BS EN 15150:2011

BSI Standards Publication

Solid biofuels — Determination of particle density

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National foreword

This British Standard is the UK implementation of EN 15150:2011. It supersedes DD CEN/TS 15150:2005 which is withdrawn.

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 density

Biocombustibles solides - Détermination de la masse volumique des particules

Feste Biobrennstoffe - Bestimmung der Partikeldichte

This European Standard was approved by CEN on 18 September 2011.

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Foreword

This document (EN 15150:2011) has been prepared by Technical Committee CEN/TC "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of an identical text or by endorsement, at the latest by May 2012, and conflicting national standards shall be withdrawn at the latest by May 2012.

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1 Scope

This European Standard describes the method for determining the particle density of compressed fuels such as pellets or briquettes. Particle density is not an absolute value and conditions for its determination have to be standardised to enable comparative determinations to be made.

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, *Solid biofuels – Terminology, definitions and descriptions*

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

EN 14961-3, *Solid biofuels – Fuel specifications and classes – Part 3: Wood briquettes for non-industrial use*

EN 14778, *Solid biofuels – Sampling*

EN 14780, *Solid biofuels – Sample preparation*

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*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 14588 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 weight of the displaced volume of a liquid. The apparent loss in weight 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.

NOTE The particle density of briquettes could also be estimated by stereometric means (see informative Annex A). This estimation could also be made if pellets are cut to determine their volume by stereometric means. Be aware of a higher variability between the replications when applying the stereometric measuring principle.

5 Reagents

5.1 Water with low content of ions (e.g. drinking water quality) in a temperature range of 10 °C to 30 °C.

5.2 A detergent named O-[4-(1,1,3,3-Tetramethylbutyl)-phenyl]-deca(oxyethylen), Octylphenoldecaethylen-glycolether, Polyethylenglycol-mono-[p-(1,1,3,3-tetramethylbutyl)-phenyl]-ether.

NOTE The exclusive use of this specific detergent with given characteristics allows to apply a fixed value for the density of the liquid (mixture with water) and ensures constant properties as wetting agent. The detergent is, for example, traded under the name Triton® X-100. The density at 20 °C is 1,07 g/l.

5.3 Paraffin with a melting point of 52 °C to 54 °C**.**

6 Apparatus

6.1 General apparatus requirements

6.1.1 Thermometer for liquids having a measuring accuracy of 1 °C

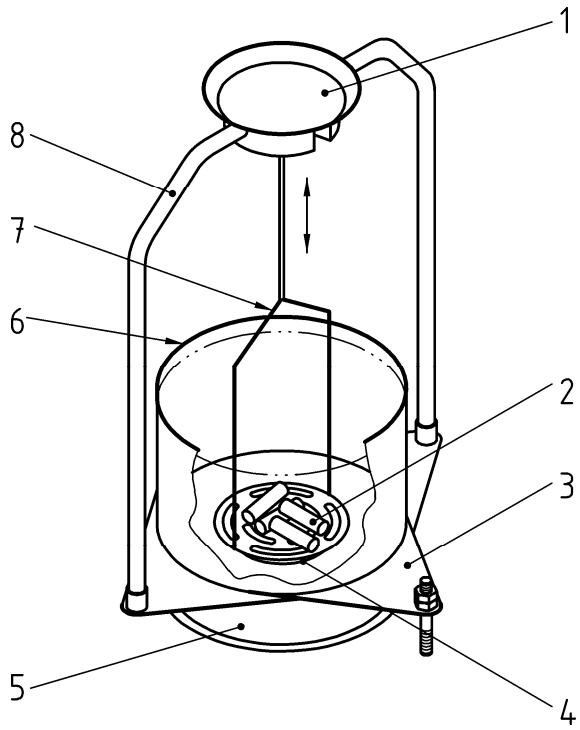
6.1.2 Facilities for moisture content determination according to EN 14774-1 or EN 14774-2

6.2 Apparatus for pellet testing

6.2.1 A balance, having sufficient accuracy to determine the weight to the nearest 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.

