INTERNATIONAL STANDARD

ISO 17225-1

Second edition
2021-06

Solid biofuels — Fuel specifications and classes —

Part 1: General requirements

Biocombustibles solides — Classes et spécifications des combustibles —

Partie 1: Exigences générales

Reference number
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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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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).

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).

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.

This document was prepared by Technical Committee ISO/TC 238, Solid biofuels.

This second edition cancels and replaces the first edition ISO 17225-1:2014, which has been technically revised. The main changes compared to the previous edition are as follows:

— particle size distribution for wood chips and hog fuel updated

— Table 15 for undensified thermally treated biomass deleted

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.

Introduction

The objective of the ISO 17225 series is to provide unambiguous and clear classification principles for solid biofuels and to serve as a tool to enable efficient trading of biofuels and to enable good understanding between seller and buyer as well as a tool for communication with equipment manufacturers. It will also facilitate authority permission procedures and reporting.

The ISO 17225 series is made for all stakeholders.

Solid biomass covers organic, non-fossil material of biological origin which may be used as fuel for heat and electrical generation.

Figure 1 describes the bioenergy utilization chain from sources of biomass, to biofuel production to final use of bioenergy. Although biomass can be used for energy generation it has many other primary uses (non-fuels) as a raw material for construction, furniture, packaging, paper products, etc.

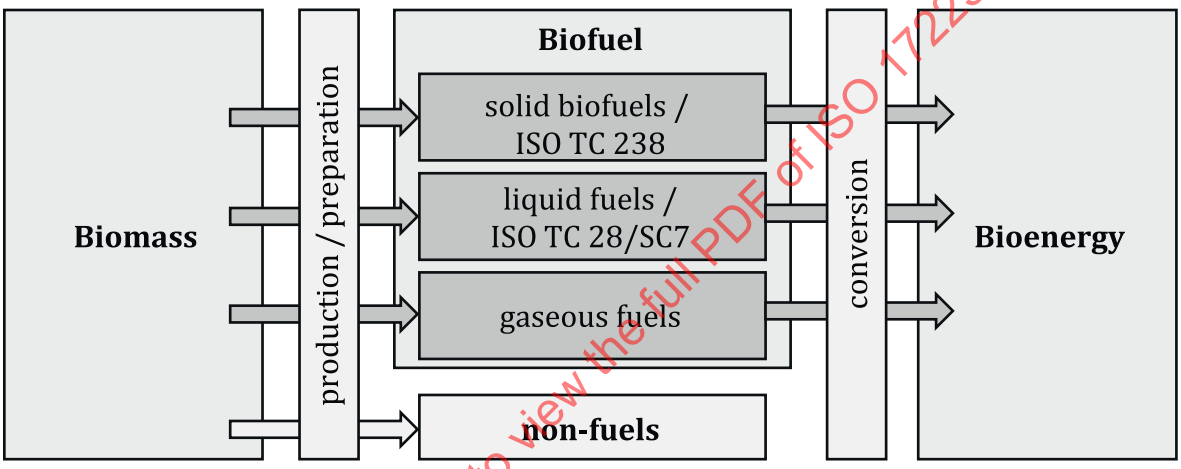


Figure 1 — ISO TC 238 within the biomass — Biofuel — Bioenergy field

The classifications given in this document are provided with the objective of using biomass as a solid biofuel and therefore do not deal with all other uses.

Although the product standards starting from Part 2 of the ISO 17225 series may be obtained separately, they require a general understanding of the standards based on and supporting ISO 17225-1. It is recommended to obtain and use ISO 17225-1 in conjunction with these standards.

In the product standards, graded means that solid biofuel is used either in commercial applications, such as in households and small commercial and public sector buildings or industrial applications, which demand the use of fuels with specified quality (properties) expressed by quality classes like A1, A2 or B.

Solid biofuels — Fuel specifications and classes —

Part 1: General requirements

1 Scope

This document determines the fuel quality classes and specifications for solid biofuels of raw and processed materials originating from

a) forestry and arboriculture;

b) agriculture and horticulture;

c) aquaculture.

Chemically treated material may not include halogenated organic compounds or heavy metals at levels higher than those in typical virgin material values (see Annex B) or higher than typical values of the country of origin.

NOTE Raw and processed material includes woody, herbaceous, fruit, aquatic biomass and biodegradable waste originating from above sectors.

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 14780, *Solid biofuels — Sample preparation*

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

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

ISO 16967, *Solid biofuels — Determination of major elements — Al, Ca, Fe, Mg, P, K, Si, Na and Ti*

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

ISO 16993, *Solid biofuels — Conversion of analytical results from one basis to another*

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

ISO 17827-1, *Solid biofuels — Determination of particle size distribution for uncompressed fuels — Part 1: Oscillating screen method using sieves with apertures of 3,15 mm and above*

ISO 17827-2, *Solid biofuels — Determination of particle size distribution for uncompressed fuels — Part 2: Vibrating screen method using sieves with aperture of 3,15 mm and below*

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

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

ISO 17830, *Solid biofuels — Particle size distribution of disintegrated 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 18123, *Solid biofuels — Determination of the content of volatile matter*

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

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, *Solid Biofuels — Sampling*

ISO 18847, *Solid biofuels — Determination of particle density of pellets and briquettes*

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

ISO 21404, *Solid biofuels — Determination of ash melting behaviour*

ISO 18846, *Solid biofuels — Determination of fines content in quantities of pellets*

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
chemical treatment
any treatment with chemicals other than air, water or heat

Note 1 to entry: Examples of chemical treatments are listed in informative Annex C.

3.2
commercial application
facility that utilize 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.

4 Symbols and abbreviated terms

The symbols and abbreviated terms used in this document conform with the SI system of units as far as possible,

A	Designation for ash content on dry basis A_d [% in mass]
ar	as received
BD	Designation for bulk density as received [kg/m^3 (loose volume)]
C	Designation for fixed carbon on dry basis C_f [% in mass]
CPF	Designation for amount of coarse pellet fines as reived [% in mass, particles ≥ 3,15 mm and < 5,6 mm]
D	Designation for diameter as received, *D* [mm]
DE	Designation for particle density as received [g/cm^3]
DT	Designation for deformation temperature of the fuel ash [°C]
DU	Designation for mechanical durability as received [% in mass]
d	dry (dry basis)
daf	dry, ash-free
E	Designation for energy density as received, E_{ar} [MJ/m^3 or kWh/m^3 loose or stacked volume] (amount of energy/volume unit)
EM_d	Designation for amount of heavy extraneous material on dry basis [% in mass]
F	Designation for amount of fines (< 3,15 mm) as determined [% in mass]
Fs	Designation for amount of small fines (< 1 mm) as determined (% in mass)
FT	Designation for flow temperature of the fuel ash [°C]
HT	Designation for hemisphere temperature of the fuel ash [°C]
L	Designation for length as received, *L* [mm]
M	Designation for moisture content as received, M_{ar} [% in mass]
P	Designation for particle size distribution on analysis moisture basis
Q	Designation for net calorific value at constant pressure as received, $Q_{p,net,ar}$ [MJ/kg or kWh/kg]
$Q_{V,gr,d}$	Gross calorific value at constant volume on dry basis [MJ/kg or kWh/kg]
$Q_{p,net,d}$	Net calorific value at constant pressure on dry basis [MJ/kg or kWh/kg]
SST	Designation for shrinkage starting temperature of the fuel ash [°C]
s	Designation for small-scale and commercial use in particle size distribution
U	Designation for moisture content as received on dry basis U_{ar} [% in mass]
VM	Designation for volatile matter on dry basis [% in mass]

NOTE 1 Fixed carbon (%) is calculated by the following: 100 – (moisture [% in mass] + ash [% in mass] + volatile matter [% in mass]). All percentages are on the same moisture basis.

NOTE 2 1 MJ/kg equals 1 GJ/t or 0,277 8 kWh/kg (1 kWh/kg equals 1 MWh/t and 1 MWh/t is 3,6 MJ/kg). 1 g/cm^3 equals 1 kg/dm^3. 1 mg/kg equals 0,000 1 %

NOTE 3 Designation symbols are used in combination with a number to specify property levels in Tables 3 to 15. For designation of chemical properties, chemical symbols such as S (sulfur), Cl (chlorine), and N (nitrogen) are used and the property class is added at the end of the symbol.

5 Principle

Solid biofuels are specified by:

a) origin and source, Clause 6;

b) major traded forms and properties, Clause 7.

For specification of origin and source, see Table 1. For major traded forms, see Table 2.

For specification of properties see Tables 3 to 15. The major traded forms of solid biofuels are covered by Tables 3 to 14. Table 15 is a general master table to be used for a specification of solid biofuels not covered by Tables 3 to 14.

Tables 3 to 15 list the normative properties, which shall be specified and informative properties, which are voluntary. Normative properties vary depending on both origin and traded form.

EXAMPLE OF SPECIFICATION

Origin: Logging residues (1.1.4)

Traded form: Wood chips

Properties: Dimensions P45, Fines F05, Moisture M40, Ash A1.5

In the case of wood chips and hog fuel (Table 5) the properties of dimensions, fines, moisture and ash are normative in the specification. Other properties are informative.

Product standards for graded solid biofuels are given in other parts of this ISO series.

6 Classification of origin and sources of solid biofuels

6.1 General

The classification is based on the biofuel origin and source. In the hierarchical classification system (Table 1) the main origin-based solid biofuel groups are:

a) woody biomass;

b) herbaceous biomass;

c) fruit biomass;

d) aquatic biomass;

e) blends and mixtures.

Woody biomass is biomass from trees, bushes and shrubs.

Herbaceous biomass is from plants that have a non-woody stem and which die back at the end of the growing season. It includes grains and their by-products.

Fruit biomass is biomass from those parts of a plant which are from or hold seeds.

Aquatic biomass is from so called hydrophytic plants or hydrophytes, which are plants that have adapted to living in or on aquatic environments.

If appropriate, also the actual species (e.g. spruce, wheat) of biomass should be stated.

The term “Blends and mixtures” in Table 1 refers to material of various origin within the given box in the classification table and appears on all four classification levels. Blends are intentionally mixed biofuels, whereas mixtures are unintentionally mixed biofuels. The origin of the blend and mixture shall be described using Table 1.

If a solid biofuel blend or mixture contains chemically treated material it shall be stated.

The second level of classification in Table 1 describes fuels from different sources within the main groups, primarily stating whether the biomass is a virgin material, a by-product or a residue from the industry.

Groups in Table 1 are further divided into third and fourth level sub-groups. The purpose of Table 1 is to allow the possibility to differentiate and specify biofuel material based on origin with as much detail as needed. With the help of typical values from informative Annex B information on physical and chemical properties can be deduced.

Examples for classification according to Table 1:

a) Whole trees without roots from birch (1.1.1.1);

b) Blend (1.1.1.5) of broad-leaf and coniferous whole trees without roots (1.1.1.1, 1.1.1.2);

c) Oil palm stem (1.1.3.3);

d) Logging residues (1.1.4);

e) Oil palm branches (1.1.4.1);

f) Logging residues from spruce stands (1.1.4.2);

g) Sawdust from broad-leaf (1.2.1.1);

h) Plywood from coniferous (1.2.2.1);

i) Plywood residues (1.2.2.1);

j) Grinding dust from furniture industry (1.2.2.1);

k) Lignin (1.2.2.4);

l) Unpainted and untreated construction wood (1.3.1.1);

m) Pallets (1.3.1.1 or 1.3.2.1);

n) Demolition wood (1.3.2.1)

o) Straw from wheat, barley, oat, rye (2.1.1.2);

p) Rice husk (2.1.1.4);

q) Reed canary grass (2.1.2.1);

r) Bamboo (2.1.2.5);

s) Grains or seeds crops from food processing industry (2.2.1.1);

t) Palm kernel or palm shell (3.1.2.3);

u) Oil palm fruit bunch (3.2.1.2);

v) Olive residues from olive pressing (3.2.2.4);

w) Kelp (4.3.2.4, Latin name to be stated);

x) Blend (5.1); 80 % in mass sawdust from coniferous (1.2.1.2) and 20 % in mass reed canary grass (2.1.2.1);

y) Mixture (1.1.1.5); whole trees without roots from birch (1.1.1.1), whole trees without roots from spruce (1.1.1.2);

z) Blend (1.2.3); 99 % in mass sawdust (1.2.1), 1 % in mass glued wood (glue content of whole mass 0,1 % in mass) (1.2.2).

