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ISO 18847

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Solid biofuels — Determination of particle density of pellets and briquettes

Biocombustibles solides — Détermination de la masse volumique unitaire des granulés et des briquettes

Reference number
ISO 18847:2016(E)

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Foreword

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The committee responsible for this document is ISO/TC 238, *Solid biofuels*.

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Introduction

Particle density is a fuel parameter of pellets and briquettes which is often considered when describing the degree of compaction of the raw material used. Particle density can be highly specific for the respective type or species of biomass and thus, it also characterizes the material's general ability to be compacted. High particle density is often associated with high resistance to abrasion or low susceptibility towards fracturing during handling and storage. A high particle density also generally leads to reduced storage volume demands and to a lower filling level in combustion chamber at constant fuel mass flow. Particle density can also affect the heat transfer rate within the fuel and thus, it can have an impact on fuel ignition and on the dynamics of gasification.

Apart from the buoyancy method which is described in this International Standard as reference method, larger particles (briquettes) are sometimes easier tested by simple stereometric means. For internal laboratory practices, such a procedure is also presented in Annex A. For small particles (pellets), this procedure is not recommended.

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Solid biofuels — Determination of particle density of pellets and briquettes

1 Scope

This International Standard specifies 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 standardized to enable comparative determinations to be made.

2 Normative references

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

ISO 14780[1)], *Solid biofuels — Sample preparation*

ISO 16559, *Solid biofuels — Terminology, definitions and descriptions*

ISO 18134-1, *Solid biofuels — Determination of moisture content — Oven dry method — Part 1: Total moisture — Reference method*

ISO 18134-2, *Solid biofuels — Determination of moisture content — Oven dry method — Part 2: Total moisture — Simplified method*

ISO 18135[2)], *Solid biofuels — Sampling*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 16559 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 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 test portion body is calculated via the density of the applied liquid.

NOTE The particle density of briquettes could alternatively be estimated by stereometric means (see Annex A).

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.

1) To be published.

2) To be published.

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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 traded for example under the name Triton® X-100. The density at +20 °C is 1,07 g/ml.

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

6 Apparatus

6.1 General apparatus requirements

A thermometer capable of reading to the nearest 1 °C.

6.2 Apparatus for pellet testing

6.2.1 A balance, having sufficient accuracy to determine the mass 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 glass beaker of about 200 ml filling volume.

6.2.3 A density determination rig placed on a 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 glass beaker (6.2.2). Through a supporting frame with suspension rods, a weighing dish ("submergence dish") is hung into the glass beaker (Figure 1), which is filled with liquid (5.1). 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 when 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 test portion material of low density is tested (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 on top 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).

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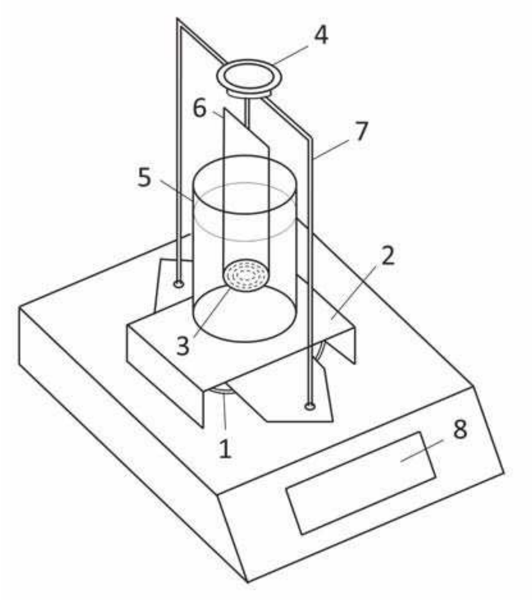

Key

1 weighing plate of balance
2 bridge
3 perforated submergence dish (for weighing in water)
4 dish (for weighing in air)
5 glass beaker
6 dish suspension
7 supporting frame
8 display of balance

NOTE Submergence dish for pellets with density below 1,0 g/m^3 is not shown in this figure.

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 mass 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 shall have a connecting point for hanging a weight to its load cell.

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

A sufficient filling volume is usually achieved when the container's cross section 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 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 briquette.

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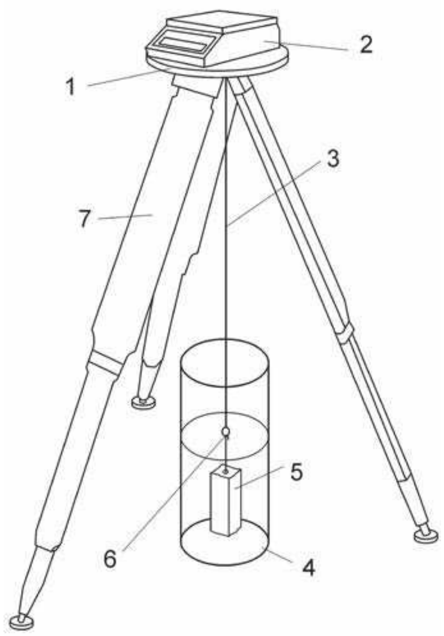
6.3.4 A tripod, where the balance can be placed on.

