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**Solid biofuels — Fuel specifications  
and classes —**

Part 8:  
**Graded thermally treated and  
densified biomass fuels for  
commercial and industrial use**

*Biocombustibles solides — Classes et spécifications des  
combustibles*

*Partie 8: Combustibles de biomasses traitées thermiquement et  
densifiées en vue d'une utilisation commerciale et industrielle*

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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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, 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 [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 238, *Solid biofuels*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 335, *Solid biofuels*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition cancels and replaces the first edition (ISO/TS 17225-8:2016), which has been technically revised.

The main changes are as follows:

- raw material basis enlarged;
- [Tables 1](#) to 6 merged into [Tables 1](#) to [3](#), to be used for pellets and briquettes;
- table for thermally treated woody biomass split in two tables ([Table 1](#) and [Table 2](#));
- threshold values for [Tables 1](#) to [3](#) stated in terms of energy;
- [Annex A](#) has been introduced to support product specification;
- [Annex B](#) has been introduced to support the calculation of the limit values in terms of energy given in [Tables 1](#) to [3](#).

A list of all parts in the ISO 17225 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

The objective of this document is to provide unambiguous and clear classification principles for solid biofuels, to serve as a tool, to enable efficient trading of biofuels, to enable good understanding between seller and buyer as well as to serve as a tool for communication with equipment manufacturers. It will also facilitate legal permission procedures and reporting.

This document supports the use of thermally treated and densified biomass in commercial and industrial energy generation applications and in industrial processes, which require classified quality.

Thermal treatment includes processes such as torrefaction, steam explosion, hydrothermal carbonization and charring, all of which represent different exposure to heat, oxygen, steam or water. Thermally treated and densified biomass fuels should only be used in plants with manufacturer approval.

For individual contracts, ISO 17225-1 can be used. ISO 17225-1 can also be used for specification of charcoal.

Although this document may be used separately, a general understanding of the standards based on and supporting ISO 17225-1 is required. It is recommended that ISO 17225-1 is used in conjunction with this document.

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# Solid biofuels — Fuel specifications and classes —

## Part 8:

# Graded thermally treated and densified biomass fuels for commercial and industrial use

## 1 Scope

This document determines the fuel quality classes and specifications of graded densified solid biofuels produced from thermally treated biomass for commercial applications and industrial use. This document covers pellets and briquettes produced from the following raw materials (see ISO 17225-1:2021, Table 1):

- woody biomass;
- herbaceous biomass;
- fruit biomass;
- aquatic biomass;
- blends and mixtures.

Subcategories of these raw materials are included.

This document does not consider products which are marketed as charcoal or as charcoal products. For these products, see ISO 17225-1:2021, Table 14.

NOTE Health, safety and environmental issues for solid biofuels are important and need special attention; however, they are outside the scope of this document.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 5370, *Solid biofuels — Determination of fines content in pellets*

ISO 14780, *Solid biofuels — Sample preparation*

ISO 16559, *Solid biofuels — Vocabulary*

ISO 16948, *Solid biofuels — Determination of total content of carbon, hydrogen and nitrogen*

ISO 16968, *Solid biofuels — Determination of minor elements*

ISO 16994, *Solid biofuels — Determination of total content of sulfur and chlorine*

ISO 17225-1:2021, *Solid biofuels — Fuel specifications and classes — Part 1: General requirements*

ISO 17828, *Solid biofuels — Determination of bulk density*

ISO 17829, *Solid Biofuels — Determination of length and diameter of pellets*

ISO 17831-1, *Solid biofuels — Determination of mechanical durability of pellets and briquettes — Part 1: Pellets*

ISO 17831-2, *Solid biofuels — Determination of mechanical durability of pellets and briquettes — Part 2: Briquettes*

ISO 18122, *Solid biofuels — Determination of ash content*

ISO 18125, *Solid biofuels — Determination of calorific value*

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

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

ISO 18135, *Solid Biofuels — Sampling*

ISO 21945, *Solid biofuels — Simplified sampling method for small scale applications*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16559 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

**3.1 pellet made from thermally treated biomass**  
densified biofuel made from thermally treated solid biomass with or without additives usually with a cylindrical form, random length typically 5 mm to 40 mm, diameter up to 25 mm and broken ends

EXAMPLE Torrefied biomass, steam exploded biomass, hydrothermally carbonized biomass, charred biomass.

Note 1 to entry: Drying is not considered as thermal treatment in this definition.

Note 2 to entry: Fuel pellets which are produced by applying the thermal treatment after densification are also included in this definition.

**3.2 briquette made from thermally treated biomass**  
densified biofuel made with or without additives in pre-determined geometric form with at least two dimensions (height, width, and length) of more than 25 mm produced by compressing thermally treated solid biomass

EXAMPLE Torrefied biomass, steam exploded biomass, hydrothermally carbonized biomass, charred biomass.

Note 1 to entry: Drying is not considered as thermal treatment in this definition.

Note 2 to entry: Fuel briquettes which are produced by applying the thermal treatment after densification are also included in this definition.

**3.3 commercial application**  
facility that utilizes solid biofuel burning appliances or equipment that have similar fuel requirements as residential appliances

Note 1 to entry: Commercial applications should not be confused with industrial applications, which can utilize a much wider array of materials and have vastly different fuel requirements.

[SOURCE: ISO 17225-1:2021, 3.2]

### 3.4 post-immersion durability reduction

**DUR<sub>pi</sub>**

measure of the drop in the durability of thermally treated biomass fuel pellets after immersion in water

Note 1 to entry: A post-immersion durability reduction value of 0 means there was no change to the durability of the thermally treated pelletized fuel as a result of wetting, whereas, for example, a post-immersion durability reduction value of 3 indicates that the durability dropped by three percentage points as a result of wetting.

Note 2 to entry: The test procedure is given in ISO 23343-1.

[SOURCE: ISO 23343-1:2021, 3.2, modified — Definition revised and Note 2 to entry added.]