Table 1 — Classification of origin and sources of solid biofuels

1. Woody biomass	1.1 Forest, plantation and other virgin wood	1.1.1 Whole trees without roots	1.1.1.1 Broad-leaf 1.1.1.2 Coniferous 1.1.1.3 Short rotation coppice 1.1.1.4 Bushes 1.1.1.5 Blends and mixtures
		1.1.2 Whole trees with roots	1.1.2.1 Broad-leaf 1.1.2.2 Coniferous 1.1.2.3 Short rotation coppice 1.1.2.4 Bushes 1.1.2.5 Blends and mixtures
		1.1.3 Stemwood	1.1.3.1 Broad-leaf with bark 1.1.3.2 Coniferous with bark 1.1.3.3 Broad-leaf without bark 1.1.3.4 Coniferous without bark 1.1.3.5 Blends and mixtures
		1.1.4 Logging residues	1.1.4.1 Fresh/Green, Broad-leaf (including leaves) 1.1.4.2 Fresh/Green, Coniferous (including needles) 1.1.4.3 Stored, Broad-leaf 1.1.4.4 Stored, Coniferous 1.1.4.5 Blends and mixtures
		1.1.5 Stumps/roots	1.1.5.1 Broad-leaf 1.1.5.2 Coniferous 1.1.5.3 Short rotation coppice 1.1.5.4 Bushes 1.1.5.5 Blends and mixtures
		1.1.6 Bark (from forestry operations)	
		1.1.7 Segregated wood from gardens, parks, roadside maintenance, vineyards, fruit orchards and driftwood from freshwater	
		1.1.8 Blends and mixtures	

Table 1 *(continued)*

	1.2 By-products and residues from wood processing industry	1.2.1 Chemically untreated wood by-products and residues	1.2.1.1 Broad-leaf with bark 1.2.1.2 Coniferous with bark 1.2.1.3 Broad-leaf without bark 1.2.1.4 Coniferous without bark 1.2.1.5 Bark (from industry operations)
		1.2.2 Chemically treated wood by-products, residues, fibres and wood constituents	1.2.2.1 Without bark 1.2.2.2 With bark 1.2.2.3 Bark (from industry operations) 1.2.2.4 Fibres and wood constituents
		1.2.3 Blends and mixtures	
	1.3 Used wood	1.3.1 Chemically untreated used wood	1.3.1.1 Without bark 1.3.1.2 With bark 1.3.1.3 Bark
		1.3.2 Chemically treated used wood	1.3.2.1 Without bark 1.3.2.2 With bark 1.3.2.3 Bark
		1.3.3 Blends and mixtures	
	1.4 Blends and mixtures		
2. Herbaceous biomass	2.1 Herbaceous biomass from agriculture and horticulture	2.1.1 Cereal crops	2.1.1.1 Whole plant 2.1.1.2 Straw parts 2.1.1.3 Grains or seeds 2.1.1.4 Husks or shells 2.1.1.5 Blends and mixtures
		2.1.2 Grasses	2.1.2.1 Whole plant 2.1.2.2 Straw parts 2.1.2.3 Seeds 2.1.2.4 Shells 2.1.2.5 Bamboo 2.1.2.6 Blends and mixtures
		2.1.3 Oil seed crops	2.1.3.1 Whole plant 2.1.3.2 Stalks and leaves 2.1.3.3 Seeds 2.1.3.4 Husks or shells 2.1.3.5 Blends and mixtures

Table 1 *(continued)*

		2.1.4 Root crops	2.1.4.1 Whole plant 2.1.4.2 Stalks and leaves 2.1.4.3 Root 2.1.4.4 Blends and mixtures
		2.1.5 Legume crops	2.1.5.1 Whole plant 2.1.5.2 Stalks and leaves 2.1.5.3 Fruit 2.1.5.4 Pods 2.1.5.5 Blends and mixtures
		2.1.6 Flowers	2.1.6.1 Whole plant 2.1.6.2 Stalks and leaves 2.1.6.3 Seeds 2.1.6.4 Blends and mixtures
		2.1.7 Segregated herbaceous biomass from gardens, parks, roadside maintenance, vineyards and fruit orchards	
		2.1.8 Blends and mixtures	
	2.2 By-products and residues from food and herbaceous processing industry	2.2.1 Chemically untreated herbaceous residues	2.2.1.1 Cereal crops and grasses 2.2.1.2 Oil seed crops 2.2.1.3 Root crops 2.2.1.4 Legume crops 2.2.1.5 Flowers 2.2.1.6 Blends and mixtures
		2.2.2 Chemically treated herbaceous residues	2.2.2.1 Cereal crops and grasses 2.2.2.2 Oil seed crops 2.2.2.3 Root crops 2.2.2.4 Legume crops 2.2.2.5 Flowers 2.2.2.6 Blends and mixtures
		2.2.3 Blends and mixtures	
	2.3 Blends and mixtures		

Table 1 *(continued)*

3. Fruit biomass	3.1 Orchard and horticulture fruit	3.1.1 Berries	3.1.1.1 Whole berries
			3.1.1.2 Flesh
			3.1.1.3 Seeds
			3.1.1.4 Blends and mixtures
		3.1.2 Stone/kernel fruits	3.1.2.1 Whole fruit
			3.1.2.2 Flesh
			3.1.2.3 Stone/kernel/fruit fibre
			3.1.2.4 Blends and mixtures
		3.1.3 Nuts and acorns	3.1.3.1 Whole nuts
			3.1.3.2 Shells/husks
			3.1.3.3 Kernels
			3.1.3.4 Blends and mixtures
		3.1.4 Blends and mixtures	
	3.2 By-products and residues from food and fruit processing industry	3.2.1 Chemically untreated fruit residues	3.2.1.1 Berries
			3.2.1.2 Stone/kernel fruits/fruit fibre
			3.2.1.3 Nuts and acorns
			3.2.1.4 Crude olive cake
			3.2.1.5 Blends and mixtures
		3.2.2 Chemically treated fruit residues	3.2.2.1 Berries
			3.2.2.2 Stone/kernel fruits
			3.2.2.3 Nuts and acorns
			3.2.2.4 Exhausted olive cake
			3.2.2.5 Blends and mixtures
		3.2.3 Blends and mixtures	
	3.3 Blends and mixtures		
4. Aquatic biomass	4.1 Algae	4.1.1 Micro algae (Latin name to be stated)	
		4.1.2 Macro algae (Latin name to be stated)	
			4.1.2.1 Green sea weed (Latin name to be stated)
			4.1.2.2 Brown sea weed (Latin name to be sated)
			4.1.2.3 Red sea weed (Latin name to be stated)
		4.1.3 Blends and mixtures	
	4.2 Water hyacinths		
	4.3 Lake and sea grass	4.3.1 Lake grass (Latin name to be stated)	
		4.3.2 Sea grass (Latin name to be stated)	
		4.3.3 Blends and mixtures	
	4.4 Reeds	4.4.1 Common reed	
		4.4.2 Other reed	
		4.4.3 Blends and mixtures	
	4.5 Blends and mixtures		
5 Blends and mixtures	5.1 Blends		
	5.2 Mixtures		

NOTE 1 If appropriate, also the actual species (e.g. spruce, wheat) of biomass can be stated according to EN 13556, *Round and sawn timber — Nomenclature of timbers used in Europe* [1].

NOTE 2 Driftwood from saltwater is not recommended as a fuel.

NOTE 3 Group 5 “Blends and mixtures” include blends and mixtures from the main origin-based solid biofuel groups 1 to 4.

6.2 Woody biomass

6.2.1 Forest, plantation and other virgin wood

Forest, plantation and other virgin wood in this group may only have been subjected to size reduction, debarking, drying or wetting. Forest, plantation and other virgin wood includes wood from forests, parks, gardens, plantations, roadside maintenance and from short rotation forests and coppice.

6.2.2 By-products and residues from wood processing industry

Wood by-products and wood residues from industrial production are classified in this group. These biofuels can be chemically untreated (for example residues from debarking, sawing or size reduction, shaping, pressing) or chemically treated wood residues from wood processing and the production of panels and furniture (glued, painted, coated, lacquered or otherwise treated wood), as long as they do not contain heavy metals or halogenated organic compounds as a result of treatment with wood preservatives or coating.

6.2.3 Used wood

This group includes post-consumer/post society wood waste; natural or merely mechanically processed wood, contaminated only to an insignificant extent during use by substances that are not normally found in wood in its natural state (for example pallets, transport cases, boxes, wood packages, cable reels, construction wood). With respect to treatment the same criteria apply as with respect to “wood processing industry by-products and residues”, i.e. the used wood shall not contain heavy metals more than in virgin wood, or halogenated organic compounds as a result of treatment with wood preservatives or coating.

6.2.4 Blends and mixtures

This refers to blends and mixtures of woody biomass in the groups 1.1 to 1.3 in Table 1. The mixing can be either intentional (blends) or unintentional (mixtures).

6.3 Herbaceous biomass

6.3.1 Herbaceous biomass from agriculture and horticulture

Material, which comes directly from the field, perhaps after a storage period, and may only have been subject to size reduction and drying. It covers herbaceous material from agricultural and horticultural fields and from gardens and parks.

6.3.2 By-products and residues from food and herbaceous processing industry

This refers to any herbaceous biomass material that is left over after industrial handling and treatment.

Examples are residues from the production of sugar from sugar beets, barley malt residues from beer production and raw vegetable residues from food processing industry.

6.3.3 Blends and mixtures

This refers to blends and mixtures of herbaceous biomass in the groups 2.1 to 2.2 in Table 1. The mixing can be either intentional (blends) or unintentional (mixtures).

6.4 Fruit biomass

6.4.1 Orchard and horticulture fruit

Fruit from trees, bushes and fruit from herbs (e.g. tomatoes and grapes) are classified in this group.

6.4.2 By-products and residues from food and fruit processing industry

This refers to a fruit biomass material that is left over after industrial handling and treatment.

Examples are pressing residues from olive oil or apple juice production and processed (e.g. heated, steamed, cooked, etc.) vegetable residues from food processing industry.

6.4.3 Blends and mixtures

This refers to blends and mixtures of fruit biomass in the groups 3.1 to 3.2 in Table 1. The mixing can be either intentional (blends) or unintentional (mixtures).

6.5 Aquatic biomass

Aquatic biomasses are divided into the following main species: algae, water hyacinths, lake and sea weed.

6.6 Biomass blends and mixtures

These include blends and mixtures of different biomasses mentioned above under 6.2 to 6.5. The mixing can be either intentional (blends) or unintentional (mixtures).

7 Specification of solid biofuels based on traded forms and properties

7.1 Traded forms of solid biofuels

Solid biofuels are traded in many different sizes and shapes. The size and shape influence the handling of the fuel as well as its combustion properties. Biofuels may be delivered e.g. in the forms shown in Table 2. Other traded forms also may be used.

Table 2 — Major traded forms and raw materials of solid biofuels

Fuel name	Typical particle size	Common preparation method
Whole tree (Table 15)	> 500 mm	No preparation or delimbed
Wood chips (Table 5)	5 mm to 100 mm	Cutting with sharp tools
Hog fuel (Table 5)	Varying	Crushing with blunt tools
Stemwood/roundwood (Table 6)	> 100 cm	Cutting with sharp tools
Logwood (Table 6)	25 cm to 100 cm	Cutting with sharp tools
Firewood (Table 6)	20 cm to 50 cm	Cutting with sharp tools
Slabs and offcuts (Table 6 or 15)	Varying	Cutting with sharp tools
Bark (Table 9)	Varying	Debarking residue from trees (shredded or un-shredded)
Bundle (Table 15)	Varying	Lengthwise oriented and bound
Fuel powder (Table 15)	< 1 mm	Milling
Sawdust (Table 7)	1 mm to 5 mm	Cutting with sharp tools
Shavings (Table 8)	1 mm to 30mm	Planing with sharp tools

Table 2 *(continued)*

Fuel name	Typical particle size	Common preparation method
Briquettes (Table 3)	Ø > 25 mm	Mechanical compression
Pellets (Table 4)	Ø ≤ 25 mm	Mechanical compression
Bales (Table 10) Small square bales Big square bales Round bales	0,1 m^3 3,7 m^3 2,1 m^3	Compressed and bound to squares Compressed and bound to squares Compressed and bound to cylinders
Chopped straw or energy grass (Table 15)	10 mm to 200 mm	Chopped during harvesting or before combustion
Grain (Table 11, Table 13) or seed (Table 12, Table 13)	Varying	No preparation or drying except for process operations necessary for storage for cereal grain
Fruit stones or kernel (Table 12)	5 mm to 20 mm	No preparation or pressing and extraction by chemicals.
Fibre cake (Table 15)	Varying	Prepared from fibrous waste by dewatering
Charcoal (Table 14)	Varying	Charcoal is prepared by the destructive distillation and pyrolysis of biomass.
Thermally treated biomass (Table Table 3, Table 4 and Table 15)	Varying	Mild treatment of biomass at a temperature between 200 and 300 °C for a short time period (e.g. 60 min).

NOTE The definitions from the different traded forms are in accordance with ISO 16559.

Figures in Annex A describe the particle size differences between different wood fuels and also the difference between wood chips and hog fuel and examples of particle size distribution for wood chips and hog fuel.

7.2 Specification of properties of solid biofuels

The documents listed in Clause 2 shall be used for the sampling (ISO 18135 or ISO 21945), sample preparation (ISO 14780) and analysis of determination of the properties of solid biofuels.

The additional parts of ISO 17225 (e.g. ISO 17225-2, ISO 17225-3, etc.) have been developed to describe graded solid biofuel products. These International Product Standards are recommended for smaller scale appliances, such as used in households and small commercial and public sector applications. Pellets, briquettes, wood chips and firewood (log wood) are traded forms commonly used for small-scale applications. ISO 17225-2 also include specifications for graded industrial pellets, ISO/TS 17225-8 includes thermally treated densified biofuels and ISO/TS 17225-9 include specifications of graded hog fuel and wood chips for industrial use.

For a specification of a solid biofuel, the denominations given in Tables 3 to 15 are normative and informative properties. In Tables 3 to 14 solid biofuels are defined by property classes. When specifying a class within a property, the average numerical value from the whole lot or defined portion from the lot (e.g. shipload, truckload or bag) shall determine which class shall be used. For an example in Table 5, the ash class A3.0 (≤ 3 % in mass) means that the ash content shall not be higher than 3,0 % in mass to belong to this class. For all properties the lowest possible class shall be stated, except for bulk density, particle density and mechanical durability where the highest possible class shall be stated. Only one class shall be specified.

EXAMPLE A fuel with a moisture content of 17 % in mass should be categorized as M20 and not M10 or M30.

A general master table (Table 15) shall be used for solid biofuels not covered by Tables 3 to 14.

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 below:

a) using previous measured values or obtained by experience of same raw material (see Annex B);

b) calculation of properties, e.g. by using typical values and considering documented specific values;

c) carrying out of analysis:

   c1) with simplified methods if available;

   c2) 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.

Conversion of a value on a dry basis (d) to a dry, ash free basis (daf) or to as received basis (ar) is given in ISO 16993.

Typical values for some physical and chemical properties of solid biofuels are listed in Annex B. These can be used as an indication of the properties when needed, however, they may not be used for the limitation of the fuel parameters.

For Tables 3 to 15: only chemically treated biomass that are included in the scope, should be considered, i.e. wood waste which can contain halogenated organic compounds or heavy metals more than virgin wood as a result of treatment with wood preservatives or coating, are not included. Examples of chemical treatment are mentioned in Annex C.

NOTE 1 It is important to carry out laboratory analysis, if raw material basis is changed.

NOTE 2 For Tables 3 to 15 is stated that the net calorific value should be specified on as received basis. The net calorific value will vary depending on the actual moisture content in the fuel. The value given in a specification is thus valid only for the actual connected moisture content. The net calorific value as received ($q_{p,\mathrm{net,ar}}$, designation Q) can be calculated using both the net calorific value on a dry basis ($q_{p,\mathrm{net,d}}$) and the moisture content (see Annex D).