6.2.2 A transparent beaker glass of about 200 ml filling volume.

6.2.3 A density determination rig which can be placed on the balance. The rig consists of a bridge which overstretches the weighing plate of the balance in order to prevent the balance from being loaded. The bridge is capable of carrying the beaker glass (6.2.2). Through a supporting frame with suspension rods a weighing dish ("submergence dish") is hung into the beaker glass (Figure 1) which is filled with liquid. The dish shall be able to accommodate at least four pellets at once. Both, the supporting frame and the submergence dish are directly loaded on the balance plate. The submergence apparatus (the dish and the suspension) can be removed for being loaded with pellets. Through the dish suspension, the submergence depth is always kept constant. The bottom of the submergence dish is 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 when it is submerged. If sample material of low density shall be applied (below 1,0 g/cm^3) a modified suspension having an inverted submergence dish is required; this is to force the pellets underneath the liquid surface and prevent them from floating atop of the liquid. For the determination of the mass in air it is useful to use a combined test rig where an additional upper weighing dish is fixed to the suspension (Figure 1).



Key

1 weighing dish (weighing in air)

2 pellets

3 bridge

4 perforated submergence dish (weighing in water)

5 weighing plate (balance)

6 beaker glass

7 dish suspension

8 supporting frame

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

6.3 Apparatus for briquette testing

6.3.1 A balance, having sufficient accuracy to determine the weight to the nearest 0,01 g. If briquettes of more than 500 g each are tested the accuracy of the balance can be reduced to 0,1 g. The balance must have a connecting point for hanging a weight to its load cell.

6.3.2 A transparent container for liquids having a sufficient filling volume to accommodate the liquid and the submerged briquette.

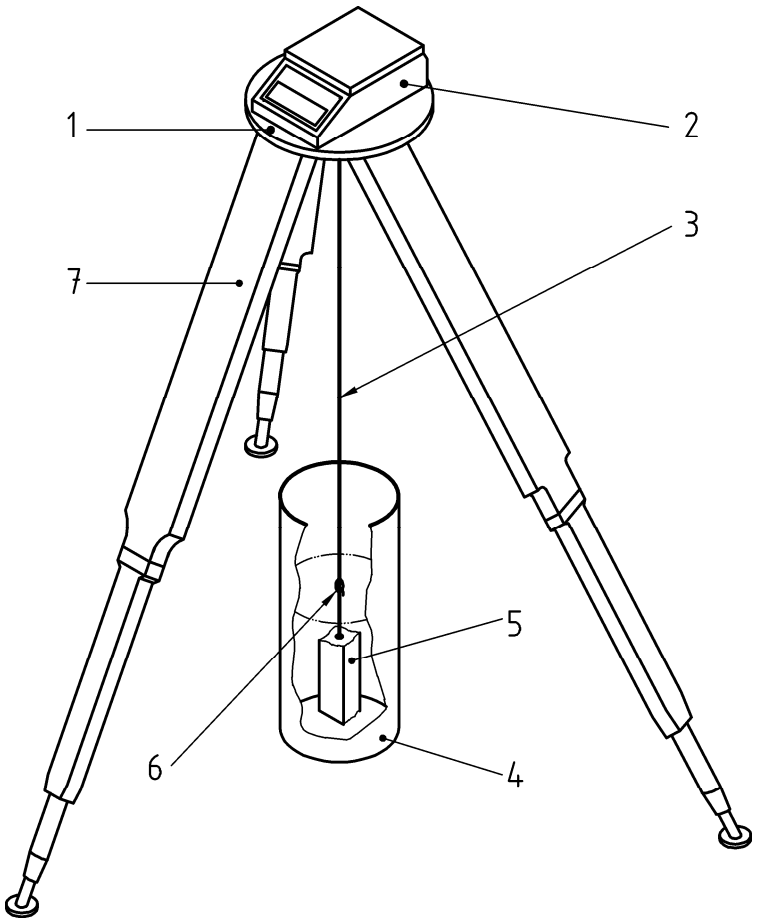
NOTE A sufficient filling volume is usually achieved when the container's cross section is about 8 times larger than the cross section of the briquette. In this case any effects by level changes of the liquid caused by submersion of the briquette are negligible. Such error would be due to a larger part of the holding steel string (see 6.3.3) being submerged.