### 3.5 thermally treated biomass

biomass whose chemical composition has been changed by heat (usually by temperatures of 200 °C to 300 °C and above)

### 3.6 thermally treated biomass grindability index

**TTBGI**

measure for the tendency of a fixed volume of thermally treated biomass material to produce fine particles after grinding under defined settings and conditions

[SOURCE: ISO/TS 21596:2021, 3.3]

### 3.7 water sorption

**W<sub>SORP</sub>**

gain or loss of water or moisture by solid biofuels through absorption and/or adsorption when exposed to water or varying levels of humidity

[SOURCE: ISO 16559:2022, 3.216]

## 4 Symbols and abbreviated terms

|                   |   |
|-------------------|---|
| A <sub>MJ</sub>   | designation for ash content on a dry basis [g/M] dry]                         |
| ar                | as received   |
| BD                | designation for bulk density as received [kg/m <sup>3</sup> , (loose volume)] |
| C <sub>f</sub>    | fixed carbon [% in mass dry]  |
| D                 | designation for diameter as received [mm]                                     |
| d                 | dry (dry basis)   |
| DT                | designation for deformation temperature of the fuel ash [°C]                  |
| DU                | designation for mechanical durability as received [% in mass]                 |
| DUR <sub>pi</sub> | designation for post-immersion durability reduction [% in mass]               |
| F                 | designation for amount of fines (<3,15 mm) as received [% in mass]            |
| F0.5              | designation for amount of fines below 0,5 mm as received [% in mass]          |

|            |   |
|------------|---|
| FT         | designation for flow temperature of the fuel ash [°C]   |
| HT         | designation for hemisphere temperature of the fuel ash [°C]   |
| <i>L</i>   | designation for length as received [mm]   |
| M          | designation for moisture as received on a wet basis, $M_{ar}$ [% in mass]   |
| Q          | designation for net calorific value as received, $q_{p,net,ar}$ [MJ/kg, GJ/t, kWh/kg or MWh/t] at constant pressure       |
| $Q_d$      | designation for net calorific value on a dry basis, $q_{p,net,d}$ [MJ/kg or GJ/t or kWh/kg or MWh/t] at constant pressure |
| SST        | designation for shrinkage starting temperature of the fuel ash [°C]   |
| TTBGI      | thermally treated biomass grindability index [% in mass]  |
| VM         | volatile matter on a dry basis [% in mass dry]  |
| $W_{SORP}$ | water sorption [% in mass]  |

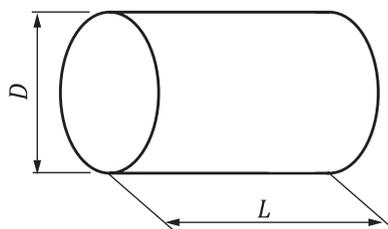
NOTE 1 1 MJ/kg equals 0,277 8 kWh/kg (1 kWh/kg equals 1 MWh/t and 1 MWh/t equals 3,6 MJ/kg). 1 g/cm<sup>3</sup> equals 1 kg/dm<sup>3</sup>. 1 mg/kg equals 0,000 1 %.

NOTE 2 Designation symbols are used with a number to specify property levels in [Tables 1 to 3](#) and [Annex A](#). For designation of chemical properties, chemical symbols such as S (sulfur), Cl (chlorine), N (nitrogen) and C (carbon) are used and the property class is added at the end of the symbol. Values of ash content and chemical properties (N, S, Cl, As, Cd, Cr, Cu, Pb, Hg, Ni and Zn) are given in g/MJ or mg/MJ, both on a dry basis, with the index MJ (e.g.  $S_{MJ}$ ).

## 5 Specification of graded pellets and briquettes produced by thermal processing

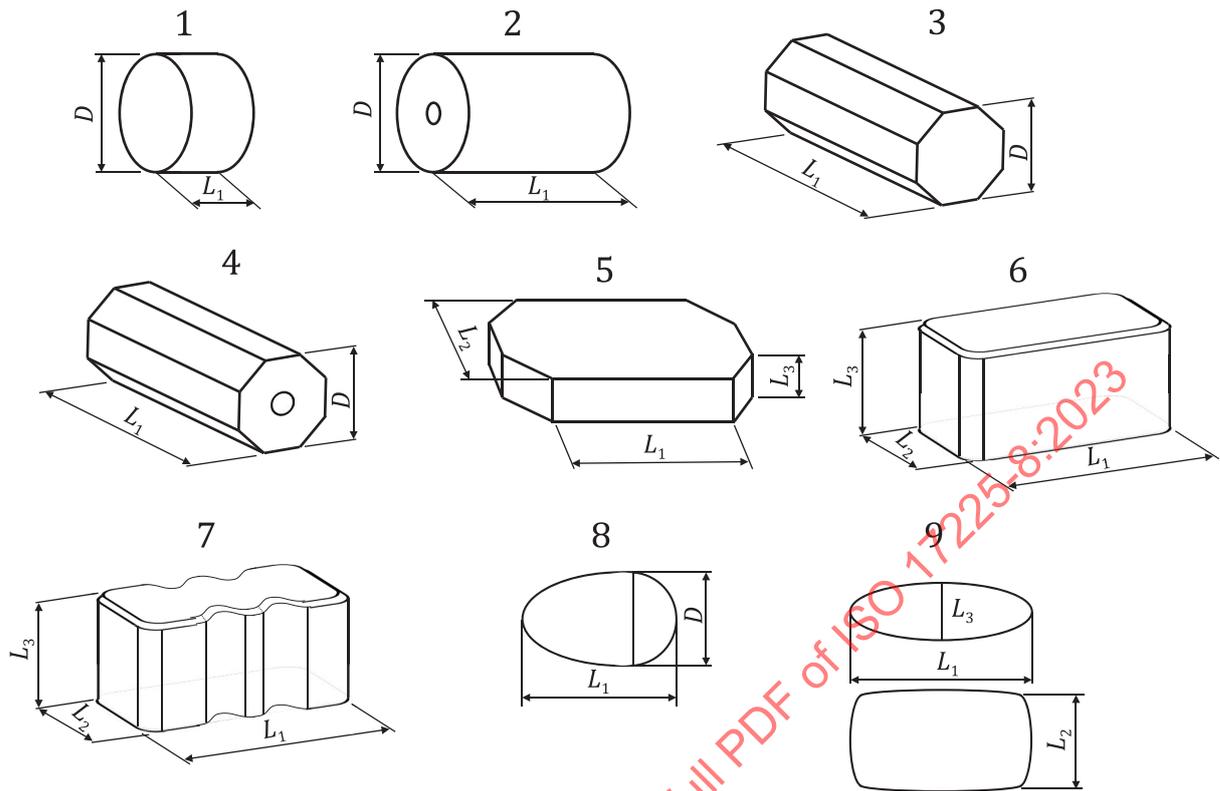
Property classes of graded densified biomass fuels produced by thermal processing of chemically untreated woody biomass, chemically untreated and/or chemically treated woody biomass and non-woody biomass are listed in [Tables 1, 2](#) and [3](#), respectively. If a densified biomass fuel produced by thermal processing cannot be classified according to [Table 1, 2](#) or [3](#), a specification shall be done according to [Annex A](#).