Table 3 — Specification of properties for briquettes

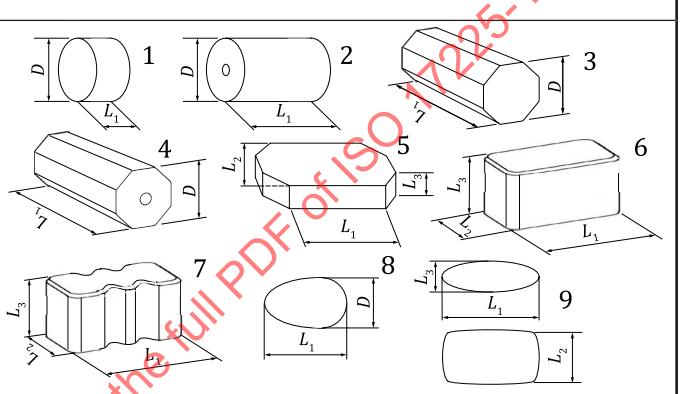
Master table		
Normative	**Origin**: According to 6.1 and Table 1	Woody biomass (1); Herbaceous biomass (2); Fruit biomass (3); Aquatic biomass (4); Blends and mixtures (5).
	Traded Form (see Table 2)	Briquette
	Dimensions (mm)	
	Diameter (D), **Length** (L)	
	Diameter, length, width and height to be stated Specify shape according to Figure 2 e.g. 1 or 2, etc.	 L_1 Length, L_2 width and L_3 height D Diameter **Figure 2 — Examples of briquettes**

Table 3 *(continued)*

Master table		
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2	
	M10	≤ 10 %
	M12	≤ 12 %
	M15	≤ 15 %
	Ash, A (% in mass of dry basis) ISO 18122	
	A0.5	≤ 0,5 %
	A0.7	≤ 0,7 %
	A1.0	≤ 1,0 %
	A1.5	≤ 1,5 %
	A2.0	≤ 2,0 %
	A3.0	≤ 3,0 %
	A5.0	≤ 5,0 %
	A7.0	≤ 7,0 %
	A10.0	≤ 10,0 %
	A10.0+	> 10,0 % (maximum value to be stated)
	Particle density, DE (g/cm^3 as received) ISO 18847	
	DE0.6	≥ 0,6 g/cm^3
	DE0.8	≥ 0,8 g/cm^3
	DE0.9	≥ 0,9 g/cm^3
	DE1.0	≥ 1,0 g/cm^3
	DE1.1	≥ 1,1 g/cm^3
	DE1.2+	> 1,2 g/cm^3 (maximum value to be stated)
	Additives [a] (% in mass of pressing mass)	Type and content of pressing aids, slagging inhibitors or any other additives to be stated
	Net calorific value, Q (MJ/kg or kWh/kg as received) ISO 18125	Minimum value to be stated [b]

Table 3 *(continued)*

Master table			
Normative/ Informative	**Mechanical durability, DU** (% in mass of briquettes after testing) ISO 17831-2		
	DU95.0	≥ 95,0 %	Informative:
	DU90.0	≥ 90,0 %	only if traded in bulk
	DU90.0-	< 90,0 % (minimum value to be stated)	
	Nitrogen, N (% in mass of dry basis) ISO 16948		
	N0.2	≤ 0,2 %	Normative:
	N0.3	≤ 0,3 %	Chemically treated biomass (1.2.2; 1.3.2; 2.2.2; 3.2.2)
	N0.5	≤ 0,5 %	Informative:
	N0.7	≤ 0,7 %	All fuels that are not chemically treated (see the exceptions above)
	N1.0	≤ 1,0 %	
	N1.5	≤ 1,5 %	
	N2.0	≤ 2,0 %	
	N3.0	≤ 3,0 %	
	N3.0+	> 3,0 % (maximum value to be stated)	
	Sulfur, S (% in mass of dry basis) ISO 16994		
	S0.02	≤ 0,02 %	Normative:
	S0.03	≤ 0,03 %	Chemically treated biomass (1.2.2; 1.3.2; 2.2.2; 3.2.2) or if sulfur containing additives have been used.
	S0.04	≤ 0,04 %	
	S0.05	≤ 0,05 %	Informative:
	S0.08	≤ 0,08 %	All fuels that are not chemically treated (see the exceptions above)
	S0.10	≤ 0,10 %	
	S0.20	≤ 0,20 %	
	S0.30	≤ 0,30 %	
	S0.30+	> 0,30 % (maximum value to be stated)	
	Chlorine, Cl (% in mass of dry basis) ISO 16994		
	Cl0.01	≤ 0,01 %	Normative:
	Cl0.02	≤ 0,02 %	Chemically treated biomass (1.2.2; 1.3.2; 2.2.2; 3.2.2)
	Cl0.03	≤ 0,03 %	Informative:
	Cl0.05	≤ 0,05 %	All fuels that are not chemically treated (see the exceptions above)
	Cl0.07	≤ 0,07 %	
	Cl0.10	≤ 0,10 %	
	Cl0.20	≤ 0,20 %	
	Cl0.30	≤ 0,30 %	
	Cl0.30+	> 0,30 % (maximum value to be stated)	

Table 3 *(continued)*

Master table		
	Fixed carbon, C [c] (% in mass of dry basis)	
	Minimum value to be stated	Normative only for thermally treated biomass briquettes
	Volatile matter, VM (% in mass of dry basis) ISO 18123	
	Maximum value to be stated	Normative only for thermally treated biomass briquettes
Informative	**Ash melting behaviour** [d] (°C) ISO 21404[3]	DT, HT and FT should be stated

[a] The maximum amount of additive is 20 % in mass of pressing mass. Type stated as chemical substance (e.g. starch, corn flour, potato flour, vegetable oil, lignin). If amount is greater, then raw material for briquette is blend.

[b] Minimum value for torrefied or other thermally treated biomass briquettes is usually ≥ 18 MJ/kg.

[c] Fixed carbon (%) is calculated by the following: 100 – (moisture [% in mass] + ash [% in mass] + volatile matter [% in mass]). All percentages are on the same moisture basis.

[d] Special attention should be paid to the ash melting behaviour for some biomass fuels, for example eucalyptus, poplar, short rotation coppice, straw, miscanthus and olive stone. It is recommended to state all characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. Shrinkage starting temperature (SST) is difficult to measure in herbaceous biomass. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used, it shall be specified.

NOTE 5 Thermally treated biomass briquettes (e.g. torrefied briquettes) are also included in Table 3.

Table 4 — Specification of properties for pellets

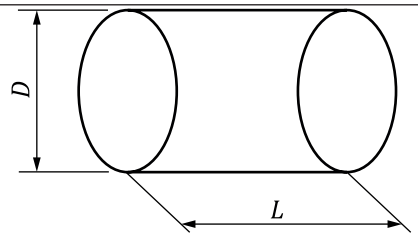
Master table			
Normative	**Origin:** According to 6.1 and Table 1		Woody biomass (1); Herbaceous biomass (2); Fruit biomass (3); Aquatic biomass (4); Blends and mixtures (5).
	Traded Form (see Table 2)		Pellets
	Dimensions (mm) ISO 17829		
	Diameter (*D*) and **Length** (*L*) [a]		
	D06	6 mm ± 1,0 mm and 3,15 mm ≤ L ≤ 40 mm	
	D08	8 mm ± 1,0 mm and 3,15 mm ≤ L ≤ 40 mm	
	D10	10 mm ± 1,0 mm and 3,15 mm ≤ L ≤ 40 mm	
	D12	12 mm ± 1,0 mm and 3,15 mm ≤ L ≤ 50 mm	
	D25	25 mm ± 1,0 mm, and 10 mm ≤ L ≤ 50 mm	
			L length and *D* diameter **Figure 3 — Dimensions (mm)**
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2		
	M05	≤ 5 %	
	M08	≤ 8 %	
	M10	≤ 10 %	
	M12	≤ 12 %	
	M15	≤ 15 %	

Table 4 *(continued)*

	Ash, A (% in mass of dry basis) ISO 18122	
	A0.5	≤ 0,5 %
	A0.7	≤ 0,7 %
	A1.0	≤ 1,0 %
	A1.2	≤ 1,2 %
	A1.5	≤ 1,5 %
	A2.0	≤ 2,0 %
	A3.0	≤ 3,0 %
	A4.0	≤ 4,0 %
	A5.0	≤ 5,0 %
	A6.0	≤ 6,0 %
	A7.0	≤ 7,0 %
	A8.0	≤ 8,0 %
	A10.0	≤ 10,0 %
	A10.0+	> 10,0 % (maximum value to be stated)
	Mechanical durability, DU (% in mass of pellets after testing) ISO 17831-1	
	DU 98.0	≥ 98,0%
	DU97.5	≥ 97,5 %
	DU96.5	≥ 96,5 %
	DU96.0	≥ 96,0 %
	DU95.0	≥ 95,0 %
	DU95.0-	< 95,0 % (minimum value to be stated)
	Amount of fines, F (% in mass, < 3,15 mm) after production when loaded or packed, ISO 18846	
	F1.0	≤ 1,0 %
	F2.0	≤ 2,0 %
	F3.0	≤ 3,0 %
	F4.0	≤ 4,0 %
	F5.0	≤ 5,0 %
	F6.0	≤ 6,0 %
	F6.0+	> 6,0 % (maximum value to be stated)
	Additives (% in mass of pressing mass) [b]	Type and content of pressing aids, slagging inhibitors or any other additives shall be stated
	Bulk density, BD (kg/ m^3 as received) ISO 17828	
	BD500	≥ 500 kg/m^3
	BD550	≥ 550 kg/m^3
	BD580	≥ 580 kg/m^3
	BD600	≥ 600 kg/m^3
	BD625	≥ 625 kg/m^3
	BD650	≥ 650 kg/m^3
	BD700	≥ 700 kg/m^3
	BD750	≥ 750 kg/m^3
	BD800+	> 800 kg/m^3 (minimum value to be stated)
	Net calorific value, Q (MJ/kg or kWh/kg as received) ISO 18125	Minimum value to be stated [c]

Table 4 *(continued)*

Normative/ Informative	**Nitrogen, N** (% in mass of dry basis) ISO 16948		
	N0.2	≤ 0,2 %	Normative:
	N0.3	≤ 0,3 %	Chemically treated biomass (1.2.2; 1.3.2; 2.2.2; 3.2.2)
	N0.5	≤ 0,5 %	Informative:
	N0.6	≤ 0,6 %	All fuels that are not chemically treated (see the exceptions above)
	N0.7	≤ 0,7 %	
	N1.0	≤ 1,0 %	
	N1.5	≤ 1,5 %	
	N2.0	≤ 2,0 %	
	N3.0	≤ 3,0 %	
	N3.0+	> 3,0 % (maximum value to be stated)	
	Sulfur, S (% in mass of dry basis) ISO 16994		
	S0.02	≤ 0,02 %	Normative:
	S0.03	≤ 0,03 %	Chemically treated biomass (1.2.2; 1.3.2; 2.2.2; 3.2.2) or if sulfur containing additives have been used.
	S0.04	≤ 0,04 %	Informative:
	S0.05	≤ 0,05 %	All fuels that are not chemically treated (see the exceptions above)
	S0.08	≤ 0,08 %	
	S0.10	≤ 0,10 %	
	S0.20	≤ 0,20 %	
	S0.30	≤ 0,30 %	
	S0.30+	> 0,30 % (maximum value to be stated)	
	Chlorine, Cl (% in mass of dry basis) ISO 16994		
	Cl0.01	≤ 0,01 %	Normative:
	Cl0.02	≤ 0,02 %	Chemically treated biomass (1.2.2; 1.3.2; 2.2.2; 3.2.2)
	Cl0.03	≤ 0,03 %	Informative:
	Cl0.05	≤ 0,05 %	All fuels that are not chemically treated (see the exceptions above)
	Cl0.07	≤ 0,07 %	
	Cl0.10	≤ 0,10 %	
	Cl0.20	≤ 0,20 %	
	Cl0.30	≤ 0,30 %	
	Cl0.30+	> 0,30 % (maximum value to be stated)	
	Fixed carbon, C [d] (% in mass of dry basis)		
	Minimum value to be stated		Normative only for thermally treated biomass pellets
	Volatile matter, VM (% in mass of dry basis) ISO 18123		
	Maximum value to be stated		Normative only for thermally treated biomass pellets
	Particle size distribution of disintegrated pellets (% in mass of dry basis) ISO 17830		Values to be stated for pellets for industrial use

Table 4 *(continued)*

Informative	**Ash melting behaviour** [e] (°C) ISO 21404[3]	DT, HT and FT should be stated
	Coarse pellet fines, CPF (3,15 mm ≤ CPF < 5,6 mm, % in mass) ISO 18846	Should be stated
	Particle density, DE, ISO 18847	Should be stated

[a] Maximum length for classes *D*06, *D*08 and *D*10 shall be ≤ 50 mm. Pellets are longer than 3,15 mm, if they stay on a round hole-sieve of 3,15 mm.

[b] The maximum amount of additive is 20 % in mass of pressing mass. Type stated (e.g. starch, corn flour, potato flour, vegetable oil, lignin). If amount is greater, then raw material for pellet is blend.

[c] Minimum value for torrefied or other thermally treated biomass pellets is usual ≥ 18 MJ/kg.

[d] Fixed carbon (%) is calculated by the following: 100 – (moisture [% in mass] + ash [% in mass] + volatile matter [% in mass]). All percentages are on the same moisture basis.

[e] Special attention should be paid to the ash melting behaviour for some biomass fuels, for example eucalyptus, poplar, short rotation coppice, straw, miscanthus and olive stone. It is recommended to state all characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.

NOTE 6 Thermally treated biomass pellets (e.g. torrefied pellets) are also included in Table 4.

