the liquid. In this case, adjusting the balance to zero (see f)) shall also be conducted with the same extra weight. The load shall not be in contact with either the walls or the bottom of the container. Read the mass in liquid immediately after submersion of the briquette in order to prevent it from up taking any liquid or from decay;

NOTE 1 The reading is usually to be conducted within the first 5 s to 8 s when the displayed value on the balance is about constant.

i) repeat the procedure from d) to h) to achieve two replications in total;

j) determine the total moisture content of the sample following the procedure given in CEN/TS 15414-1 or CEN/TS 15414-2.

NOTE 2 For regularly shaped briquettes, the particle density can also be estimated by stereometry (see Annex B).

8 Calculation

8.1 Calculate the density of the applied liquid (water and soap) at the given temperature according to the volume fractions in the mixture as determined in 7.1 b) or 7.2 b). The temperature impact on the density of water is listed in Table A.1.

NOTE The information on the density of the liquid soap can be procured from the manufacturer or be determined by measurement. This for example can be performed in accordance with EN ISO 3675, or by applying any other useful method. Temperature effects on the density of the liquid soap can here be neglected.

8.2 Calculate the density, ρ_M, of each group of pellets respectively each briquette by Equation (1):

$$\rho_M = \frac{m_a}{m_a - m_l} \times \rho_l \quad (1)$$

where

ρ_M is the density of either the group of pellets or the individual briquette at the given mass fraction of moisture, M;

m_a is the mass of the sample in air (including sample moisture) as recorded in 7.1 d) and 7.2 d), respectively;

m_l is the mass of the sample in liquid (including sample moisture) as recorded in 7.1 h) and 7.2 h), respectively;

ρ_l is the density of the applied liquid as calculated in 8.1.

NOTE As a matter of principle, the rise of the liquid surface in the liquid containment, which is caused by the displacement through the sample, increases the buoyancy because a larger share of the suspension is now also submerged. However, this effect is negligible.

8.3 Calculate the arithmetic means of the total number of replications for pellets as defined in 7.1 j) and for briquettes, respectively, as defined in 7.2 j) and report them as the mean particle density to the nearest 0,01 g/cm^3.

9 Precision

The test methods specified in this Technical Specification were not validated in the frame of the QUOVADIS project (see [1]).

The coefficient of variation of duplicate determinations for pellets, carried out in one laboratory by the same operator with the same apparatus within a short interval of time on the same analysis sample was in the range from 3 % to 8 %.

Precision data of briquettes were not determined (see NOTE 1 in Clause 1).

10 Test report

The test report shall include at least the following information:

a) name of the testing laboratory;

b) date of the test;

b) identification of the product or sample tested;

c) reference to this Technical Specification, i.e. CEN/TS 15405;

d) mass fraction of moisture measured of the sample;

e) test results at the given mass fraction of moisture according to 8.3;

f) any deviation from this Technical Specification;

g) any unusual features observed during the determination which may have affected the test result and details of any operations not included in this Technical Specification or regarded as optional.

Annex A
(informative)

Correction values for the density of water as a function of temperature

Table A.1 — Density values of H_2O at a given temperature T (in °C)

