
**Solid biofuels — Determination
of particle density of pellets and
briquettes**

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

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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 14780¹⁾, *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 18135²⁾, *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.

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.

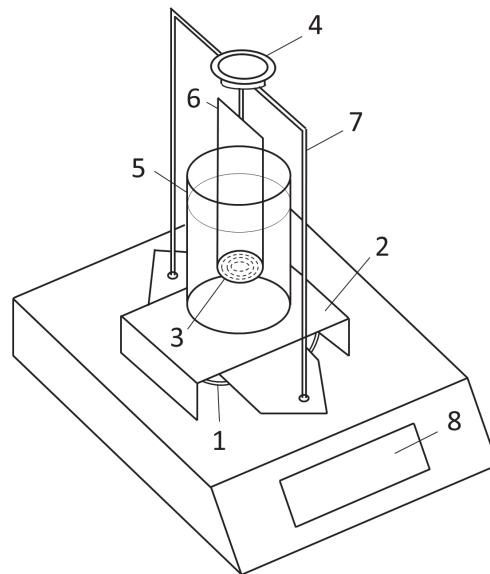
Due to the high sensitivity of the balance, the test rig shall be placed into a wind protection cabinet to allow undisturbed and immediate reading of the displayed values.

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

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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/cm³), 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).

**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
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NOTE Submergence dish for pellets with density below $1,0 \text{ g/m}^3$ 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.

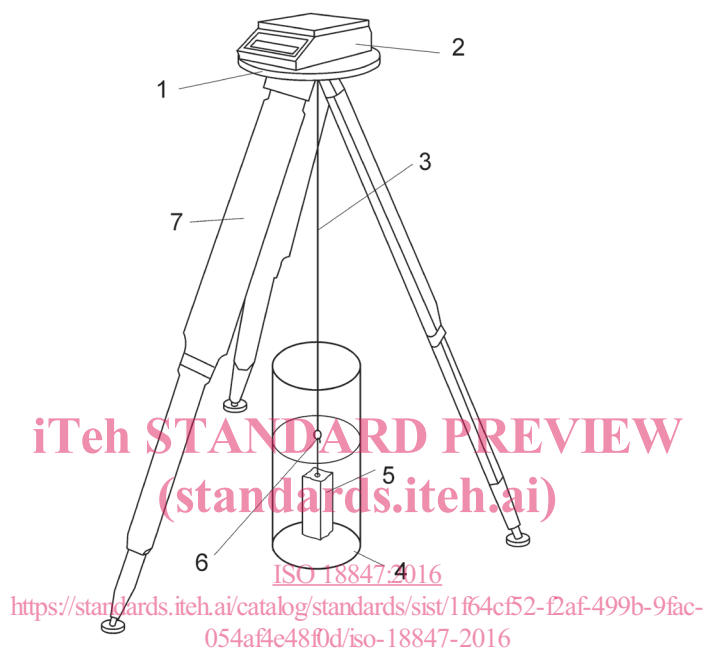
The end of the string is equipped with a hook or a ring, which allows an easy appending of the briquette.

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/cm³), 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.

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 ($x_{CMC} = 0,15$ 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/cm³), 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.