Table 5 — Specification of properties for wood chips and hog fuel

Master table					
Normative	**Origin**: According to 6.1 and Table 1.			Woody biomass (1)	
	Traded Form			Wood chips or hog fuel [a]	
	Dimensions for P16s – P63 (mm) ISO 17827-1 [a,b, c, e, f]				
	Particle size class	Main fraction (minimum 60 % in mass), mm	Coarse fraction, % in mass (sieve aperture size or length of particle, mm)	Fines fraction (F) (< 3,15 mm), % in mass	Maximum length (*L*) of particles [e], mm
	P16s	3,15 mm ≤ *m* < 16 mm	≤ 6 %, ≥ 31,5 mm	≤ 15 %	45 mm
	P31s	3,15 mm ≤ *m* < 31,5 mm	≤ 6 %, ≥ 45 mm	≤ 10 %	120 mm
	P45s	3,15 mm ≤ *m* < 45 mm	≤ 10 %, ≥ 63 mm	≤ 10 %	200 mm
	P16	3,15 mm ≤ *m* < 16 mm	≤ 6 %, ≥ 31,5 mm	to be stated from F-classes below	value to be stated
	P31	3,15 mm ≤ *m* < 31,5 mm	≤ 6 %, ≥ 45 mm		
	P45	3,15 mm ≤ *m* < 45 mm	≤ 10 %, ≥ 63 mm		
	P63	3,15 mm ≤ *m* < 63 mm	≤ 10 %, ≥ 100 mm		
	Dimensions for PL10 – PL30+ (mm) ISO 17827-1 [a, d, e, f]				
	Particle size class	Particle size fractions (% in mass)	Mass of long particles (100 mm ≤ m ≤ maximum length of particle), % in mass	Fines fraction (F) (< 3,15 mm), % in mass	Maximum length (*L*) of particle, mm
	PL 10	all screening results to be stated	0 % ≤ m ≤ 10 %	to be stated from F-classes below	value to be stated
	PL 20		10 % < m ≤ 20 %		
	PL 30		20 % < m ≤ 30 %		
	PL 30+		*L* > 30 % (value to be stated)		
	Fines fraction, F (< 3,15 mm % in mass) ISO 17827-1				
	F02	≤ 2 %			
	F05	≤ 5 %			
	F10	≤ 10 %			
	F15	≤ 15 %			
	F20	≤ 20 %			
	F25	≤ 25 %			
	F30	≤ 30 %			
	F30+	> 30 % (maximum value to be stated)			
	Moisture, M [f] (% in mass as received) ISO 18134-1, ISO 18134-2				
	M10	≤ 10 %			
	M15	≤ 15 %			
	M20	≤ 20 %			
	M25	≤ 25 %			
	M30	≤ 30 %			
	M35	≤ 35 %			
	M40	≤ 40 %			
	M45	≤ 45 %			
	M50	≤ 50 %			
	M55	≤ 55 %			
	M55+	> 55 % (maximum value to be stated)			

Table 5 *(continued)*

	Ash, A (% in mass of dry basis) ISO 18122		
	A0.5	≤ 0,5 %	
	A0.7	≤ 0,7 %	
	A1.0	≤ 1,0 %	
	A1.5	≤ 1,5 %	
	A2.0	≤ 2,0 %	
	A3.0	≤ 3,0 %	
	A5.0	≤ 5,0 %	
	A7.0	≤ 7,0 %	
	A10.0	≤ 10,0 %	
	A10.0+	> 10,0 % (maximum value to be stated)	
Normative/ Informative	**Nitrogen, N** (% in mass of dry basis) ISO 16948		
	N0.2	≤ 0,2 %	Normative:
	N0.3	≤ 0,3 %	Chemically treated biomass (1.2.2; 1.3.2)
	N0.5	≤ 0,5 %	Informative:
	N1.0	≤ 1,0 %	All fuels that are not chemically treated (see the exceptions above)
	N1.5	≤ 1,5 %	
	N2.0	≤ 2,0 %	
	N3.0	≤ 3,0 %	
	N3.0+	> 3,0 % (maximum value to be stated)	
	Sulfur, S (% in mass of dry basis) ISO 16994		
	S0.02	≤ 0,02 %	Normative:
	S0.03	≤ 0,03 %	Chemically treated biomass (1.2.2; 1.3.2)
	S0.04	≤ 0,04 %	Informative:
	S0.05	≤ 0,05 %	All fuels that are not chemically treated (see the exceptions above)
	S0.08	≤ 0,08 %	
	S0.10	≤ 0,10 %	
	S0.10+	> 0,10 % (maximum value to be stated)	
	Chlorine, Cl (% in mass of dry basis) ISO 16994		
	Cl0.02	≤ 0,02 %	Normative:
	Cl0.03	≤ 0,03 %	Chemically treated biomass (1.2.2, 1.3.2)
	Cl0.05	≤ 0,05 %	Informative:
	Cl0.07	≤ 0,07 %	All fuels that are not chemically treated (see the exceptions above)
	Cl0.10	≤ 0,10 %	
	Cl0.10+	> 0,10 % (maximum value to be stated)	

Table 5 *(continued)*

Informative	**Net calorific value, Q** (MJ/kg or kWh/kg as received) or **energy density, E** (MJ/ m^3 or kWh/m^3) ISO 18125		Minimum value to be stated
	Bulk density, BD (kg/m^3 as received) ISO 17828		
	BD100	≥ 100	Recommended to be stated if traded on a volume basis
	BD150	≥ 150	
	BD200	≥ 200	
	BD250	≥ 250	
	BD300	≥ 300	
	BD350	≥ 350	
	BD400	≥ 400	
	BD450+	> 450 (minimum value to be stated)	
	Heavy extraneous materials, EM_d [2] (% in mass) ISO 19743		Value should be stated
	Ash melting behaviour [g] (°C) ISO 21404[3]		DT, HT and FT should be stated

[a] For the production of hog fuel raw materials often contain stones or other heavy extraneous materials e.g. stumps/roots, wood from garden/parks or used wood. It is recommended to determine and specify the content of these stones or other heavy extraneous materials (EM_d) in % in mass according to ISO 19743[2]. Heavy extraneous material shall be sorted out before sieving. This material shall not be reported as part of the fuel fractions. The declaration of the ash content alone is not able provide sufficient information to describe the impacts of a hog fuel batch on feeding and conversion processes. Small stones, sand and soil which pass the 3,15 mm sieve contribute to the ash content but not to the content of heavy extraneous material.

[b] Use Ps-classes for wood chips and hog fuel for residential and small-scale commercial applications. The numerical values for dimensions up to P45s refer to the mass of particle sizes (at least 60 % in mass) passing through the mentioned round hole sieve sizes (ISO 17827-1) and staying on the mentioned lower sieve size. Sieves with sieve aperture sizes to be used for size classification are: 3,15 mm, 16 mm, 31,5 mm, 45 mm and 63 mm. Any sample can only belong to one size class, which always is the lowest possible class based on the main fraction. (ISO 17827-1).

[c] The numerical values (P-class) for dimensions up to P63 refer to the mass of particle sizes (at least 60 % in mass) passing through the mentioned round hole sieve size (ISO 17827-1) and staying on the mentioned lower sieve size. Sieves with sieve aperture sizes to be used for size classification are: 3,15 mm, 16 mm, 31,5 mm, 45 mm, 63 mm. Any sample can only belong to one size class, which always is the lowest possible class based on the main fraction. (ISO 17827-1).

[d] The fuel in the PL classes is typically made of logging residues, garden and park wood or used wood. These fuels can contain many long particles or lot of fines and therefore there is no clear main fraction. For PL classes all screening results shall be reported. Sieves with sieve aperture sizes to be used for size classification are: 3,15 mm, 16 mm, 31,5 mm, 45 mm, 63 mm.

[e] Maximum length only has to be determined for those particles, which are found in the coarse fraction.

[f] Lowest possible M-class to be stated. Values below 10 % in mass to be stated. In specifications, e.g. for energy conversion systems or in contracts, the minimum and maximum M-class should be stated.

[g] Special attention should be paid to the ash melting behaviour for some biomass fuels, for example eucalyptus, poplar, short rotation coppice. It is recommended to state all characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT, hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.

Table 6 — Specification of properties for log wood, firewood

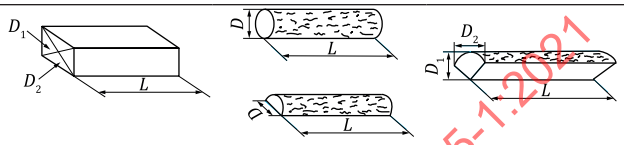
<table>
<tr><td colspan="7">Master table</td></tr>
<tr><td rowspan="20">Normative</td><td colspan="2">Origin: According to 6.1 and Table 1.</td><td colspan="4">Woody biomass (1.1 or 1.2.1)
Wood species to be stated</td></tr>
<tr><td colspan="2">Traded Form</td><td colspan="4">Stem wood/round wood, Log wood, firewood</td></tr>
<tr><td colspan="6">Dimensions (cm)</td></tr>
<tr><td colspan="6">Length (L) (maximum length of a single piece), cm [a]</td></tr>
<tr><td>L20-</td><td>< 20 cm</td><td colspan="4" rowspan="8"> 
L Length
D_1 Diameter D_2 diameter D Diameter
select maximum diameter of D_1 or D_2
Figure 4 — Examples</td></tr>
<tr><td>L20</td><td>20 cm ± 2 cm</td></tr>
<tr><td>L25</td><td>25 cm ± 2 cm</td></tr>
<tr><td>L30</td><td>30 cm ± 2 cm</td></tr>
<tr><td>L33</td><td>33 cm ± 2 cm</td></tr>
<tr><td>L40</td><td>40 cm ± 2 cm</td></tr>
<tr><td>L50</td><td>50 cm ± 4 cm</td></tr>
<tr><td>L100</td><td>100 cm ± 5 cm</td></tr>
<tr><td>L100+</td><td>> 100 cm (maximum value to be stated)</td></tr>
<tr><td colspan="6">Diameter (D) Diameter of a single piece (cm)</td></tr>
<tr><td>Diam-eter class</td><td>Main fraction, (minimum 70 % of mass) (cm)</td><td>Coarse fraction, % of mass [a]</td><td>Maximum diame-ter (cm)</td><td>Small firewood, % of mass (D2 and D5)</td></tr>
<tr><td>D2</td><td>≤ 2</td><td>≤ 15</td><td>3</td><td>-</td></tr>
<tr><td>D5</td><td>2 ≤ D ≤ 5</td><td>≤ 15</td><td>8</td><td>-</td></tr>
<tr><td>D10</td><td>5 ≤ D ≤ 10</td><td>≤ 15</td><td>15</td><td>15</td></tr>
<tr><td>D15</td><td>10 ≤ D ≤ 15</td><td>≤ 15</td><td>20</td><td>10</td></tr>
<tr><td>D20</td><td>15 ≤ D ≤ 20</td><td>≤ 15</td><td>25</td><td>10</td></tr>
<tr><td>D25</td><td>20 ≤ D ≤ 25</td><td>≤ 15</td><td>30</td><td>10</td></tr>
<tr><td>D30</td><td>25 ≤ D ≤ 30</td><td>≤ 15</td><td>35</td><td>10</td></tr>
<tr><td>D35</td><td>20 ≤ D ≤ 35</td><td>≤ 15</td><td>40</td><td>10</td></tr>
<tr><td>D35+</td><td>D ≥ 35</td><td>to be stated</td><td>to be stated</td><td>to be stated</td></tr>
<tr><td colspan="6">Moisture, M (% in mass as received on wet basis) [b] ISO 18134-1, ISO 18134-2</td></tr>
<tr><td>M10</td><td colspan="5">≤ 10 %</td></tr>
<tr><td>M15</td><td colspan="5">≤ 15 %</td></tr>
<tr><td>M20</td><td colspan="5">≤ 20 %</td></tr>
<tr><td>M25</td><td colspan="5">≤ 25 %</td></tr>
<tr><td>M30</td><td colspan="5">≤ 30 %</td></tr>
<tr><td>M35</td><td colspan="5">≤ 35 %</td></tr>
<tr><td>M40</td><td colspan="5">≤ 40 %</td></tr>
<tr><td>M45</td><td colspan="5">≤ 45 %</td></tr>
<tr><td>M55</td><td colspan="5">≤ 55 %</td></tr>
<tr><td>M55+</td><td colspan="5">> 55 % (maximum value to be stated)</td></tr>
<tr><td colspan="2">Volume, m³ stacked or loose or weight, kg as received</td><td colspan="4">To be stated which unit is used when retailed (m³ stacked or m³ loose, kg) and/or packaged log woods weight.</td></tr>
</table>

Table 6 *(continued)*

Informative	**Energy density, E** [c] (MJ/m^3 or kWh/m^3 stacked or loose) or **Net calorific value, Q** (MJ/kg or kWh/kg as received) ISO 18125	Recommended to be specified when retailed.
	Proportion of split volume (% of pieces)	No split (= mainly round wood) ≥ 50 % ≥ 90 %
	The cut-off surface	To be stated if the cut-off surface of log wood are even and smooth [d] or ends of log wood is uneven
	Decay and mould	No visible decay or mould ≤ 5 % of pieces If significant amount (more than 10 % of pieces) of decay or mould exists it should be stated.
	Drying	Recommended to be stated, if firewood is dried by natural seasoning by ambient air or artificially by hot air.

[a] Diameter between upper limit of the main fraction and maximum diameter.

[b] M (% in mass) on wet basis and U (% in mass) on dry basis. Moisture content should not be less 10 % in mass on wet basis (M). The lowest possible moisture content class to be stated. Calculation from M to U or from U to M is presented Formula E.1 and Formula E.2.

[c] The energy density may be calculated according to Annex D on the basis of the bulk density, the moisture content and the net calorific value of the dry fuel. Example: For a firewood with a net calorific value on dry basis, E of 5,3 kWh/kg and an actual moisture content M_{ar} of 15 % in mass, the net calorific value on as received basis E_{ar} is 4,43 kWh/kg. For a bulk density BD of 410 kg/stacked m^3, the energy density E_{ar} is 1 800 kWh/stacked m^3.

[d] Cuts of chainsaw or circular saw are considered to be smooth and even.