The specification of pellets made from thermally treated biomass is stated in accordance with [Tables 1 to 3](#) and [Figure 1](#), while briquettes made from thermally treated biomass are specified in accordance with [Tables 1 to 3](#) and [Figure 2](#). If other traded forms are used, the main dimensions (e.g. height, width, length) shall be stated.



**Key**  
*D* diameter  
*L* length

**Figure 1 — Dimensions of pellets**

**Key**

- $D$  diameter  
 $L_1$  length  
 $L_2$  width  
 $L_3$  height

**Figure 2 — Shapes and dimensions of briquettes**

Sampling and sample preparation shall be done according to ISO 18135 or ISO 21945 and ISO 14780, respectively. Analyses of the properties shall be carried out in accordance with the appropriate standard, i.e. ISO 5370, ISO 16948, ISO 16968, ISO 16994, ISO 17828, ISO 17829, ISO 17831-1, ISO 17831-2, ISO 18122, ISO 18125, ISO 18134-1, and ISO 18134-2. For specification of the origin and source, ISO 17225-1 shall be applied.

If data for chemical or physical properties are available, further analysis may not be required.

To ensure resources are used appropriately and the declaration is accurate, use the most appropriate measure as follows:

- a) using previous measured values or experience of the same raw material;
- b) calculation of properties, for example using typical values and considering generally accepted and documented specific values;
- c) carrying out analysis:
  - 1) with simplified methods, if available;
  - 2) with reference methods.

The responsibility of the producer or supplier to provide correct and accurate information is exactly the same whether laboratory analysis is performed or not. Typical values do not release the producer or supplier from providing accurate and reliable information.

To assign a fuel to a property class, all properties listed as normative in [Table 1](#), [2](#) and [3](#) as well as [Table A.1](#) shall be determined. The determination of properties listed as informative is recommended. The classes of mechanical, physical and chemical properties shall be stated when leaving the final point of loading for delivery to the end user. Between the factory gates and the end user, distributors shall take appropriate measures to maintain the stated level of fines. The quality class according to [Table 1](#), [Table 2](#), [Table 3](#) or the specification according to [Table A.1](#) shall be given in the product declaration.

Ash content and concentration of chemical elements N, S, Cl, As, Cd, Cr, Cu, Pb, Hg, Ni and Zn are influenced by thermal processing and shall be stated in terms of energy with the units g/MJ or mg/MJ (dry), respectively. To calculate the unit mg/MJ from mg/kg, the concentration of chemical elements (mg/kg on a dry basis) shall be divided by the net calorific value ( $Q_d$ , MJ/kg on a dry basis). Values in percentage mass (dry) shall be additionally multiplied by 10 to obtain values in g/MJ (dry). The reference values used for the calculation of the normative limit values in terms of energy are listed in [Annex B](#). In any analytical report or product declaration, values shall be stated additionally in terms of mass (in mg/kg dry or % mass dry). The values shall be rounded individually according to the significant digits of each property specified in [Table 1](#), [2](#) and [3](#).

NOTE 1 For a sample of thermally treated pellets with a lead content of 12 mg/kg dry and a calorific value of 19 MJ/kg dry the resulting value for  $Pb_{MJ}$  is 0,63 mg/MJ dry and exceeds the limit value of 0,53 mg/MJ dry for TW1. A sample with the same lead content of 12 mg/kg dry and a calorific value of 24,5 MJ/kg dry results in a value of 0,49 mg/MJ dry and fulfils the requirement of class TW1.

NOTE 2 According to ISO 17225-1:2021, Annex D, the net calorific value (at constant pressure) on a dry basis can be calculated according to [Formula \(1\)](#).

$$q_{p,net,d} = [q_{p,net,ar} + 0,024\ 43 \times M_{ar}] \times \frac{100}{100 - M_{ar}} \quad (1)$$

where

- $q_{p,net,ar}$  is the net calorific value (at constant pressure) as received, in megajoules per kilogram (MJ/kg);
- $q_{p,net,d}$  is the net calorific value (at constant pressure) in dry matter, in megajoules per kilogram (MJ/kg);
- $M_{ar}$  is the moisture content as received in % mass;
- 0,024 43 is the correction factor of the enthalpy of vaporization (constant pressure) for water (moisture) at 25 °C, in megajoules per kilogram (MJ/kg) per 1 % in mass of moisture.