6.3.3 A non absorbent thin steel string which can be hung to the connecting point of the balance. The end of the string is equipped with a hook or a ring, which allows an easy appending of the sample.

6.3.4 A tripod where the balance can be placed on. The tripod must have a plate with an opening which allows the string to pass through unhindered while hanging to the balance (Figure 2).

6.3.5 A technical support (e.g. steel loops or bracket) to hang up the briquette on the lower connecting point while it is being submerged in the liquid.

6.3.6 If sample material of low density shall be tested (below 1,0 g/cm^3) a removable weight is required, which is positioned onto the sample in a way which prevents the briquette from floating atop of the liquid.



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)

7 Sample preparation

7.1 Sampling and sample preparation shall be done in accordance with EN 14778 and EN 14780.

7.2 A total sample weight of 500 g (pellets with a diameter equal to or below 12 mm) or 1 000 g for pellets with a diameter above 12 mm or a minimum of 15 briquettes is required.

7.3 From the fuel a sub-sample of minimum 40 pellets or 10 briquettes is selected and stored in the room where the measuring will be conducted for at least two days.

7.4 For low density and coarse textured briquettes a rapid disintegration after submergence in the liquid may happen, thus the reading may be difficult to take. The sample can then be coated by submerging in liquid paraffin (5.3), preferable at a temperature of 90 °C.

NOTE Be aware of the additional volume, which reduces the density slightly.

8 Procedure

8.1 Procedure for pellets (up to a diameter of 25 mm according to EN 14961-1 and EN 14961-3).

8.1.1 Fill the beaker glass with water to a filling level which ensures that full submersion of all pellets on the submergence dish can be achieved.

8.1.2 Add 1,5 grams per litre of the detergent (5.2) to the water in the beaker glass and stir until full homogeneity of the liquid is achieved. Position the beaker glass with the liquid onto the bridge.

NOTE 1 At 1,5 grams per litre of the above detergent the critical micelle concentration in water (xCMC=0,15 g/l) is exceeded by ten times. It is advised to use a magnetic stirring device for better homogeneity.

8.1.3 Check the temperature of the liquid within reasonable intervals.

8.1.4 Determine the total weight of a group of at least four pellets in air and record the measurement to the nearest 0,001 g.

8.1.5 Position the empty submergence apparatus onto the designated bracket of the supporting frame. The submergence apparatus shall not touch the bottom or the walls of the beaker glass.

8.1.6 Tare the balance to zero while the empty submergence dish is below liquid surface at maximum depth.

8.1.7 Remove the submergence apparatus and place the same four pellets as measured in 8.1.4 onto the submergence dish and carefully place it back onto the designated bracket of the supporting frame.

8.1.8 While the group of pellets is submerged in the liquid, read the total weight from the balance and record it to the nearest 0,001 g.

NOTE 1 The reading of the weight in liquid should take place immediately after submersion of the pellets in order to prevent them from up taking any liquid or from decay. The reading can usually be conducted within the first 3 to 5 s when the displayed value on the balance is relatively constant.

NOTE 2 It is useful to apply a manually triggered electronical data logging from the balance to a computer, in order to facilitate the reading particularly if the displayed value remains relatively inconstant.

8.1.9 Remove the pellets from the liquid immediately after recording in order to avoid liquid contamination by dissolving pellets.

8.1.10 Repeat the procedure of 8.1.4 to 8.1.9 nine times to achieve ten replications in total. Replace the water at minimum after ten replications.