T °C	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9
10	0,999 73	0,999 72	0,999 71	0,999 70	0,999 69	0,999 68	0,999 67	0,999 66	0,999 65	0,999 64
11	0,999 63	0,999 62	0,999 61	0,999 60	0,999 59	0,999 58	0,999 57	0,999 56	0,999 55	0,999 54
12	0,999 53	0,999 51	0,999 50	0,999 49	0,999 48	0,999 47	0,999 46	0,999 44	0,999 43	0,999 42
13	0,999 41	0,999 39	0,999 38	0,999 37	0,999 35	0,999 34	0,999 33	0,999 31	0,999 30	0,999 29
14	0,999 27	0,999 26	0,999 24	0,999 23	0,999 22	0,999 20	0,999 19	0,999 17	0,999 16	0,999 14
15	0,999 13	0,999 11	0,999 10	0,999 08	0,999 07	0,999 05	0,999 04	0,999 02	0,999 00	0,998 99
16	0,998 97	0,998 96	0,998 94	0,998 92	0,998 91	0,998 89	0,998 87	0,998 85	0,998 84	0,998 82
17.	0,998 80	0,998 79	0,998 77	0,998 75	0,998 73	0,998 71	0,998 70	0,998 68	0,998 66	0,998 64
18	0,998 62	0,998 60	0,998 59	0,998 57	0,998 55	0,998 53	0,998 51	0,998 49	0,998 47	0,998 45
19	0,998 43	0,998 41	0,998 39	0,998 37	0,998 35	0,998 33	0,998 31	0,998 29	0,998 27	0,998 25
20	0,998 23	0,998 21	0,998 19	0,998 17	0,998 15	0,998 13	0,998 11	0,998 08	0,998 06	0,998 04
21	0,998 02	0,998 00	0,997 98	0,997 95	0,997 93	0,997 91	0,997 89	0,997 86	0,997 84	0,997 82
22	0,997 80	0,997 77	0,997 75	0,997 73	0,997 71	0,997 68	0,997 66	0,997 64	0,997 61	0,997 59
23	0,997 56	0,997 54	0,997 52	0,997 49	0,997 47	0,997 44	0,997 42	0,997 40	0,997 37	0,997 35
24	0,997 32	0,997 30	0,997 27	0,997 25	0,997 22	0,997 20	0,997 17	0,997 15	0,997 12	0,997 10
25	0,997 07	0,997 04	0,997 02	0,996 99	0,996 97	0,996 94	0,996 91	0,996 89	0,996 86	0,996 84
26	0,996 81	0,996 78	0,996 76	0,996 73	0,996 70	0,996 68	0,996 65	0,996 62	0,996 59	0,996 57
27	0,996 54	0,996 51	0,996 48	0,996 46	0,996 43	0,996 40	0,996 37	0,996 34	0,996 32	0,996 29
28	0,996 26	0,996 23	0,996 20	0,996 17	0,996 14	0,996 12	0,996 09	0,996 06	0,996 03	0,996 00
29	0,995 97	0,995 94	0,995 91	0,995 88	0,995 85	0,995 82	0,995 79	0,995 76	0,995 73	0,995 70
30	0,995 67	0,995 64	0,995 61	0,995 58	0,995 55	0,995 52	0,995 49	0,995 46	0,995 43	0,995 40

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Annex B
(informative)