**Table 1 — Specification of graded densified biomass fuels produced from thermally processed chemically untreated woody biomass**

| Master table                                    |  |   |  |   |  |
|---|--|---|--|---|--|
|   | Property<br>(analysis method)  | Unit                                      | TW1  | TW2   |  |
| Normative                                       | <b>Origin and source</b><br>(ISO 17225-1:2021,<br>Table 1)   |   | 1.1 Forest, plantation and other virgin wood<br>1.2.1 Chemically untreated wood by-products and<br>residues <sup>a</sup> |   |  |
|   | <b>Traded form</b> (see<br>ISO 17225-1:2021,<br>Table 2)   |   | Pellets or briquettes  |   |  |
|   | <b>Dimensions</b> (mm), ISO 17829  |   |  |   |  |
|   | <b>Diameter (D)<sup>b</sup> and<br/>length (L)<sup>c</sup> of pellets</b> in<br>accordance with <a href="#">Figure 1</a>   | mm  | D06, 6 ± 1;<br>D08, 8 ± 1;<br>3,15 ≤ L ≤ 40  | D06, 6 ± 1;<br>D08, 8 ± 1;<br>3,15 ≤ L ≤ 40 |  |
|   | <b>Diameter (D), length (L)<br/>and shape</b> of briquettes<br>in accordance with<br><a href="#">Figure 2</a>  | mm  | Values to be stated  |   |  |
|   | <b>Moisture, M<sup>d</sup></b> ,<br>ISO 18134-1, ISO 18134-2   | % in mass as<br>received, on<br>wet basis | M08 ≤ 8  | M08 ≤ 8                                     |  |
|   | <b>Ash, A<sub>MJ</sub></b> , ISO 18122   | g/MJ dry                                  | A0.6 ≤ 0,6   | A1.6 ≤ 1,6                                  |  |
|   | <b>Mechanical durability</b><br>to be stated for pellets<br>and for briquettes with<br>shape 9 ( <a href="#">Figure 2</a> ), <b>DU</b> ,<br>ISO 17831-1, ISO 17831-2 | % in mass as<br>received                  | DU97.5 ≥ 97,5  | DU97.5 ≥ 97,5                               |  |
|   | <b>Amount of fines, F<sup>d</sup></b> , to be<br>stated for pellets and for<br>briquettes with shape 9<br>( <a href="#">Figure 2</a> ), ISO 5370                     | % in mass as<br>received                  | F2.0 ≤ 2,0<br>(value to be stated)   | F4.0 ≤ 4,0<br>(value to be stated)          |  |
|   | <b>Amount of fines below<br/>0,5 mm, F0.5<sup>d</sup></b> , to be<br>stated for pellets and for<br>briquettes with shape 9<br>( <a href="#">Figure 2</a> ), ISO 5370 | % in mass as<br>received                  | Value to be stated   | Value to be stated                          |  |
|   | <b>Additives<sup>e</sup></b>   | % in mass as<br>received                  | ≤4<br>(value to be stated)   | ≤5<br>(value to be stated)                  |  |
|   | <b>Bulk density, BD</b> , to be<br>stated for pellets and for<br>briquettes with shape 9<br>( <a href="#">Figure 2</a> ), ISO 17828                                  | kg/m <sup>3</sup> as re-<br>ceived        | BD650 ≥ 650  | BD600 ≥ 600                                 |  |
|   | <b>Net calorific value, Q<sup>d</sup></b> ,<br>ISO 18125   | MJ/kg as re-<br>ceived                    | Q20 ≥ 20<br>(value to be stated)   | Q19 ≥ 19<br>(value to be stated)            |  |
|   | <b>Nitrogen, N<sub>MJ</sub></b> , ISO 16948  | g/MJ dry                                  | N0.26 ≤ 0,26   | N0.53 ≤ 0,53                                |  |
|   | <b>Sulfur, S<sub>MJ</sub></b> , ISO 16994  | g/MJ dry                                  | S0.03 ≤ 0,03   | S0.05 ≤ 0,05                                |  |
|   | <b>Chlorine, Cl<sub>MJ</sub></b> , ISO 16994   | g/MJ dry                                  | Cl0.03 ≤ 0,03  | Cl0.05 ≤ 0,05                               |  |
| <b>Arsenic, As<sub>MJ</sub></b> , ISO 16968     | mg/MJ dry  | As0.05 ≤ 0,05                             | As0.11 ≤ 0,11  |   |  |
| <b>Cadmium, Cd<sub>MJ</sub></b> ,<br>ISO 16968  | mg/MJ dry  | Cd0.03 ≤ 0,03                             | Cd0.05 ≤ 0,05  |   |  |
| <b>Chromium, Cr<sub>MJ</sub></b> ,<br>ISO 16968 | mg/MJ dry  | Cr0.53 ≤ 0,53                             | Cr0.79 ≤ 0,79  |   |  |
| <b>Copper, Cu<sub>MJ</sub></b> , ISO 16968      | mg/MJ dry  | Cu0.53 ≤ 0,53                             | Cu1.05 ≤ 1,05  |   |  |