8.1.11 Determine the total moisture content using a portion of the initial sample material following the procedure given in EN 14774-1 or EN 14774-2.

8.2 Procedure for briquettes (with a diameter equal or higher than 25 mm, according to EN 14961-1 and EN 14961-3).

8.2.1 Fill the liquid container with water to a filling level, which ensures that full submersion of all briquettes can be achieved.

8.2.2 Add 1,5 grams per litre of the detergent (5.2) to the water in the container and stir until full homogeneity of the liquid is achieved.

8.2.3 Check the temperature of the liquid within reasonable intervals.

8.2.4 Determine the total weight 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.

8.2.5 Fix the empty steel loop or any other briquette mounting armature to the connection ring of the string 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.

8.2.6 Tare the balance to zero while the empty mounting armature is below liquid surface.

8.2.7 Remove the mounting armature from the container and fix the same sample briquette as measured in 8.2.4 to the mounting equipment. Fix it to the connecting ring and carefully submerge the total load into the liquid.

8.2.8 While the briquette is submerged in the liquid read the total weight from the balance 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/cm³ is tested, an extra weight shall be fixed to the load which shall prevent it from floating atop of the liquid. In this case, the taring of the balance to zero (8.2.6) has to be conducted with the same extra weight, too.

NOTE The load should not be in contact with either the walls or the bottom of the container. The reading of the weight in liquid should take place immediately after submersion of the briquette in order to prevent it from up taking any liquid or from decay. The reading can usually be conducted within the first 3 s to 5 s when the displayed value on the balance is about constant.

8.2.9 Remove the briquettes from the liquid immediately after recording in order to avoid liquid contamination by dissolving briquettes.

8.2.10 Repeat the procedure of 8.2.4 to 8.2.9 nine times to achieve ten replications in total. Replace the water at minimum after ten replications.

8.2.11 Determine the total moisture using a portion of the initial sample material following the procedure given in EN 14774-1 or EN 14774-2.

9 Calculation

9.1 The density of the liquid (water and reagent) is usually 0,9958 g/cm³. Apply this value for the calculation below or use a density which was determined individually.

9.2 Calculate the density of each group of pellets or of each briquette according to the following equation:

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

where:

ρ_M is the density of either the group of pellets or the individual briquette at the given moisture content M, in grams/cm³

m_a is the mass of the sample in air (including sample moisture) as recorded in 8.1.4 or in 8.2.4, respectively, in grams

m_l is the mass of the sample in liquid (including sample moisture) as recorded in 8.1.8 or in 8.2.8, respectively, in grams

ρ_l is the density of the applied liquid, as given in 9.1, in g/cm³

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 lager share of the suspension is now submerged, too. However, this effect may be neglected.

9.3 Calculate the arithmetic mean of the total number of replications as defined in 8.1.9 (for pellets) or 8.2.9 (for briquettes) and report it as the mean particle density to the nearest 0,01 g/cm³.

10 Precision

Because of the varying nature of the solid biofuels covered by this standard it is not possible at this time to give a precision statement (repeatability or reproducibility) for this test method.

11 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 according to EN 14961-1;

— a reference to this European standard;

— any deviation from the standard;