Table 7 — Specification of properties for sawdust

Master table			
Normative	**Origin**: According to 6.1 and Table 1.		Woody biomass (1)
	Traded Form		Sawdust
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2		
	M10	≤ 10 %	
	M15	≤ 15 %	
	M20	≤ 20 %	
	M25	≤ 25 %	
	M30	≤ 30 %	
	M35	≤ 35 %	
	M45	≤ 45 %	
	M50	≤ 50 %	
	M55	≤ 55 %	
	M60	≤ 60 %	
	M65	≤ 65 %	
	M65+	> 65 % (maximum value to be stated)	
	Ash, A (% in mass of dry basis) ISO 18122		

Table 7 *(continued)*

	A0.5	≤ 0,5 %	
	A0.7	≤ 0,7 %	
	A1.0	≤ 1,0 %	
	A1.5	≤ 1,5 %	
	A2.0	≤ 2,0 %	
	A3.0	≤ 3,0 %	
	A5.0	≤ 5,0 %	
	A7.0	≤ 7,0 %	
	A10.0	≤ 10,0 %	
	A10.0+	> 10,0 % (maximum value to be stated)	
	Net calorific value, Q (MJ/kg or kWh/kg as received) or **energy density, E** (MJ/m^3 or kWh/m^3 loose) ISO 18125		Minimum value to be stated
Normative/ Informative	**Nitrogen, N** (% in mass of dry basis) ISO 16948		
	N0.2	≤ 0,2 %	Normative:
	N0.3	≤ 0,3 %	Chemically treated biomass (1.2.2; 1.3.2)
	N0.5	≤ 0,5 %	Informative:
	N1.0	≤ 1,0 %	All fuels that are not chemically treated (see the exceptions above)
	N2.0	≤ 2,0 %	
	N3.0	≤ 3,0 %	
	N3.0+	> 3,0 % (maximum value to be stated)	
	Chlorine, Cl (weight of dry basis, % in mass) ISO 16994		
	Cl0.01	≤ 0,01 %	Normative:
	Cl0.02	≤ 0,02 %	Chemically treated biomass (1.2.2; 1.3.2)
	Cl0.03	≤ 0,03 %	Informative:
	Cl0.07	≤ 0,07 %	All fuels that are not chemically treated (see the exceptions above)
	Cl0.10	≤ 0,10 %	
	Cl0.10+	> 0,10 % (maximum value to be stated)	
Informative	**Bulk density, BD** (kg/m^3 as received) ISO 17828		
	BD100	≥ 100 kg/m^3	Recommended to be stated if traded by volume basis
	BD150	≥ 150 kg/m^3	
	BD200	≥ 200 kg/m^3	
	BD250	≥ 250 kg/m^3	
	BD300	≥ 300 kg/m^3	
	BD350	≥ 350 kg/m^3	
	BD400 +	> 400 kg/m^3 (minimum value to be stated)	
	Ash melting behaviour [a] (°C) ISO 21404[3]		DT, HT and FT should be stated
	Sieving		If material is sieved, the sieve aperture size of the sieve(s) should be stated

[a] It is recommended to state all characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.

NOTE 7 Particle size of sawdust is considered to be homogenous. Particle size distribution can be specified, if requested.

Table 8 — Specification of properties for shavings

Master table			
Normative	**Origin**: According to 6.1 and Table 1.		Woody biomass (1)
	Traded Form		Shavings
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2		
	M10	≤ 10 %	
	M15	≤ 15 %	
	M20	≤ 20 %	
	M30	≤ 30 %	
	M30+	> 30 % (maximum value to be stated)	
	Ash, A (% in mass of dry basis) ISO 18122		
	A0.5	≤ 0,5 %	
	A0.7	≤ 0,7 %	
	A1.0	≤ 1,0 %	
	A1.5	≤ 1,5 %	
	A2.0	≤ 2,0 %	
	A3.0	≤ 3,0 %	
	A5.0	≤ 5,0 %	
	A7.0	≤ 7,0 %	
	A10.0	≤ 10,0 %	
	A10.0+	> 10,0 % (maximum value to be stated)	
	Net calorific value, Q (MJ/kg or kWh/kg as received) or **energy density, E** (MJ/m³ or kWh/m³ loose) ISO 18125		Minimum value to be stated
Normative/ Informative	**Nitrogen, N** (% in mass of dry basis) ISO 16948		
	N0.2	≤ 0,2 %	Normative:
	N0.3	≤ 0,3 %	Chemically treated biomass (1.2.2; 1.3.2)
	N0.5	≤ 0,5 %	Informative:
	N1.0	≤ 1,0 %	All fuels that are not chemically treated (see the exceptions above)
	N2.0	≤ 2,0 %	
	N3.0	≤ 3,0 %	
	N3.0+	> 3,0 % (maximum value to be stated)	
	Chlorine, Cl (weight of dry basis, % in mass) ISO 16994		
	Cl0.01	≤ 0,01 %	Normative:
	Cl0.02	≤ 0,02 %	Chemically treated biomass (1.2.2; 1.3.2)
	Cl0.03	≤ 0,03 %	Informative:
	Cl0.07	≤ 0,07 %	All fuels that are not chemically treated (see the exceptions above)
	Cl0.10	≤ 0,10 %	
	Cl0.10+	> 0,10 % (maximum value to be stated)	

Table 8 *(continued)*

Informative	**Bulk density, BD** (kg/m^3 as received) ISO 17828		
	BD100	≥ 100 kg/m^3	Recommended to be stated if traded by volume basis
	BD150	≥ 150 kg/m^3	
	BD200	≥ 200 kg/m^3	
	BD250	≥ 250 kg/m^3	
	BD300	≥ 300 kg/m^3	
	BD350+	> 350 kg/m^3 (minimum value to be stated)	
	Ash melting behaviour [a] (°C) ISO 21404 [3]		DT, HT and FT should be stated
	Sieving		If material is sieved, the sieve aperture size of sieve(s) should be stated
[a] It is recommended to state all characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.			

NOTE 8 Particle size of shavings is considered to be homogenous. Particle size distribution can be specified, if requested.

Table 9 — Specification of properties for bark

Master table			
Normative	**Origin**: According to 6.1 and Table 1.		Woody biomass (1.1.6, 1.2.1.5, 1.2.2.3, 1.3.1.3, 1.3.2.3)
	Traded Form:		Bark
	Dimensions (mm) ISO 17827-1		
	Particle class	Minimum 95 % in mass of particles below the particle class in length, mm [a]	Max. length of a particle, mm
	P16	< 16 mm	45 mm
	P31	< 31,5 mm	63 mm
	P45	< 45 mm	100 mm
	P63	< 63 mm	150 mm
	P100	< 100 mm	250 mm
	P200	< 200 mm	350 mm
	P300	< 300 mm	500 mm
	Moisture, M (% in mass as received) [b] ISO 18134-1, ISO 18134-2		
	M20	≤ 20 %	
	M25	≤ 25 %	
	M30	≤ 30 %	
	M35	≤ 35 %	
	M40	≤ 40 %	
	M45	≤ 45 %	
	M50	≤ 50 %	
	M55	≤ 55 %	
	M60	≤ 60 %	
	M65	≤ 65 %	
	M65+	> 65 % (maximum value to be stated)	

Table 9 *(continued)*

	Ash, A (% in mass of dry basis) ISO 18122		
	A1.0	≤ 1,0 %	
	A1.5	≤ 1,5 %	
	A2.0	≤ 2,0 %	
	A3.0	≤ 3,0 %	
	A5.0	≤ 5,0 %	
	A7.0	≤ 7,0 %	
	A10.0	≤ 10,0 %	
	A10.0+	> 10,0 % (maximum value to be stated)	
	Shredding		To be stated if bark is shredded or not into pieces
	Net calorific value, Q (MJ/kg or kWh/kg as received) or **energy density, E** (MJ/m³ or kWh/m³ loose) ISO 18125		Minimum value to be stated
Normative/ Informative	**Nitrogen, N** (% in mass of dry basis) ISO 16948		
	N0.5	≤ 0,5 %	Normative:
	N1.0	≤ 1,0 %	Chemically treated biomass (1.2.2; 1.3.2)
	N2.0	≤ 2,0 %	Informative:
	N3.0	≤ 3,0 %	All fuels that are not chemically treated (see the exceptions above)
	N3.0+	> 3,0 % (maximum value to be stated)	
	Chlorine, Cl (% in mass of dry basis) ISO 16994		
	Cl0.02	≤ 0,02 %	Normative:
	Cl0.03	≤ 0,03 %	Chemically treated biomass (1.2.2; 1.3.2)
	Cl0.07	≤ 0,07 %	Informative:
	Cl0.10	≤ 0,10 %	All fuels that are not chemically treated (see the exceptions above)
	Cl0.10+	> 0,10 % (maximum value to be stated)	
Informative	**Bulk density, BD** (kg/m³ as received) ISO 17828		
	BD250	≥ 250 kg/m³	Recommended to be stated if traded on a volume basis
	BD300	≥ 300 kg/m³	
	BD350	≥ 350 kg/m³	
	BD400	≥ 400 kg/m³	
	BD450	≥ 450 kg/m³	
	Ash melting behaviour [c] (°C) ISO 21404[3]		DT, HT and FT should be stated

[a] The numerical values (P-class) for dimension refer to the particle sizes (at least 95 % by mass) passing through the mentioned round hole sieve size (ISO 17827-1). Sieves with sieve aperture sizes to be used for size classification are: 3,15 mm, 16 mm, 31,5 mm, 45 mm and 63 mm. If a sample fulfils the criteria of more than one class attach it to the lowest possible class.

[b] Lowest possible property class to be stated. Certain boilers require minimum moisture content, which should to be stated.

[c] It is recommended to state all characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.

Table 10 — Specification of properties for bales of straw, reed canary grass and Miscanthus

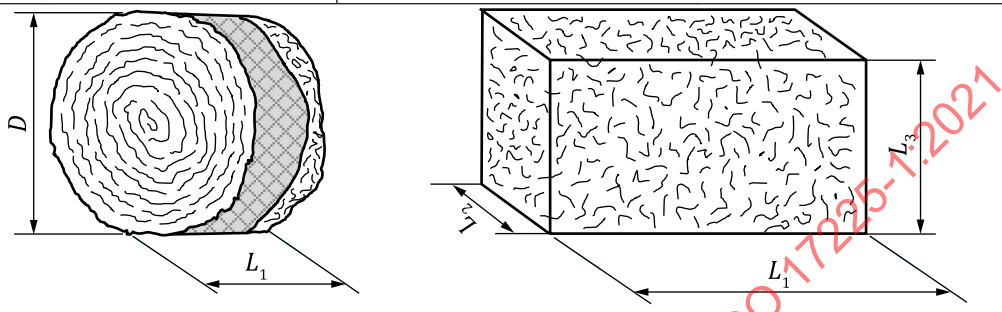
Master table				
Normative	**Origin:** According to 6.1 and Table 1.	2.1.1.2 Cereal crop straw, 2.1.2.1 Whole plant (Reed canary grass and Miscanthus), 2.1.2.2 Grass straw, 2.1.3.2 Oil seed crops stalks and leaves		
	Traded Form	Round bale and square bale		
	 *D* Diameter L_1 Length, L_2 Width and L_3 Height **Figure 5 — Dimensions (m)**			
	Round bale	Diameter (*D*)	Length (L_1)	
	D1	1,2 m – 1,5 m	1,2 m	
	D2	1,6 m – 1,8 m	1,5 m	
	Square bale [a]	Length (L_1)	Width (L_2)	Height (L_3)
	P1	≤ 0,5 m	≤ 0,4 m	≤ 0,35 m
	P2	1,5 m – 2,8 m	≤ 1,2 m	≤ 0,9 m
	P3	1,0 m – 3,0 m	≤ 1,2 m	≤ 1,3 m
	P3+	> 3 m (value to be stated)	> 1,2 m (value to be stated)	> 1,3 m (value to be stated)
	Bulk density of bale, BD (kg/m^3 as received) ISO 17828			
	BD80	≥ 80 kg/m^3		
	BD100	≥ 100 kg/m^3		
	BD120	≥ 120 kg/m^3		
	BD160	≥ 160 kg/m^3		
	BD180	≥ 180 kg/m^3		
	BD220	≥ 220 kg/m^3		
	BD240+	≥ 240 kg/m^3 (minimum value to be stated)		
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2			
	M10	≤ 10 %		
	M15	≤ 15 %		
	M20	≤ 20 %		
	M25	≤ 25 %		
	M30	≤ 30 %		
	M30+	> 30 % (maximum value to be stated)		

Table 10 *(continued)*

	Ash, A (% in mass of dry basis) ISO 18122		
	A3.0	≤ 3 %	
	A4.0	≤ 4 %	
	A5.0	≤ 5 %	
	A6.0	≤ 6 %	
	A7.0	≤ 7 %	
	A8.0	≤ 8 %	
	A10.0	≤ 10 %	
	A10.0+	> 10 % (maximum value to be stated)	
	Chlorine, Cl (% in mass of dry basis) ISO 16994		
	Cl0.01	≤ 0,01 %	
	Cl0.02	≤ 0,02 %	
	Cl0.03	≤ 0,03 %	
	Cl0.07	≤ 0,07 %	
	Cl0.10	≤ 0,10 %	
	Cl0.10+	> 0.10 % (maximum value to be stated)	
	Species of biomass		To be stated (Examples: wheat straw (*triticum)*, spring harvested reed canary grass (*Phalaris arundinacea L.*) or Miscanthus (*Miscanthus sinensis giganteus*))
	Net calorific value, Q (MJ/kg or kWh/kg as received) or **energy density, E** (MJ/m^3 or kWh/m^3) ISO 18125		Minimum value to be stated
Informative	**Nitrogen, N** (% in mass on dry basis)		
	N0.5	≤ 0,5 %	It is recommended to state Nitrogen content.
	N1.0	≤ 1,0%	
	N2.0	≤ 2 %	
	N2.0+	> 2 % (maximum value to be stated)	
	Production method		It is recommended to declare production methods that influence the size of the straw particles in the bale. For instance, whether the crop has been threshed by rotation or oscillation and whether the straw has been chopped. Harvested as a whole plant for Reed canary grass and Miscanthus.
	Type of binding of bales		Tying material is recommended to be specified (net, twine, wire or string).
	Ash melting behaviour [b] (°C) ISO 21404[3]		DT, HT and FT should be stated

[a] Lowest class to be stated.

[b] It is recommended to state the characteristic temperatures (deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. Shrinkage starting temperature (SST) is difficult to measure in herbaceous biomass. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.