**Table 1 (continued)**

| Master table       |  |                               |                                     |                                     |
|--------------------|--|-------------------------------|-------------------------------------|-------------------------------------|
|                    | Property<br>(analysis method)  | Unit                          | TW1                                 | TW2                                 |
|                    | <b>Lead, Pb<sub>MJ</sub></b> , ISO 16968   | mg/MJ dry                     | Pb0.53 ≤ 0,53                       | Pb1.05 ≤ 1,05                       |
|                    | <b>Mercury, Hg<sub>MJ</sub></b> , ISO 16968  | mg/MJ dry                     | Hg0.005 ≤ 0,005                     | Hg0.005 ≤ 0,005                     |
|                    | <b>Nickel, Ni<sub>MJ</sub></b> , ISO 16968   | mg/MJ dry                     | Ni0.53 ≤ 0,53                       | Ni0.53 ≤ 0,53                       |
|                    | <b>Zinc, Zn<sub>MJ</sub></b> , ISO 16968   | mg/MJ dry                     | Zn5.26 ≤ 5,26                       | Zn5.26 ≤ 5,26                       |
|                    | <b>Fixed carbon, C<sub>f</sub><sup>f</sup></b>   | % in mass dry                 | Value to be stated                  | Value to be stated                  |
| <b>Informative</b> | <b>Total carbon, C</b> , ISO 16948   | % in mass dry                 | Value should be stated              | Value should be stated              |
|                    | <b>Volatile matter, VM</b> , ISO 18123   | % in mass dry                 | Value should be stated              | Value should be stated              |
|                    | <b>Ash melting behaviour<sup>g</sup></b> , ISO 21404   | °C                            | SST, DT, HT and FT should be stated | SST, DT, HT and FT should be stated |
|                    | <b>Thermally treated biomass grindability index, TTbGI</b> , ISO/TS 21596  | % in mass                     | Value should be stated              | Value should be stated              |
|                    | <b>Water sorption, W<sub>SORP</sub> and post-immersion durability reduction, DUR<sub>pi</sub></b> , ISO 23343-1  | % in mass                     | Values should be stated             | Values should be stated             |
|                    | <b>Particle density, DE</b> , ISO 18847  | g/cm <sup>3</sup> as received | Value should be stated              | Value should be stated              |
| <sup>a</sup>       | Negligible levels of glue, grease and other timber production additives (< 1 % in mass) used in saw-mills during production of timber and timber product from virgin wood are acceptable, if all chemical parameters of the pellets are clearly within the limits and/or concentrations are too small to be concerned with.  |                               |                                     |                                     |
| <sup>b</sup>       | Selected size class D06 or D08 to be stated.   |                               |                                     |                                     |
| <sup>c</sup>       | For D06 and D08, the amount of pellets longer than 40 mm may be 1 % in mass. Maximum length shall be ≤ 45 mm.  |                               |                                     |                                     |
| <sup>d</sup>       | At the final point of delivery.  |                               |                                     |                                     |
| <sup>e</sup>       | Type and amount of additive(s) to aid production, delivery or combustion (e.g. pressing aids, slagging inhibitors or any other additives such as starch, corn flour, potato flour, vegetable oil or lignin) shall be stated.   |                               |                                     |                                     |
| <sup>f</sup>       | Fixed carbon (% in mass dry) is calculated as follows: 100 – (ash [% in mass dry] + volatile matter [% in mass dry]).  |                               |                                     |                                     |
| <sup>g</sup>       | Special attention should be paid to the ash melting behaviour for some thermally treated biomass fuels, for example those produced from eucalyptus, poplar and short rotation coppice. It is recommended that all characteristic temperatures [shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)] are stated in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If an alternative ashing temperature is applied, it shall be specified. |                               |                                     |                                     |

**Table 2 — Specification of graded densified biomass fuels produced from thermally processed chemically untreated and/or chemically treated woody biomass**

| Master table                                 |  |                                     |   |   |  |
|--|--|-------------------------------------|---|---|--|
|  | Property<br>(analysis method)  | Unit                                | TOW1  | TOW2  |  |
| Normative                                    | <b>Origin and source</b><br>(ISO 17225-1:2021,<br>Table 1)   |                                     | 1.1 Forest, plantation and other virgin wood<br>1.2 By-products and residues from wood processing industry<br>1.3 Used wood <sup>a, b</sup> |   |  |
|  | <b>Traded form</b> (see<br>ISO 17225-1:2021,<br>Table 2)   |                                     | Pellets or briquettes   |   |  |
|  | <b>Dimensions</b> (mm), ISO 17829  |                                     |   |   |  |
|  | <b>Diameter (D)<sup>c</sup> and length (L)<sup>d</sup></b> of pellets in accordance with <a href="#">Figure 1</a>  | mm                                  | D06, 6 ± 1;<br>D08, 8 ± 1;<br>D10, 10 ± 1;<br>3,15 ≤ L ≤ 40   | D06, 6 ± 1;<br>D08, 8 ± 1;<br>D10, 10 ± 1;<br>3,15 ≤ L ≤ 40 |  |
|  | <b>Diameter (D), length (L) and shape</b> of briquettes in accordance with <a href="#">Figure 2</a>  | mm                                  | Values to be stated   |   |  |
|  | <b>Moisture, M<sup>e</sup></b> , ISO 18134-1, ISO 18134-2  | % in mass as received, on wet basis | M08 ≤ 8   | M08 ≤ 8   |  |
|  | <b>Ash, A<sub>MJ</sub></b> , ISO 18122   | g/MJ dry                            | A2.1 ≤ 2,1  | A4.2 ≤ 4,2  |  |
|  | <b>Mechanical durability</b> to be stated for pellets and for briquettes with shape 9 ( <a href="#">Figure 2</a> ), <b>DU</b> , ISO 17831-1, ISO 17831-2 | % in mass as received               | DU97.5 ≥ 97,5   | DU96.0 ≥ 96,0   |  |
|  | <b>Amount of fines, F<sup>e</sup></b> , to be stated for pellets and for briquettes with shape 9 ( <a href="#">Figure 2</a> ), ISO 5370                  | % in mass as received               | F2.0 ≤ 2,0  | F4.0 ≤ 4,0  |  |
|  | <b>Amount of fines below 0,5 mm, F0.5<sup>e</sup></b> , to be stated for pellets and for briquettes with shape 9 ( <a href="#">Figure 2</a> ), ISO 5370  | % in mass as received               | Value to be stated  | Value to be stated  |  |
|  | <b>Additives<sup>f</sup></b>   | % in mass as received               | ≤4<br>(value to be stated)  | ≤5<br>(value to be stated)                                  |  |
|  | <b>Bulk density, BD</b> , to be stated for pellets and for briquettes with shape 9 ( <a href="#">Figure 2</a> ), ISO 17828                               | kg/m <sup>3</sup> as received       | BD650 ≥ 650   | BD600 ≥ 600   |  |
|  | <b>Net calorific value, Q<sup>e</sup></b> , ISO 18125  | MJ/kg as received                   | Q19 ≥ 19<br>(value to be stated)  | Q19 ≥ 19<br>(value to be stated)                            |  |
|  | <b>Nitrogen, N<sub>MJ</sub></b> , ISO 16948  | g/MJ dry                            | N0.53 ≤ 0,53  | N1.05 ≤ 1,05  |  |
|  | <b>Sulfur, S<sub>MJ</sub></b> , ISO 16994  | g/MJ dry                            | S0.05 ≤ 0,05  | S0.16 ≤ 0,16  |  |
| <b>Chlorine, Cl<sub>MJ</sub></b> , ISO 16994 | g/MJ dry   | Cl0.05 ≤ 0,05                       | Cl0.11 ≤ 0,11   |   |  |
| <b>Arsenic, As<sub>MJ</sub></b> , ISO 16968  | mg/MJ dry  | As0.11 ≤ 0,11                       | As0.21 ≤ 0,21   |   |  |
| <b>Cadmium, Cd<sub>MJ</sub></b> , ISO 16968  | mg/MJ dry  | Cd0.03 ≤ 0,03                       | Cd0.05 ≤ 0,05   |   |  |
| <b>Chromium, Cr<sub>MJ</sub></b> , ISO 16968 | mg/MJ dry  | Cr1.05 ≤ 1,05                       | Cr1.58 ≤ 1,58   |   |  |