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

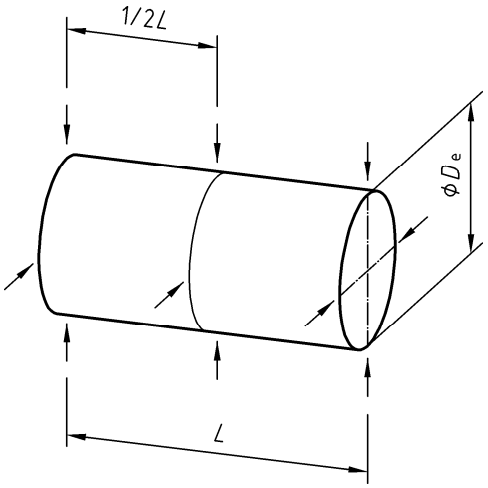
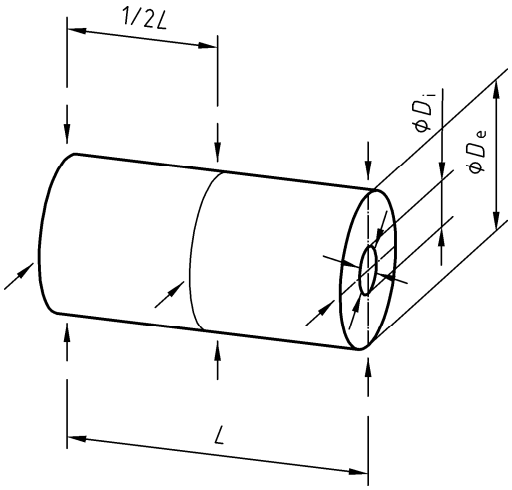
— the measured moisture content of the sample;

— the test result at given moisture content according to 9.3.

Annex A
(informative)

Stereometric volume estimation

A.1 Suggested estimation procedure for regularly shaped cylindrical briquettes or pellets which have been cut to achieve regular shape:

Briquettes without central hole and pellets	Briquettes with central hole
	
Calliper measurements: - Length (*L*): 2 Measurements per briquette/pellet, each with 90 degrees offset - External diameter (De): 6 measurements per briquette/pellet (twice at both ends and in the middle at ½ L).	*Calliper measurements:* - Length (*L*): 2 Measurements per briquette, each with 90 degrees offset - External diameter (De): 6 measurements per briquette (twice at both ends and in the middle at ½ L) - Internal diameter (Di) 4 measurements per briquette, twice at both ends
Calculation $V_p = \frac{Dem^2 \times \pi \times L}{4}$ With V_p volume of the briquette/pellet (cm³) *L* length (cm) *Dem* mean value of the 6 measurements for *De* (cm)	*Calculation* $V_p = V_e - V_i$ where $V_e = \frac{Dem^2 \times \pi \times L}{4}$ and $V_i = \frac{Dim^2 \times \pi \times L}{4}$ with V_p volume of the briquette (cm³) V_e external volume of the particle (cm³) V_i volume of the hole (cm³) *L* length (cm). *Dem* mean value of 6 measurements for *De* (cm). *Dim* mean value of 4 measurements for *Di* (cm)

Suggested number of replications: minimum 5 for briquettes and 10 for pellets.

A.2 Suggested alternative estimation procedure for briquettes (also suitable for irregularly shaped briquettes):

— Take a paper sheet (Type A4, 21 cm x 29,7 cm), weigh it with a precision of 0,1 mg (M_s in g) and measure its dimensions in cm at a precision of 0,01 cm. Calculate the surface A_s.

— Place the briquette standing upright on the base in the middle of the sheet.

— 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.

— Cut out the area precisely on the line using a pair of scissors.

— Weigh the cut out piece of paper (M_p in g.) with an accuracy of 0,1 mg.

— Apply calliper measurement (twice) for the length of the briquette (L_b) in cm (two measurements) and – if applicable – the diameter of any central hole (*Di* in cm) (four measurements: two at both ends of the briquette, each with an offset of 90°).

Calculation:

The surface of the briquette's base is (without hole):

$$A_b = \frac{A_s \times M_p}{M_s}$$

where

A_b base surface (cm²)

A_s surface of the original uncut paper sheet (cm²)

M_p mass of the cut piece of paper (g)

M_s mass of the original uncut paper sheet (g)

In case of any central hole in the briquette, reduce the surface of the base accordingly.

The briquette volume is:

$$V_b = A_b \times L_b$$

where

V_b the volume of the briquette (cm³)

A_b the surface of the briquette (cm²)

L_b the length of the briquette (cm)

Suggested number of replications: minimum 5.

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