Volume determination of regularly shaped briquettes by stereometry

B.1 Procedure suggested for cylindrical briquettes

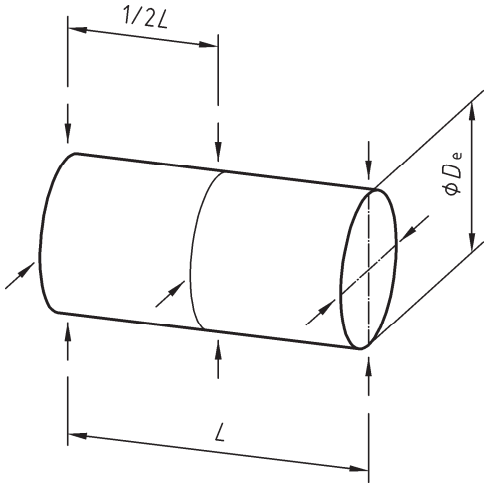

Figure B.1 — Briquettes without central hole

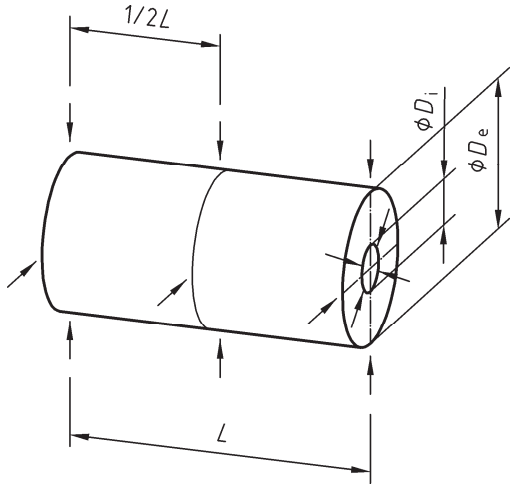

Figure B.2 — Briquettes with central hole

Calliper measurements:
- length, L: two measurements per briquette, each with 90 ° offset;
- external diameter, D_e: six measurements per briquette (twice at both ends and in the middle at ½ L).

Calculation:

$$V_p = \frac{D_e^2 \times \pi \times L}{4} \quad \text{(B.1)}$$

where

V_p is the volume of the briquette, in cubic centimetre;
L is the length of the briquette, in centimetre;
D_e is the mean value of six measurements of the external diameter, in centimetre.

Calliper measurements:
- length, L: two measurements per briquette, each with 90 ° offset;
- external diameter, D_e: six measurements per briquette (twice at both ends and in the middle at ½ L);
- internal diameter, D_i: four measurements per briquette, twice at both ends.

Calculation:

$$V_p = V_e - V_i \quad \text{(B.2)}$$

with $$V_e = \frac{D_e^2 \times \pi \times L}{4} \quad \text{(B.3)}$$

and $$V_i = \frac{D_i^2 \times \pi \times L}{4} \quad \text{(B.4)}$$

where

V_p is the volume of the briquette, in cubic centimetre;
V_e is the external volume of the particle, in cubic centimetre;
V_i is the volume of the hole, in cubic centimetre;
L is the length of the briquette, in centimetre;
D_e is the mean value of six measurements of the external diameter, in centimetre;
D_i is the mean value of four measurements of the internal diameter, in centimetre.

B.2 Procedure suggested for non-cylindrical briquettes

a) Take a paper sheet (type A 4, 21 cm $\times$ 29,7 cm), weigh it to the nearest 0,1 mg (M_s in grams) and measure its dimensions in centimetres to the nearest 0,01 cm; calculate the surface A_s;

b) place the briquette standing upright on the base in the middle of the sheet;

c) use a sharp pencil (0,5 mm) to draw the circumferential line around the base of the briquette. The use of a special line marking equipment is advisable here;

d) cut out the area precisely on the line using a pair of scissors;

e) weigh the cut out piece of paper (M_p in grams) to the nearest 0,1 mg;

f) use calliper measurement (twice) for the length of the briquette (L_b) in centimetres (two measurements) and, if applicable, the diameter of any central hole (D_i in centimetres) (four measurements: two at both ends of the briquette, each with an offset of 90°).

Calculation:

The base surface of the briquette (without hole) is calculated by Equation (B.5):

$$A_b = \frac{A_s \times M_p}{M_s} \tag{B.5}$$

where

A_b is the base surface of the briquette, in square centimetres;

A_S is the surface of the original uncut paper sheet, in square centimetres;

M_p is the mass of the cut piece of paper, in grams;

M_s is the mass of the original uncut paper sheet, in grams.

Reduce the surface of the base accordingly if there is a central hole in the briquette.

The briquette volume is calculated by Equation (B.6):

$$V_b = A_b \times L_b \tag{B.6}$$

where

V_b is the volume of the briquette, in cubic centimetres;

A_b is the surface of the briquette, in square centimetres;

L_b is the length of the briquette, in centimetres.

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[2] CEN Guide 13: *Validation of environmental test methods*, Edition 1, October 2008

[3] CEN/TS 15150, *Solid biofuels — Methods for the determination of particle density*

[4] CEN/TS 15639, *Solid recovered fuels — Determination of density of pellets and briquettes*

[5] EN ISO 3675, *Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method (ISO 3675:1998)*

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