**Table 2 (continued)**

| Master table |  |                                    |  |  |
|--------------|--|------------------------------------|--|--|
|              | Property<br>(analysis method)  | Unit                               | TOW1                                   | TOW2                                   |
|              | <b>Copper, Cu<sub>MJ</sub></b> , ISO 16968   | mg/MJ dry                          | Cu1.58 ≤ 1,58                          | Cu2.63 ≤ 2,63                          |
|              | <b>Lead, Pb<sub>MJ</sub></b> , ISO 16968   | mg/MJ dry                          | Pb1.05 ≤ 1,05                          | Pb1.58 ≤ 1,58                          |
|              | <b>Mercury, Hg<sub>MJ</sub></b> ,<br>ISO 16968   | mg/MJ dry                          | Hg0.005 ≤ 0,005                        | Hg0.005 ≤ 0,005                        |
|              | <b>Nickel, Ni<sub>MJ</sub></b> , ISO 16968   | mg/MJ dry                          | Ni0.53 ≤ 0,53                          | Ni0.53 ≤ 0,53                          |
|              | <b>Zinc, Zn<sub>MJ</sub></b> , ISO 16968   | mg/MJ dry                          | Zn7.89 ≤ 7,89                          | Zn10.5 ≤ 10,5                          |
|              | <b>Fixed carbon, C<sub>f</sub><sup>g</sup></b>   | % in mass dry                      | Value to be stated                     | Value to be stated                     |
| Informative  | <b>Total carbon, C</b> ,<br>ISO 16948  | % in mass dry                      | Value should be stated                 | Value should be stated                 |
|              | <b>Volatile matter, VM</b> ,<br>ISO 18123  | % in mass dry                      | Value should be stated                 | Value should be stated                 |
|              | <b>Ash melting behaviour<sup>h</sup></b> ,<br>ISO 21404  | °C                                 | SST, DT, HT and FT<br>should be stated | SST, DT, HT and FT should<br>be stated |
|              | <b>Thermally treated bio-<br/>mass grindability index,<br/>TTBGI</b> , ISO/TS 21596  | % in mass                          | Value should be stated                 | Value should be stated                 |
|              | <b>Water sorption, W<sub>SORP</sub><br/>and post-immersion<br/>durability reduction<br/>(DUR<sub>pi</sub>)</b> , ISO 23343-1   | % in mass                          | Values should be stated                | Values should be stated                |
|              | <b>Particle density, DE</b> ,<br>ISO 18847   | g/cm <sup>3</sup> as re-<br>ceived | Value should be stated                 | Value should be stated                 |
| a            | 1.3.2 Chemically treated used wood may only be used as a fuel in installations with applicable permission.   |                                    |  |  |
| b            | 1.2.2 Chemically treated wood by-products, residues, fibres and wood constituents and 1.3.2 Chemically treated used wood are included even if they do contain heavy metals or halogenated organic compounds more than typical virgin material values or typical values of country of origin, as long as the thermally treated biomass meets the limit values from this table.  |                                    |  |  |
| c            | Selected size class D06, D08 or D10 to be stated.  |                                    |  |  |
| d            | For D06 to D10, the amount of pellets longer than 40 mm may be 1 % in mass. Maximum length shall be ≤ 45 mm.   |                                    |  |  |
| e            | At the final point of delivery.  |                                    |  |  |
| f            | Type and amount of additive(s) to aid production, delivery or combustion (e.g. pressing aids, slagging inhibitors or any other additives such as starch, corn flour, potato flour, vegetable oil or lignin) shall be stated.   |                                    |  |  |
| g            | Fixed carbon (% in mass dry) is calculated as follows: 100 – (ash [% in mass dry] + volatile matter [% in mass dry]).  |                                    |  |  |
| h            | Special attention should be paid to the ash melting behaviour for some thermally treated biomass fuels, for example those produced from eucalyptus, poplar, short rotation coppice and used wood. It is recommended that all characteristic temperatures [[shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)] are stated in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If an alternative ashing temperature is applied, it shall be specified. |                                    |  |  |