Table 11 — Specification of properties for energy grain

Master table		
Normative	**Origin**: According to 6.1 and Table 1	Herbaceous biomass (2.1.1.3)
	Traded Form	Grain (species to be stated e.g. wheat)
	Dimensions (mm), Diameter [a] (*D),* (5 % in mass may have diameter over the class) ISO 17827-1, ISO 17827-2	
	D05	1 mm ≤ *D* < 5 mm
	D10	5 mm ≤ *D* < 10 mm
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2	
	M10	≤ 10 %
	M15	≤ 15 %
	Ash, A (% in mass of dry basis) ISO 18122	
	A2.0	≤ 2,0 %
	A3.0	≤ 3,0 %
	A5.0	≤ 5,0 %
	A5.0+	> 5,0 % (maximum value to be stated)
	Net calorific value, Q (MJ/kg or kWh/kg as received) ISO 18125	Minimum value to be stated
	Nitrogen, N (% in mass, dry basis) ISO 16948	
	N2.0	≤ 2,0 %
	N2.0+	> 2,0 % (maximum value to be stated)
	Sulfur, S (% in mass, dry basis) ISO 16994	
	S0.20	≤ 0,20 %
	S0.20+	> 0,20 % (maximum value to be stated)
	Chlorine, Cl (% in mass, dry basis) ISO 16994	
	Cl0.05	≤ 0,05 %
	Cl0.10	≤ 0,10 %
	Cl0.15	≤ 0,15 %
	Cl0.15+	> 0,15 % (maximum value to be stated)
Informative	**Amount of small fines, Fs** (% in mass, Fs < 1 mm for *D* 05) ISO 17827-2	
	Fs1.0	≤ 1,0 %
	Fs1.0+	> 1,0 % (without additive)
	Amount of fines, F (% in mass, < 3,15 mm for *D* 10) ISO 17827-1	
	F1.0	≤ 1,0 %
	F1.0+	> 1,0 % (without additive)
	Bulk density, BD (kg/m^3 as received) ISO 17828	
	BD350	≥ 350 kg/m^3
	BD450	≥ 450 kg/m^3
	BD550	≥ 550 kg/m^3
	BD600	≥ 600 kg/m^3
	BD650+	> 650 kg/m^3 (minimum value to be stated)
	Ash melting behaviour [a] (°C) ISO 21404 [3]	DT, HT and FT should be stated

[a] It is recommended to state all characteristic temperatures (deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. Shrinkage starting temperature (SST) is difficult to measure in herbaceous biomass. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.

When using cereal grain materials for combustion special attention should be paid to risk of corrosion in boilers and flue gas system. Be aware that different types and varieties of grains, grown under different conditions and soil type, can have a specific fuel ash composition, i.e. high content of P, K will prevent to capture chlorine (K will form K-phosphates instead of KCl in the ash and that will result in high hydrochloric emissions.

Table 12 — Specification of properties for olive residues

Master table			
Normative	**Origin**: According to 6.1 and Table 1		Fruit biomass (3.2.1.2, 3.2.1.4,3.2.2.2,3.2.2.4)
	Traded Form		Grain or seed, kernel
	Dimensions (mm) ISO 17827-1, ISO 17827-2		
	Diameter (D) [a]		
	D03	1 mm ≤ D < 3,15 mm	
	D05	1 mm ≤ D < 5 mm	
	D10	1 mm ≤ D < 10 mm	
	D10+	≥ 10 mm (maximum value to be stated)	
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2		
	M10	≤ 10 %	
	M15	≤ 15 %	
	Ash, A (% in mass of dry basis) ISO 18122		
	A1.5	≤ 1,5 %	
	A2.0	≤ 2,0 %	
	A3.0	≤ 3,0 %	
	A5.0	≤ 5,0 %	
	A7.0	≤ 7,0 %	
	A10.0	≤ 10,0 %	
	A10.0+	> 10,0 % (maximum value to be stated)	
	Additives (% in mass)		Type and amount of additive to be stated
	Net calorific value, Q [b] (MJ/kg or kWh/kg as received) ISO 18125		Minimum value to be stated
	Nitrogen, N (% in mass of dry basis) ISO 16948		
	N1.0	≤ 1,0 %	
	N1.5	≤ 1,5 %	
	N2.0	≤ 2,0 %	
	N3.0	≤ 3,0 %	
	N3.0+	> 3,0 % (maximum value to be stated)	

Table 12 *(continued)*

Informative	**Amount of small fines, Fs** (% in mass, < 1 mm for *D* 03 and *D* 05) ISO 17827-2		
	Fs1.0	≤ 1,0 %	
	Fs1.0+	> 1,0 % (without additive)	
	Amount of fines, F (% in mass, < 3,15 mm for *D* 10 and D10+) ISO 17827-1		
	F1.0	≤ 1,0 %	
	F1.0+	> 1,0 % (without additive)	
	Bulk density, BD as received (kg/m^3) ISO 17828		Recommended to be stated if traded on a volume basis
	Chlorine, Cl (% in mass of dry basis) ISO 16994		
	Cl 0.10	≤ 0,10 %	
	Cl 0.15	≤ 0,15 %	
	Cl0.15+	> 0,15 % (maximum value to be stated)	
	Sulfur, S (% in mass of dry basis) ISO 16994		
	S0.15	≤ 0,15 %	
	S0.20	≤ 0,20 %	
	S0.20+	> 0,20 % (maximum value to be stated)	
	Ash melting behaviour [c] (°C) ISO 21404 [3]		DT, HT and FT should be stated

[a] 5 % in mass may have diameter over the class. Lowest possible class to be stated.

[b] Additives can reduce net calorific value.

[c] It is recommended to state all characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.

Table 13 — Specification of properties for fruit seeds

Master table			
Normative	**Origin**: According to 6.1 and Table 1		Fruit biomass (3.1.1.3, 3.1.3, 3.2.1.2, 3.2.1.3, 3.2.2.2, 3.2.2.3)
	Traded Form		Fruit seed or kernel
	Dimensions (mm) ISO 17827-1, ISO 17827-2		
	Diameter (*D*) [a] (5 % in mass may have a diameter over the class)		
	D03	1 mm ≤ *D* < 3,15 mm	
	D05	1 mm ≤ *D* < 5 mm	
	D10	1 mm ≤ *D* < 10 mm	
	D10+	≥10 mm (maximum value to be stated)	
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2		
	M10	M ≤ 10 %	
	M15	M ≤ 15 %	
	Ash, A (% in mass of dry basis) ISO 18122		
	A1.5	≤ 1,5 %	
	A2.0	≤ 2,0 %	
	A3.0	≤ 3,0 %	
	A5.0	≤ 5,0 %	
	A7.0	≤ 7,0 %	
	A10.0	≤ 10,0 %	
	A10.0+	> 10,0 % (maximum value to be stated)	

Table 13 *(continued)*

	Additives (% in mass)		Type and amount of additive to be stated
	Net calorific value, Q [b] (MJ/kg or kWh/kg as received), ISO 18125		Minimum value to be stated
	Nitrogen, N (% in mass of dry basis) ISO 16948		
	N1.0	≤ 1,0 %	
	N1.5	≤ 1,5 %	
	N2.0	≤ 2,0 %	
	N3.0	≤ 3,0 %	
	N3.0+	> 3,0 % (maximum value to be stated)	
Informative	**Amount of small fines, Fs** (% in mass, < 1 mm) ISO 17827-1		
	Fs1.0	≤ 1,0 %	
	Fs1.0+	> 1,0 %	
	Bulk density (BD) (kg/m^3 as received) ISO 17828		Recommended to be stated if traded on a volume basis
	Chlorine, Cl (% in mass of dry basis) ISO 16994		
	Cl 0.10	≤ 0,10 %	
	Cl 0.15	≤ 0,15 %	
	Cl 0.15+	> 0,15 % (maximum value to be stated)	
	Sulfur, S (% in mass of dry basis) ISO 16994		
	S0.15	≤ 0,15 %	
	S0.20	≤ 0,20 %	
	S0.20+	> 0,20 % (maximum value to be stated)	
	Ash melting behaviour [c] (°C) ISO 21404[3]		DT, HT and FT should be stated

[a] Lowest possible class to be stated.

[b] Additives can reduce net calorific value.

[c] It is recommended to state all characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.

NOTE 9 Fruit seeds include kernels, nuts and acorns.

Table 14 — Specification of properties for charcoals

Master table				
Normative	**Origin**: According to 6.1 and Table 1		Woody biomass (1.1 and 1.2.1); Fruit biomass (3)	
	Traded Form (see Table 2)		Charcoal	
	Dimensions (mm) ISO 17827-1			
	Particle class	All particles (mm)	Small particle fraction, (% in mass)	Coarse fraction, (% in mass), max. length of particle, mm
	P80	0 mm ≤ *P* ≤ 150 mm	≤ 7 %, ≤ 10 mm < 20, ≤ 20 mm	≤ 10 %, 80 mm to 150 mm, all < 150 mm
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2			
	M8	≤ 8 %		
	M10	≤ 10 %		
	Ash, A (% in mass of dry basis) ISO 18122			
	A5.0	≤ 5,0 %		
	A8.0	≤ 8,0 %		
	A8.0+	> 8,0 % (maximum value to be stated)		
	Fixed carbon, C [a] (% in mass of dry basis)			
	C60	≥ 60 %		
	C75	≥ 75 %		
	Bulk density (BD) (kg/m^3 as received) ISO 17828			
	BD130	≥ 130 kg/m^3		
	BD150	≥ 150 kg/m^3		
	Net calorific value, Q (MJ/kg or kWh/kg as received) ISO 18125			Minimum value to be stated
	Volatile matter, VM (% in mass) ISO 18123			Value to be stated

[a] Fixed carbon (%) is calculated by the following: 100 – (moisture [% in mass] + ash [% in mass] + volatile matter [% in mass]). All percentage are on the same moisture basis.

Table 15 — General master table for specification of properties for other solid biofuels

General Master Table			
Normative	**Origin**		To be specified in accordance to 6.1 and Table 1, as detailed as needed.
	Traded Form		A short description of the form of the biofuel (see Table 2 for guidelines).
	Dimensions (mm)		If dimensions are not suitable to express as diameter and length other formats may be used, and then shall be clearly stated.
	D_x L_y	x = Maximum diameter y = Maximum length	
	Moisture, M (% in mass as received) ISO 18134-1, ISO 18134-2		Recommended to be stated as a class: M10, M15, M20, M25, M30; M35, M40, M45, M50; M55, M60, M65, M65+ (maximum value to be stated)
	MXX	≤ XX %	
	Ash, A (% in mass of dry basis) ISO 18122		Recommended to be stated as a class: A0.5, A0.7, A1.0, A1.5, A2.0, A3.0, A5.0, A7.0, A10, A10+ (maximum value to be stated)
	AXX.X	≤ XX,X %	
Normative/ Informative	**Additives** (% in mass of dry basis)		If any type of additive is added to the fuel, amount and type shall be stated. The maximum amount of additive is 20 % in mass in solid biofuels. If amount is greater, then solid biofuel is a blend.
	Net calorific value, Q (MJ/kg or kWh/kg as received) or **energy density, E** (MJ/m^3 or kWh/m^3) ISO 18125		Minimum value to be stated.
	Bulk density (BD) (kg/m^3 as received) ISO 17828		Recommended to be stated in the classes (minimum value): BD100, BD150, BD200, BD250, BD300, BD350, BD400, BD450, BD500, BD550, BD600, BD650, BD750, DB850+.
	Nitrogen, N (% in mass, dry basis) ISO 16948		Nitrogen is normative only for chemically treated biomass. Recommended to be stated as a class N0.2, N0.3, N0.5, N1.0, N1.5, N2.0, N3.0, N3.0+ (maximum value to be stated)
	NX.X	≤ X,X %	
	Sulfur, S (% in mass, dry basis) ISO 16994		Sulfur is normative only for chemically treated biomass or if sulfur containing additives have been used. Recommended to be stated as a class S0.03, S0.05, S0.1, S0.2, S0.3 and S0.3+ (if S > 0.3 % maximum value to be stated)
	SX.XX	≤ X,XX %	
	Chlorine, Cl (% in mass, dry basis) ISO 16994		Chlorine is normative only for chemically treated biomass. Recommended to be state as a class: Cl0.01, Cl0.02, Cl0.03, Cl0.07, Cl0.10 and Cl0.10+ (if Cl > 0,10 % maximum value to be stated)
	ClX.XX	≤ X,XX %	
	Volatile matter, VM (% in mass) ISO 18123		Normative only for thermally treated biomass. Maximum value to be stated
	Fixed carbon, Cf (% in mass, dry basis)		Normative only for thermally treated biomass. Maximum value to be stated.
	Further specification of dimensions		It is recommended that maximum allowed amount of fine and coarse particles of the fuel should be stated.
	Others e.g. major (ISO 16967) and minor elements (ISO 16968)		Properties that are specific to the actual solid biofuel and considered as containing useful information.
Informative	**Ash melting behaviour** [a] (°C), ISO 21404[3]		DT, HT and FT should be stated
[a] It is recommended to state all characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions. The default ashing temperature according to ISO 21404 is 550 °C ± 10 °C. If alternative ashing temperature is used it shall be specified.			

NOTE 10 Property classes from Tables 3 to 14 can be used if also appropriate in this master table.