The tripod should have a plate with an opening which allows the string to pass through unhindered to the balance (Figure 2) while hanging.

6.3.5 A steel loop or any other steel support device, to which the briquette can be fixed while freely hanging and which allows to be fixed to the lower connecting point (Figure 2) of the steel string.

6.3.6 A removable weight, required if test material of low density is tested (below 1,0 g/cm^3), which is positioned onto the briquette in a way which prevents the briquette from floating on top of the liquid.



Key

1 carrying plate with opening

2 balance

3 steel string

4 transparent 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 A laboratory sample shall be obtained in accordance with ISO 18135 and test samples shall be prepared in accordance with ISO 14780.

7.2 A total test sample mass 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 test sample, a test portion of minimum 40 pellets or 10 briquettes is selected and stored in a sealed container to retain the moisture content as received.

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7.4 For low density and coarse textured briquettes, a rapid disintegration after submergence in the liquid may happen, thus the reading can be difficult to take. If this is the case, the briquettes can then be coated by submerging in liquid paraffin (5.3), preferably at a temperature of 90 °C, before performing the test.

NOTE If using coating, be aware of the additional volume which reduces the measured particle density slightly.

8 Procedure

8.1 Procedure for pellets

8.1.1 Fill the glass beaker 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 g/l of the detergent (5.2) to the water in the glass beaker and stir until full homogeneity of the liquid is achieved. Position the glass beaker with the liquid onto the bridge.

NOTE At 1,5 g/l 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 to ensure that the requirements in 5.1 are met.

8.1.4 Determine the total mass 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 glass beaker.

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.

If pellets of low density are tested (below 1,0 g/cm^3), they can float on top of the detergent solution. In this case, use the inverted submergence dish (6.2.3) to force the pellets underneath the liquid surface. If pellets do not behave uniformly, it can be necessary to perform the test on the individual pellets instead of submerging all four pellets in a group.

8.1.8 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. The reading of the mass in liquid shall take place immediately after submersion of the pellets in order to prevent them from up taking any liquid or from decomposition. The reading can usually be conducted within the first three seconds to five seconds when the displayed value on the balance is relatively constant.

NOTE It is useful to apply a manually triggered electronic 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 detergent solution at minimum after ten replications.

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8.1.11 Determine the total moisture content according to ISO 18134-1 or ISO 18134-2 using a test portion of the original test sample.

8.2 Procedure for briquettes

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 g/l 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 to ensure that the requirements in 5.1 are met.

8.2.4 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.

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 mass 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/cm^3 is tested, an extra weight shall be fixed to the load to prevent it from floating on top of the liquid. In this case, the taring of the balance to zero (8.2.6) has to include the same extra weight. The load shall not be in contact with either the walls or the bottom of the container. The reading of the mass in liquid shall take place as soon as possible after submersion of the briquette in order to prevent it from taking up any liquid or from decay. The reading is usually conducted within three seconds to five seconds after submerging, when the displayed value on the balance is constant.

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

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

8.2.11 Determine the total moisture content according to ISO 18134-1 or ISO 18134-2 using a test portion of the original test sample.

9 Calculation

9.1 The density of the liquid (water and reagent) when properly prepared is 0,995 8 g/cm^3. Apply this value for the calculation below or use a density, which was determined individually.

9.2 Calculate the particle density of each group of pellets or of each briquette according to Formula (1):

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

where

ρ_M is the density of either the group of pellets or the individual briquette at the given moisture content M, in g/cm^3;

m_a is the mass of the test portion in air (including test portion moisture) as recorded in 8.1.4 or in 8.2.4, respectively, in g;

m_l is the mass of the test portion in liquid (including test portion moisture) as recorded in 8.1.8 or in 8.2.8, respectively, in g;

ρ_l is the density of the applied liquid, as given in 9.1, in g/cm^3.

As a matter of principle, the rise of the liquid surface in the liquid containment, which is caused by the displacement through the test portion (pellets) or test sample (briquettes), increases the buoyancy because a larger share of the suspension is now submerged, too. However, this effect can be neglected.

9.3 Calculate the arithmetic mean value of the total number of replications as defined in 8.1.10 (for pellets) or 8.2.10 (for briquettes) and report it as the mean particle density to the nearest 0,01 g/cm^3.