Table 3 — Specification of graded densified biomass fuels produced from thermally processed non-woody biomass

| Master table                                 |  |   |   |   |  |
|--|--|---|---|---|--|
|  | Property<br>(analysis method)  | Unit                                      | TA1   | TA2   |  |
| Normative                                    | <b>Origin and source</b><br>(ISO 17225-1:2021,<br>Table 1)   |   | 2 Herbaceous biomass<br>3 Fruit biomass<br>4 Aquatic biomass<br>5 Blends and mixtures                               |   |  |
|  | <b>Traded form</b> (see<br>ISO 17225-1:2021,<br>Table 2)   |   | Pellets or briquettes   |   |  |
|  | <b>Dimensions</b> (mm), ISO 17829  |   |   |   |  |
|  | <b>Diameter (D)<sup>a</sup> and<br/>length (L)<sup>b</sup> of pellets</b> in<br>accordance with <a href="#">Figure 1</a>   | mm  | D06 to D25, $D \pm 1$ ;<br>$3,15 \leq L \leq 40$<br>(from D06 to D10)<br>$3,15 \leq L \leq 50$<br>(from D12 to D25) | D06 to D25, $D \pm 1$ ;<br>$3,15 \leq L \leq 40$<br>(from D06 to D10)<br>$3,15 \leq L \leq 50$<br>(from D12 to D25) |  |
|  | <b>Diameter (D), length (L)<br/>and shape</b> of briquettes<br>in accordance with<br><a href="#">Figure 2</a>  | mm  | Values to be stated   |   |  |
|  | <b>Moisture, M<sup>c</sup></b> , ISO 18134-<br>1, ISO 18134-2  | % in mass as<br>received, on<br>wet basis | M08 $\leq$ 8  | M08 $\leq$ 8  |  |
|  | <b>Ash, A<sub>MJ</sub></b> , ISO 18122   | g/MJ dry                                  | A3.5 $\leq$ 3,5   | A7.1 $\leq$ 7,1   |  |
|  | <b>Mechanical durability</b><br>to be stated for pellets<br>and for briquettes with<br>shape 9 ( <a href="#">Figure 2</a> ), <b>DU</b> ,<br>ISO 17831-1, ISO 17831-2 | % in mass as<br>received                  | DU97.5 $\geq$ 97,5  | DU96.0 $\geq$ 96,0  |  |
|  | <b>Amount of fines, F<sup>c</sup></b> , to be<br>stated for pellets and for<br>briquettes with shape 9<br>( <a href="#">Figure 2</a> ) ISO 5370                      | % in mass as<br>received                  | F2.0 $\leq$ 2,0   | F4.0 $\leq$ 4,0   |  |
|  | <b>Amount of fines below<br/>0,5 mm, F0.5<sup>c</sup></b> , to be<br>stated for pellets and for<br>briquettes with shape 9<br>( <a href="#">Figure 2</a> ), ISO 5370 | % in mass as<br>received                  | Value to be stated  | Value to be stated  |  |
|  | <b>Additives<sup>d</sup></b>   | % in mass as<br>received                  | $\leq$ 4<br>(value to be stated)  | $\leq$ 5<br>(value to be stated)  |  |
|  | <b>Bulk density, BD</b> , to be<br>stated for pellets and for<br>briquettes with shape 9<br>( <a href="#">Figure 2</a> ), ISO 17828                                  | kg/m <sup>3</sup> as re-<br>ceived        | BD650 $\geq$ 650  | BD600 $\geq$ 600  |  |
|  | <b>Net calorific value, Q<sup>c</sup></b> ,<br>ISO 18125   | MJ/kg as re-<br>ceived                    | Q18 $\geq$ 18<br>(value to be stated)   | Q17 $\geq$ 17<br>(value to be stated)   |  |
|  | <b>Nitrogen, N<sub>MJ</sub></b> , ISO 16948  | g/MJ dry                                  | N0.88 $\leq$ 0,88   | N1.47 $\leq$ 1,47   |  |
| <b>Sulfur, S<sub>MJ</sub></b> , ISO 16994    | g/MJ dry   | S0.06 $\leq$ 0,06                         | S0.18 $\leq$ 0,18   |   |  |
| <b>Chlorine, Cl<sub>MJ</sub></b> , ISO 16994 | g/MJ dry   | Cl0.06 $\leq$ 0,06                        | Cl0.12 $\leq$ 0,12  |   |  |
| <b>Arsenic, As<sub>MJ</sub></b> , ISO 16968  | mg/MJ dry  | As0.12 $\leq$ 0,12                        | As0.24 $\leq$ 0,24  |   |  |

Table 3 (continued)

| Master table       |   |                                    |  |  |
|--------------------|---|------------------------------------|--|--|
|                    | Property<br>(analysis method)   | Unit                               | TA1                                    | TA2                                    |
|                    | <b>Cadmium, Cd<sub>MJ</sub></b> ,<br>ISO 16968  | mg/MJ dry                          | Cd0.03 ≤ 0,03                          | Cd0.06 ≤ 0,06                          |
|                    | <b>Chromium, Cr<sub>MJ</sub></b> ,<br>ISO 16968   | mg/MJ dry                          | Cr1.76 ≤ 1,76                          | Cr2.94 ≤ 2,94                          |
|                    | <b>Copper, Cu<sub>MJ</sub></b> , ISO 16968  | mg/MJ dry                          | Cu1.76 ≤ 1,76                          | Cu2.94 ≤ 2,94                          |
|                    | <b>Lead, Pb<sub>MJ</sub></b> , ISO 16968  | mg/MJ dry                          | Pb0.59 ≤ 0,59                          | Pb1.76 ≤ 1,76                          |
|                    | <b>Mercury, Hg<sub>MJ</sub></b> ,<br>ISO 16968  | mg/MJ dry                          | Hg0.006 ≤ 0,006                        | Hg0.006 ≤ 0,006                        |
|                    | <b>Nickel, Ni<sub>MJ</sub></b> , ISO 16968  | mg/MJ dry                          | Ni0.59 ≤ 0,59                          | Ni0.59 ≤ 0,59                          |
|                    | <b>Zinc, Zn<sub>MJ</sub></b> , ISO 16968  | mg/MJ dry                          | Zn5.88 ≤ 5,88                          | Zn11.8 ≤ 11,8                          |
|                    | <b>Fixed carbon, C<sub>f</sub><sup>e</sup></b>  | % in mass dry                      | Value to be stated                     | Value to be stated                     |
| <b>Informative</b> | <b>Total carbon, C</b> ,<br>ISO 16948   | % in mass dry                      | Value should be stated                 | Value should be stated                 |
|                    | <b>Volatile matter, VM</b> ,<br>ISO 18123   | % in mass dry                      | Value should be stated                 | Value should be stated                 |
|                    | <b>Ash melting behaviour<sup>f</sup></b> ,<br>ISO 21404   | °C                                 | SST, DT, HT and FT<br>should be stated | SST, DT, HT and FT should<br>be stated |
|                    | <b>Thermally treated bio-<br/>mass grindability index,<br/>TTBGI</b> , ISO/TS 21596   | % in mass                          | Value should be stated                 | Value should be stated                 |
|                    | <b>Water sorption, W<sub>SORP</sub><br/>and post-immersion<br/>durability reduction,<br/>DUR<sub>pi</sub></b> , ISO 23343-1 | % in mass                          | Values should be stated                | Values should be stated                |
|                    | <b>Particle density, DE</b> ,<br>ISO 18847  | g/cm <sup>3</sup> as re-<br>ceived | Value should be stated                 | Value should be stated                 |