Annex A
(informative)

Illustrations of typical forms of wood fuels and examples of particles sizes for wood chips and hog fuel

A.1 Visually classifying wood fuels based on a typical particle size[1)]

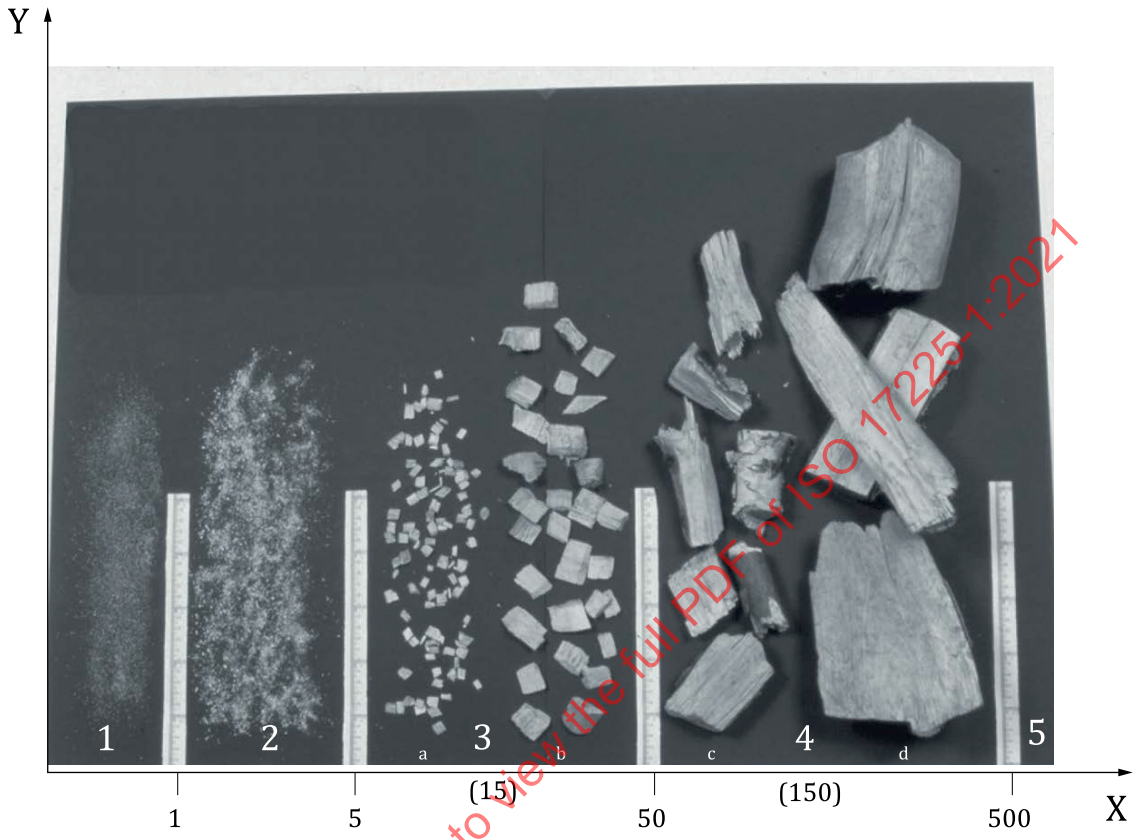


Figure A.1 — Classification of wood fuels based on fuel particle size

1) Source: Jan Erik Mattsson, Swedish University of Agricultural Science, Department of Agricultural Engineering, PO Box 66, SE-23066, Alnarp, Sweden.

Key

1 wood powder
2 sawdust
3 wood chips
4 smallwood
5 wholewood

A.2 Visual differentiation between wood chips and hog fuel[2)]

a) Wood chips (cut with sharp tools)

b) Hog fuel (crushed with blunt tools)

Figure A.2 — Close examination of wood chips and hog fuel

A.3 Examples of particle size distribution for wood chips and hog fuel

Table A.3.1 — Raw material for wood chips is stem wood without bark (1.1.3.4), particle size class is P16s and maximum length of particle is 38 mm

Screen, mm	Fines	Main fraction		Coarse fraction				Max. length, mm
	< 3,15 mm	3,15-16 mm	16-31,5 mm	31,5-45 mm	45-63 mm	63-100 mm	>100 mm	
mass on screen, % in mass	2,6	97,4	0,0	0,0	0,0	0,0	0,0	38

2) Source: Jan Erik Mattsson, Swedish University of Agricultural Science, Department of Agricultural Engineering, PO Box 66, SE-23066, Alnarp, Sweden.

For P16s Coarse fraction (particles ≥ 31,5 mm) should be ≤ 6 %. In this case coarse fraction is 0,0 %. Fines (< 3,15 mm) should be ≤ 15 %, in this case it is 2,6 %. Maximum length of particles should be less than 45 mm. In this case it is 38 mm.

Table A.3.2 — Raw material for wood chips is delimbed stem wood (1.1.3), particle size class is P31, F15. Maximum length of particle is 100 mm

Screen, mm	Fines	Main fraction			Coarse fraction			Max. length, mm
	< 3,15 mm	3,15-16 mm	16-31,5 mm	31,5-45 mm	45-63 mm	63-100 mm	> 100 mm	
mass on screen, % in mass	11,9	56,9	22,7	2,5	2,3	3,7	0,0	100

For P31 Coarse fraction (particles ≥ 45 mm) should be ≤ 6 %. In this case coarse fraction is 6 %.

Table A.3.3 — Raw material for wood chips is whole trees without roots (1.1.1), particle size class is P45, F20. Maximum length of particle is 100 mm

Screen, mm	Fines	Main fraction				Coarse fraction		Max. length, mm
	< 3,15 mm	3,15-16 mm	16-31,5 mm	31,5-45 mm	45-63 mm	63-100 mm	> 100 mm	
mass on screen, % in mass	16,1	46,7	0,0	31,1	3,4	2,7	0	100

For P45 Coarse fraction (particles ≥ 63 mm) should be ≤ 10 %. In this case coarse fraction is 2,7 %.

Table A.3.4 — Raw material for hog fuel is spruce stumps (1.1.5.2), particle size class is P63, F25. Maximum length of particle is 300 mm

Screen, mm	Fines	Main fraction					Coarse fraction	Max. length, mm
	< 3,15 mm	3,15-16 mm	16-31,5 mm	31,5-45 mm	45-63 mm	63-100 mm	> 100 mm	
mass on screen, % in mass	20,7	23,8	21,3	8,4	15,2	1,7	8,8	300

For P63 Coarse fraction (particles ≥ 100 mm) should be ≤ 10 %. In this case coarse fraction is 8,8 %.

Table A.3.5 — Raw material for hog fuel is road size maintenance wood (1.1.7), particle size class is PL30+ (45,6), F05. Maximum length of particle is 400 mm

Screen, mm	Fines	Other screening results						Max. length, mm
	< 3,15 mm	3,15-16 mm	16-31,5 mm	31,5-45 mm	45-63 mm	63-100 mm	> 100 mm	
mass on screen, % in mass	2,2	21,7	22,6	6,5	0,8	0,5	45,6	400

Table A.3.6 — Raw material for hog fuel is pruning residues (1.1.7), particle size class is PL20, F05 and maximum length 220 mm

Screen, mm	Fines	Other screening results						Max. length, mm
	< 3,15 mm	3,15-16 mm	16-31,5 mm	31,5-45 mm	45-63 mm	63-100 mm	> 100 mm	
mass on screen, % in mass	3,4	30,1	38,1	7,4	0,5	3,2	17,3	220

Table A.3.7 — Raw material for wood chips is logging residues (1.1.4), particle size class is PL30, F20 and maximum length 300 mm

Screen, mm	Fines	Other screening results						Max. length, mm
	< 3,15 mm	3,15-16 mm	16-31,5 mm	31,5-45 mm	45-63 mm	63-100 mm	> 100 mm	
mass on screen, % in mass	19,5	23,2	13,4	10,5	6,3	1,9	25,2	300

Annex B
(informative)

Typical values of solid biomass fuels

Table B.1 — Typical values for virgin wood materials, without or with insignificant amounts of bark, leaves and needles

Parameter	Unit	Coniferous wood (1.1.3.4 and 1.2.1.4)		Broad-leaf wood (1.1.3.3 and 1.2.1.3)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	0,3	0,1 to 1,0	0,3	0,2 to 1,0
Gross calorific value $Q_{V,\mathrm{gr,d}}$	MJ/kg d	20,5	20,0 to 20,8	20,1	19,4 to 20,4
Net calorific value $Q_{p,\mathrm{net,d}}$	MJ/kg d	19,1	18,5 to 19,8	18,9	18,4 to 19,2
Carbon, C	% in mass d	51	47 to 54	49	48 to 52
Hydrogen, H	% in mass d	6,3	5,6 to 7,0	6,2	5,9 to 6,5
Oxygen, O	% in mass d	42	40 to 44	44	41 to 45
Nitrogen, N	% in mass d	0,1	< 0,1 to 0,5	0,1	< 0,1 to 0,5
Sulfur, S	% in mass d	< 0,02	< 0,01 to 0,02	0,02	< 0,01 to 0,05
Chlorine, Cl	% in mass d	0,01	< 0,01 to 0,03	0,01	< 0,01 to 0,03
Fluorine, F	% in mass d	< 0,000 5	< 0,000 5	< 0,000 5	< 0,000 5
Aluminium, Al	mg/kg d	100	30 to 400	20	< 10 to 50
Calcium, Ca	mg/kg d	900	500 to 1 000	1 200	800 to 20 000
Iron, Fe	mg/kg d	25	10 to 100	25	10 to 100
Potassium, K	mg/kg d	400	200 to 500	800	500 to 1 500
Magnesium, Mg	mg/kg d	150	100 to 200	200	100 to 400
Manganese, Mn	mg/kg d	100	40 to 200	83	not specified
Sodium, Na	mg/kg d	20	10 to 50	50	10 to 200
Phosphorus, P	mg/kg d	60	50 to 100	100	50 to 200
Silicon, Si	mg/kg d	150	100 to 200	150	100 to 200
Titanium, Ti	mg/kg d	< 20	< 20	< 20	< 20
Arsenic, As	mg/kg d	< 0,1	< 0,1 to 1,0	< 0,1	< 0,1 to 1,0
Cadmium, Cd	mg/kg d	0,10	< 0,05 to 0,50	0,10	< 0,05 to 0,50
Chromium, Cr	mg/kg d	1,0	0,2 to 10,0	1,0	0,2 to 10,0
Copper, Cu	mg/kg d	2,0	0,5 to 10,0	2,0	0,5 to 10,0
Mercury, Hg	mg/kg d	0,02	< 0,02 to 0,05	0,02	< 0,02 to 0,05
Nickel, Ni	mg/kg d	0,5	< 0,1 to 10,0	0,5	< 0,1 to 10,0
Lead, Pb	mg/kg d	2,0	< 0,5 to 10,0	2,0	< 0,5 to 10,0

Table B.1 *(continued)*

Parameter	Unit	Coniferous wood (1.1.3.4 and 1.2.1.4)		Broad-leaf wood (1.1.3.3 and 1.2.1.3)	
		Typical value	Typical variation	Typical value	Typical variation
Vanadium, V	mg/kg d	< 2	< 2	< 2	< 2
Zinc, Zn	mg/kg d	10	5 to 50	10	5 to 100
[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch and German research. Formulas how to calculate different bases are given in ISO 16993					

Table B.2 — Typical values for virgin bark materials

Parameter	Unit	Bark from coniferous wood (1.1.6 and 1.2.1.5)		Bark from broad-leaf wood (1.1.6 and 1.2.1.5)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	3,0	< 1 to 5	1,8	0,8 to 5,0
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	20,4	18,0 to 21,4	20	18,0 to 22,7
Net calorific value $Q_{p,net,d}$	MJ/kg d	19,2	17,5 to 20,5	19	17,1 to 21,3
Carbon, C	% in mass d	52	48 to 55	52	47 to 55
Hydrogen, H	% in mass d	5,9	5,5 to 6,4	5,8	5,3 to 6,4
Oxygen, O	% in mass d	38	34 to 42	38	32 to 42
Nitrogen, N	% in mass d	0,5	0,3 to 0,9	0,3	0,1 to 0,8
Sulfur, S	% in mass d	0,03	< 0,02 to 0,05	0,03	< 0,02 to 0,20
Chlorine, Cl	% in mass d	0,02	< 0,01 to 0,05	0,02	< 0,01 to 0,05
Fluorine, F	% in mass d	0,001	< 0,000 5 to 0,002	not specified	not specified
Aluminium, Al	mg/kg d	800	400 to 1 200	50	30 to 100
Calcium, Ca	mg/kg d	5 000	1 000 to 15 000	15 000	10 000 to 20 000
Iron, Fe	mg/kg d	500	100 to 800	100	50 to 200
Potassium, K	mg/kg d	2 000	1 000 to 3 000	2 000	1 000 to 3 200
Magnesium, Mg	mg/kg d	1 000	400 to 1 500	500	400 to 1 000
Manganese, Mn	mg/kg d	500	9 to 840	190	not specified
Sodium, Na	mg/kg d	300	70 to 2 000	100	20 to 1 000
Phosphorus, P	mg/kg d	400	20 to 600	400	300 to 700
Silicon, Si	mg/kg d	2 000	500 to 5 000	2 500	2 000 to 20 000
Arsenic, As	mg/kg d	1,0	0,1 to 4,0	0,4	0,1 to 4
Cadmium, Cd	mg/kg d	0,5	0,2 to 1,0	0,5	0,2 to 1,2
Chromium, Cr	mg/kg d	5	1 to 10	5	1 to 30
Copper, Cu	mg/kg d	5	3 to 30	5	2 to 20
Mercury, Hg	mg/kg d	0,05	0,01 to 0,1,	< 0,05	not specified
Nickel, Ni	mg/kg d	10	2 to 20	10	2 to 10
Lead, Pb	mg/kg d	4	1 to 30	15	2 to 30
Vanadium, V	mg/kg d	1,0	0,7 to 2,0	2	1 to 4

Table B.2 *(continued)*

Parameter	Unit	Bark from coniferous wood (1.1.6 and 1.2.1.5)		Bark from broad-leaf wood (1.1.6 and 1.2.1.5)	
		Typical value	Typical variation	Typical value	Typical variation
Zinc, Zn	mg/kg d	100	70 to 200	50	7 to 200
[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch and German research. Formulas how to calculate different bases are given in ISO 16993.					