10 Precision and bias

10.1 General

Table 1 — Maximum acceptable differences between results obtained

	Repeatability limit	Reproducibility limits
Pellets	5%	7%
Briquettes	5%	7%

10.2 Repeatability

The results calculated in 9.3 (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 test sample, shall not differ by more than the values given in Table 1[2].

10.3 Reproducibility

The results calculated in 9.3, performed in each of two different laboratories on representative test portions taken from the same test sample shall not differ by more than the values given in Table 1[2].

11 Test report

The test report shall include at least the following information:

a) identification of the laboratory performing the test and the date of the test;

b) identification of the product (or sample) tested;

c) reference to this International Standard, i.e. ISO 18847;

d) results of the particle density as mean value in accordance with 9.3;

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e) any unusual features observed during the determination, which can affect the result;

f) any deviation from this International Standard or operations regarded as optional.

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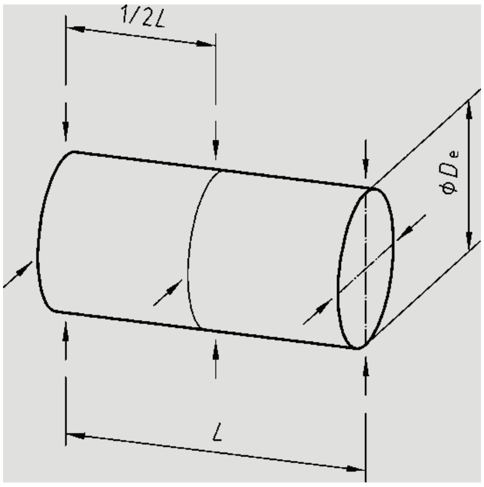
Annex A
(informative)

Stereometric volume estimation

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



Key

L length

D_e external diameter

Figure A.1 — Measurement points at briquettes without 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).

The suggested number of replications is a minimum of five.

Calculation:

$$V_b = \frac{{D_{em}}^2 \times \pi \times L_m}{4} \quad \text{(A.1)}$$

where

V_b is the volume of the briquette, in cm³;

L_m is the mean length of the two measurements for L, in cm;

D_{em} is the mean value of the six measurements for D_e, in cm.

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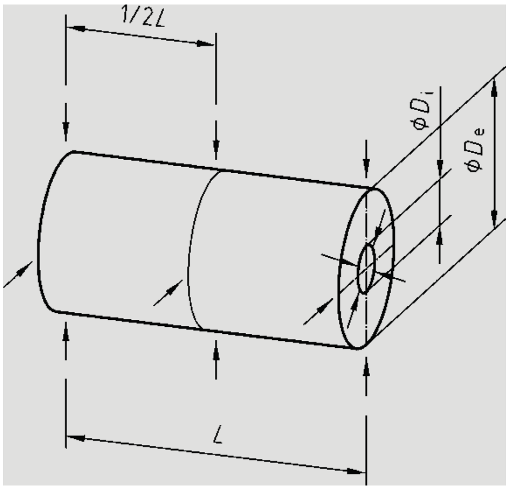

Key

L length

D_e external diameter

D_i internal diameter

Figure A.2 — Measurement points at 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);

— Internal diameter (D_i): four measurements per briquette, twice at both ends.

Calculation:

$$V_b = V_e - V_i \quad \text{(A.2)}$$

where

$$V_b = \frac{{D_{em}}^2 \times \pi \times L_m}{4} \quad \text{(A.3)}$$

and

$$V_b = \frac{{D_{im}}^2 \times \pi \times L_m}{4} \quad \text{(A.4)}$$

where

V_b is the volume of the briquette, in cm³;

V_e is the external volume of the particle, in cm³;

V_i is the volume of the hole, in cm³;

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L_m is the mean length of the two measurements for L, in cm;

D_{em} is the mean value of six measurements for D_e, in cm;

D_{im} is the mean value of four measurements for D_i, in cm.

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

— Weigh a paper sheet 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 (D_i in cm) (four measurements: two at both ends of the briquette, each with an offset of 90°).

The suggested minimum number of replications is five.

Calculation:

The surface of the briquette's base is (without hole) as given by Formula (A.5):

$$A_b = \frac{A_s \times M_p}{M_s} \quad \text{(A.5)}$$

where

A_b is the base surface, in cm²;

A_s is the surface of the original uncut paper sheet, in cm²;

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

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

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

The briquette volume is as given by Formula (A.6):

$$V_b = A_b \times L_b \quad \text{(A.6)}$$

where

V_b is the volume of the briquette, in cm³;

A_b is the surface of the briquette, in cm²;

L_b is the length of the briquette, in cm.

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