<sup>a</sup> Selected size (e.g. D06, D08, D10, D12 or D25) of pellets to be stated.

<sup>b</sup> For D06 to D10 the amount of pellets longer than 40 mm may be 1 % in mass. Maximum length shall be ≤ 45 mm.

<sup>c</sup> At the final point of delivery.

<sup>d</sup> Type and amount of additive(s) to aid production, delivery or combustion (e.g. pressing aids, slagging inhibitors or any other additives such as starch, corn flour, potato flour, vegetable oil or lignin) shall be stated.

<sup>e</sup> Fixed carbon (% in mass dry) is calculated as follows: 100 – [ash [% in mass dry] + volatile matter [% in mass dry]].

<sup>f</sup> Special attention should be paid to the ash melting behaviour for some thermally treated biomass fuels, for example those produced from straw and miscanthus. It is recommended that all characteristic temperatures [shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)] are stated in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If an alternative ashing temperature is applied, it shall be specified.

## Annex A (normative)

### Template for specification of densified and non-densified biomass fuels produced by thermal processing

Thermally treated densified biomass fuels which cannot be classified according to [Tables 1 to 3](#) shall be specified according to the properties given in [Table A.1](#). Non-densified thermally treated biomass fuels shall be specified according to the properties given in [Table A.1](#) except for the parameters mechanical durability ( $DU$ ), diameter ( $D$ ) and length ( $L$ ).

Ash content and concentration of chemical elements N, S, Cl, As, Cd, Cr, Cu, Pb, Hg, Ni and Zn are influenced by thermal processing and shall be stated in terms of energy with the units g/MJ or mg/MJ (dry), respectively. To calculate the unit mg/MJ from mg/kg, the concentration of chemical elements (mg/kg on dry basis) shall be divided by the net calorific value ( $Q_{net}$ , MJ/kg on dry basis). Values in percentage mass (dry) basis shall be additionally multiplied by 10 to obtain values in g/MJ (dry). The net calorific value on a dry basis can be calculated according to [Formula \(1\)](#) which is specified in [Clause 5](#), Note 2. The values shall be rounded individually according to the significant digits of each property specified in [Table 1](#), [2](#) and [3](#).

**Table A.1 — List of properties for the specification of thermally treated densified and non-densified biomass fuels**

| Master table                                     |   |                                     |   |
|--|---|-------------------------------------|---|
|  | Property (analysis method)  | Unit                                | Specification   |
| Normative  | <b>Origin and source</b> (ISO 17225-1:2021, Table 1)                              |                                     | To be stated  |
|  | <b>Traded form</b> (see ISO 17225-1:2021, Table 2)                                |                                     | Pellets or briquettes   |
|  | <b>Dimensions</b> (mm), ISO 17829   |                                     |   |
|  | <b>Diameter (<math>D</math>) and Length (<math>L</math>)</b> of pellets           | mm                                  | Value to be stated according <a href="#">Figure 1</a>                                       |
|  | <b>Diameter (<math>D</math>), Length (<math>L</math>) and Shape</b> of briquettes | mm                                  | Value to be stated according <a href="#">Figure 2</a>                                       |
|  | <b>Moisture, <math>M^a</math></b> , ISO 18134-1, ISO 18134-2                      | % in mass as received, on wet basis | Value to be stated  |
|  | <b>Ash, <math>A_{MJ}</math></b> , ISO 18122                                       | g/MJ dry                            | Value to be stated  |
|  | <b>Mechanical durability, <math>DU</math></b> , ISO 17831-1, ISO 17831-2          | % in mass as received               | Value to be stated for pellets and for briquettes with shape 9 ( <a href="#">Figure 2</a> ) |
|  | <b>Amount of fines, <math>F^a</math></b> , ISO 5370                               | % in mass as received               | Value to be stated for pellets and for briquettes with shape 9 ( <a href="#">Figure 2</a> ) |
|  | <b>Amount of fines below 0,5 mm, <math>F_{0.5}^a</math></b> , ISO 5370            | % in mass as received               | Value to be stated for pellets and for briquettes with shape 9 ( <a href="#">Figure 2</a> ) |
|  | <b>Additives<sup>b</sup></b>  | % in mass as received               | Type and amount to be stated  |
|  | <b>Bulk density, <math>BD</math></b> , ISO 17828                                  | kg/m <sup>3</sup> as received       | Value to be stated for pellets and briquettes with shape 9 ( <a href="#">Figure 2</a> )     |
|  | <b>Net calorific value, <math>Q^a</math></b> , ISO 18125                          | MJ/kg as received                   | Value to be stated  |
| <b>Nitrogen, <math>N_{MJ}</math></b> , ISO 16948 | g/MJ dry  | Value to be stated                  |   |
| <b>Sulfur, <math>S_{MJ}</math></b> , ISO 16994   | g/MJ dry  | Value to be stated                  |   |