Table B.3 — Typical values for virgin wood materials, logging residues

Parameter	Unit	Coniferous wood (1.1.4.2 and 1.1.4.4)		Broad-leaf wood (1.1.4.1 and 1.1.4.3)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	3,0	< 1 to 10	5,0	2 to 10
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	20,5	19,5 to 21,5	19,7	19,5 to 20,0
Net calorific value $Q_{p,net,d}$	MJ/kg d	19,2	18,5 to 20,5	18,7	18,3 to 18,5
Carbon, C	% in mass d	51	48 to 52	51	50 to 51
Hydrogen, H	% in mass d	6,0	5,7 to 6,2	6,0	5,8 to 6,1
Oxygen, O	% in mass d	40	38 to 44	40	40 to 43
Nitrogen, N	% in mass d	0,5	0,3 to 0,8	0,5	0,3 to 0,8
Sulfur, S	% in mass d	< 0,02	< 0,02 to 0,06	0,04	0,01 to 0,08
Chlorine, Cl	% in mass d	0,01	< 0,01 to 0,04	0,01	< 0,01 to 0,02
Fluorine, F	% in mass d	0,001	not specified	0,002	0,0 to 0,001
Aluminium, Al	mg/kg d	not specified	not specified	250	1 to 3 000
Calcium, Ca	mg/kg d	5 000	2 000 to 8 000	4 000	3 000 to 5 000
Iron, Fe	mg/kg d	1 500	500 to 2 000	150	10 to 1 500
Potassium, K	mg/kg d	2 000	1 000 to 4 000	1 500	1 000 to 4 000
Magnesium, Mg	mg/kg d	800	400 to 2 000	250	100 to 400
Manganese, Mn	mg/kg d	130	80 to 170	120	10 to 800
Sodium, Na	mg/kg d	200	75 to 300	100	20 to 200
Phosphorus, P	mg/kg d	500	not specified	300	30 to 1 000
Silicon, Si	mg/kg d	3 000	200 to 10 000	150	75 to 250
Titanium, Ti	mg/kg d	not specified	not specified	7	1 to 40
Arsenic, As	mg/kg d	0,6	0,2 to 1	1	0 to 2
Cadmium, Cd	mg/kg d	0,2	0,1 to 0,8	0,5	0 to 3
Chromium, Cr	mg/kg d	1	0,7 to 1,2	8	1 to 40
Copper, Cu	mg/kg d	10	10 to 200	10	1 to 100
Mercury, Hg	mg/kg d	0,03	not specified	0,02	0 to 2
Nickel, Ni	mg/kg d	1,6	0,4 to 3	10	1 to 80
Lead, Pb	mg/kg d	1,3	0,4 to 4	1,5	0,5 to 5
Vanadium, V	mg/kg d	0,6	0,1 to 1	0,5	0,1 to 3
Zinc, Zn	mg/kg d	20	8 to 30	50	2 to 100

Table B.3 *(continued)*

Parameter	Unit	Coniferous wood (1.1.4.2 and 1.1.4.4)		Broad-leaf wood (1.1.4.1 and 1.1.4.3)	
		Typical value	Typical variation	Typical value	Typical variation
[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch, Spanish and German research. Formulas how to calculate different bases are given in ISO 16993.					

Table B.4 — Typical values for virgin wood materials, short rotation coppice

Parameter	Unit	Willow (Salix) (1.1.1.3)		Poplar (1.1.1.3)		Eucalyptus (1.1.1.3)	
		Typical value	Typical variation	Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	2,0	1,1 to 4,0	2,0	1,5 to 3,4	2,0	0,5 to 4,0
Gross calorific value $q_{V,gr,d}$	MJ/kg d	19,9	19,2 to 20,4	19,8	19,5 to 20,1	19,5	19,3 to 21,2
Net calorific value $q_{p,net,d}$	MJ/kg d	18,4	17,7 to 19,0	18,4	18,1 to 18,8	18,1	17,6 to 18,4
Carbon, C	% in mass d	48	46 to 49	48	46 to 50	49	46 to 52,7
Hydrogen, H	% in mass d	6,1	5,7 to 6,4	6,2	5,7 to 6,5	5,8	4,8 to 6,2
Oxygen, O	% in mass d	43	40 to 44	43	39 to 45	42	42 to 43
Nitrogen, N	% in mass d	0,5	0,2 to 0,8	0,4	0,2 to 0,6	0,5	0,1 to 1,4
Sulfur, S	% in mass d	0,05	0,02 to 0,10	0,03	0,02 to 0,10	< 0,02	< 0,01 to 0,11
Chlorine, Cl	% in mass d	0,03	0,01 to 0,05	< 0,01	< 0,01 to 0,05	0,1	< 0,09 to 0,18
Fluorine, F	% in mass d	0,003	0 to 0,01	not specified		< 0,01	< 0,01
Aluminium, Al	mg/kg d	50	3 to 100	10	not specified	10	1 to 14
Calcium, Ca	mg/kg d	5 000	2 000 to 9 000	5 000	4 000 to 6 000	1 200	900 to 3 000
Iron, Fe	mg/kg d	100	30 to 600	30	not specified	7	3 to 14
Potassium, K	mg/kg d	2 500	1 700 to 4 000	2 500	2 000 to 4 000	5 000	1 500 to 6 000
Magnesium, Mg	mg/kg d	500	200 to 800	500	200 to 800	400	380 to 1 500
Manganese, Mn	mg/kg d	97	79 to 160	20	not specified	not specified	
Sodium, Na	mg/kg d	not specified	10 to 450	25	10 to 60	50	20 to 85
Phosphorus, P	mg/kg d	800	500 to 1 300	1 000	800 to 1 100	500	90 to 1 000
Silicon, Si	mg/kg d	500	2 to 2 000	not specified		30	28 to 46
Titanium, Ti	mg/kg d	10	< 10 to 50	not specified		0,3	0,2 to 1,7

Parameter	Unit	Willow (Salix) (1.1.1.3)		Poplar (1.1.1.3)		Eucalyptus (1.1.1.3)	
		Typical value	Typical variation	Typical value	Typical variation	Typical value	Typical variation
Arsenic, As	mg/kg d	< 0,1	< 0,1	< 0,1	< 0,1 to 0,2	< 0,4	< 0,4
Cadmium, Cd	mg/kg d	2	0,2 to 5	0,5	0,2 to 1	0,1	< 0,2
Chromium, Cr	mg/kg d	1	0,3 to 5	1	0,3 to 2	0,4	< 1
Copper, Cu	mg/kg d	3	2 to 4	3	2 to 4	3	3 to 4
Mercury, Hg	mg/kg d	< 0,03	< 0,03	< 0,03	< 0,03	not specified	
Nickel, Ni	mg/kg d	0,5	0,2 to 2	0,5	0,2 to 1,0	1	0,3 to 3
Lead, Pb	mg/kg d	0,1	0,1 to 0,2	0,1	0,1 to 0,3	1	0,3 to 2
Vanadium, V	mg/kg d	0,3	0,2 to 0,6	not specified		0,3	< 0,5
Zinc, Zn	mg/kg d	70	40 to 100	50	30 to 100	6	< 10

[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch, Spanish, French and German research. Formulas how to calculate different bases are given in ISO 16993.

Table B.5 — Typical values for virgin straw materials, with insignificant amounts of grains

Parameter	Unit	Straw from wheat, rye, barley (2.1.1.2)		Straw from oilseed rape (2.1.3.2)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	5	2 to 10	5	2 to 10
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	18,8	16,6 to 20,1	18,8	16,6 to 20,1
Net calorific value $Q_{p,net,d}$	MJ/kg d	17,6	15,8 to 19,1	17,6	15,8 to 19,1
Carbon, C	% in mass d	47	41 to 50	48	42 to 52
Hydrogen, H	% in mass d	6,0	5,4 to 6,5	6,0	5,4 to 6,5
Oxygen, O	% in mass d	41	36 to 45	41	36 to 45
Nitrogen, N	% in mass d	0,5	0,2 to 1,5	0,8	0,3 to 1,6
Sulfur, S	% in mass d	0,1	< 0,05 to 0,2	0,3	< 0,05 to 0,7
Chlorine, Cl	% in mass d	0,4	< 0,1 to 1,2	0,5	< 0,1 to 1,1
Fluorine, F	% in mass d	0,000 5	not specified	not specified	not specified
Aluminium, Al	mg/kg d	50	Up to 700	50	Up to 700
Calcium, Ca	mg/kg d	4 000	2 000 to 7 000	15 000	8 000 to 20 000
Iron, Fe	mg/kg d	100	Up to 500	100	Up to 500
Potassium, K	mg/kg d	10 000	2 000 to 26 000	10 000	2 000 to 26 000
Magnesium, Mg	mg/kg d	700	400 to 1 300	700	300 to 2 200
Manganese, Mn	mg/kg d	40	20 to 100	not specified	not specified
Sodium, Na	mg/kg d	500	Up to 3 000	500	Up to 3 000
Phosphorus, P	mg/kg d	1 000	300 to 2 900	1 000	300 to 2 700
Silicon, Si	mg/kg d	10 000	1 000 to 20 000	1 000	100 to 3 000
Titanium, Ti	mg/kg d	70	5 to 200	not specified	not specified
Arsenic, As	mg/kg d	< 0,1	< 0,1 to 2,0	< 0,1	< 0,1 to 0,5
Cadmium, Cd	mg/kg d	0,10	< 0,05 to 0,30	0,10	< 0,05 to 0,30
Chromium, Cr	mg/kg d	10	1 to 60	10	1 to 60
Copper, Cu	mg/kg d	2	1 to 10	2	1 to 10
Mercury, Hg	mg/kg d	0,02	< 0,02 to 0,05	0,02	< 0,02 to 0,05
Nickel, Ni	mg/kg d	1,0	0,2 to 4,0	1,0	0,2 to 4,0
Lead, Pb	mg/kg d	0,5	0,1 to 3,0	2,0	1,0 to 13,0
Vanadium, V	mg/kg d	3	1 to 6	not specified	not specified
Zinc, Zn	mg/kg d	10	3 to 60	10	5 to 20

[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch and German research. Formulas how to calculate different bases are given in ISO 16993.

Table B.6 — Typical values for virgin cereal grain materials

Parameter	Unit	Grain from wheat, rye, barley (2.1.1.3)		Grains from rape (2.1.1.3)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	2	1,2 to 4	4,3	3,75 to 5,5
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	18, 0	16,5 to 19, 6	28,1	27,5 to 29,0
Net calorific value $Q_{p,net,d}$	MJ/kg d	16,5	15,0 to 18,1	26,6	not specified
Carbon, C	% in mass d	45	42 to 50	60	not specified
Hydrogen, H	% in mass d	6,5	5,5 to 6,5	7,1	not specified
Oxygen, O	% in mass d	44	43 to 50	23	not specified
Nitrogen, N	% in mass d	2	not specified	3,8	not specified
Sulfur, S	% in mass d	0,16	0,05 to 0,1	0,1	not specified
Chlorine, Cl	% in mass d	0,11	0,05 to 0,5	0,07	0,01 to 0,15
Aluminium, Al	mg/kg d	not specified	< 20	not specified	not specified
Calcium, Ca	mg/kg d	600	100 to 1 200	5 000	3 200 to 6 400
Iron, Fe	mg/kg d	75	15 to 200	93	not specified
Potassium, K	mg/kg d	5 000	3 700 to 6 500	8 400	not specified
Magnesium, Mg	mg/kg d	1 400	1 000 to 2 100	2 600	not specified
Manganese, Mn	mg/kg d	30	9 to 60	39	not specified
Sodium, Na	mg/kg d	100	50 to 120	100	50 to 120
Phosphorus, P	mg/kg d	3 400	2 100 to 4 300	7 300	not specified
Silicon, Si	mg/kg d	50	10 to 200	not specified	not specified
Titanium, Ti	mg/kg d	not specified	< 50 to 100	not specified	not specified
Arsenic, As	mg/kg d	≤ 0,5	0,0 to 0,7	not specified	not specified
Cadmium, Cd	mg/kg d	0,01	0,0 to 0,7	not specified	not specified
Chromium, Cr	mg/kg d	0,5	< 0,5 to 1,0	not specified	not specified
Copper, Cu	mg/kg d	5	1,5 to 12	2,6	not specified
Mercury, Hg	mg/kg d	< 0,02	< 0,02	not specified	not specified
Nickel, Ni	mg/kg d	1,0	0,2 to 2,0	not specified	not specified
Lead, Pb	mg/kg d	0,9	≤ 0,1 to 1	not specified	not specified
Vanadium, V	mg/kg d	not specified	not specified	not specified	not specified
Zinc, Zn	mg/kg d	22	17 to 34	not specified	not specified

[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish, Dutch, French (including rye) and German research. Formulas how to calculate different bases are given in ISO 16993.

Table B.7 — Typical values for virgin reed canary grass

Parameter	Unit	Summer harvest (July – Oct) (2.1.2.1)		Delayed harvest (March – May) (2.1.2.1)	
		Typical value	Typical variation	Typical value	Typical variation
Ash	% in mass d	6,5	2,5 to 10	6,9	1,0 to 8,0
Gross calorific value $Q_{V,gr,d}$	MJ/kg d	17,7	not specified	17,8	17,7 to 18,0
Net calorific value $Q_{p,net,d}$	MJ/kg d	16,6	not specified	16,5	16,5 to 17,0
Carbon, C	% in mass d	46	not specified	46	45 to 50
Hydrogen, H	% in mass d	5,7	not specified	5,8	5,7 to 6,2
Oxygen, O	% in mass d	40	not specified	42	40 to 43
Nitrogen, N	% in mass d	1,3	not specified	0,9	0,4 to 2,0
Sulfur, S	% in mass d	0,1	0,1 to 0,2	0,13	0,04 to 0,17
Chlorine, Cl	% in mass d	0,5	0,2 to 0,6	0,025	0,01 to 0,09
Aluminium, Al	mg/kg d	not specified	not specified	not specified	20
Calcium, Ca	mg/kg d	3 500	1 300 to 5 700	2 000	800 to 3 200
Iron, Fe	mg/kg d	not specified	not specified	140	60 to 220
Potassium, K	mg/kg d	12 000	3 100 to 22 000	2 700	< 800 to 6 000
Magnesium, Mg	mg/kg d	1 300	300 to 2 300	500	100 to 900
Manganese, Mn	mg/kg d	not specified	not specified	160	< 200
Sodium, Na	mg/kg d	200	< 100 to 400	200	< 20 to 400
Phosphorus, P	mg/kg d	1 700	500 to 3 000	1 100	300 to 2 000
Silicon, Si	mg/kg d	12 000	< 1 000 to 25 000	18 000	2 300 to 30 000
Arsenic, As	mg/kg d	0,1	< 0,1 to 0,2	0,2	< 0,1 to 0,5
Cadmium, Cd	mg/kg d	0,04	< 0,04 to 0,10	0,06	< 0,04 to 0,20
Chromium, Cr	mg/kg d	not specified	not specified	not specified	not specified
Copper, Cu	mg/kg d	not specified	not specified	not specified	not specified
Mercury, Hg	mg/kg d	0,03	< 0,02 to 0,05	0,03	< 0,02 to 0,05
Nickel, Ni	mg/kg d	not specified	not specified	not specified	not specified
Lead, Pb	mg/kg d	1,0	< 0,5 to 4,0	2,0	< 0,5 to 5,0

[a] Data are obtained from a combination of mainly Swedish, Finnish, Danish and German research. Formulas how to calculate different bases are given in ISO 16993.