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Solid biofuels — Characterization of wood chip fuels — Essential information for producers, suppliers and users

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Foreword

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This document was prepared by Technical Committee 238, *Solid biofuels and pyrogenic biocarbon*.

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

For effective use of solid biofuels in heating and power facilities, it is crucial to assess fuel quality starting from the planning stage through daily routine operation. It is equally critical to be familiar with the quality specifications needed for a particular application and to determine key fuel properties using proven and well-validated test methods.

Numerous International Standards exist to characterize various types of solid biofuels, including wood chips, pellets, and briquettes for a variety of residential, commercial, and industrial applications. In addition to providing detailed information on fuel specifications and classes and test methods, these International Standards make it possible to draw up clear and unambiguous fuel supply contracts. They also support the creation of quality assurance and certification systems.

Wood chips are among the most commonly used solid biofuels in space heating applications in commercial and institutional buildings, district heating, light industry and greenhouses. Wood chips specifications and test methods are described in a large number of International Standards, either as stand-alone, or as part of International Standards addressing various types of solid biofuels.

This document is intended primarily for wood chip producers, traders, and owners and operators of energy facilities in small to medium residential, commercial and public sectors. It is based on relevant International Standards. The aim of this document is to provide practical guidance and examples on quality specifications relevant to wood chips, presents guiding principles for assessing the quality of wood chip fuel and gives common procurement approaches. Only those quality properties and their test methods that are critical for both internal quality control purposes and smooth and efficient boiler operation are included in this document.

Clause 4 describes general information about the quality of wood chips. Clause 5 provides guidance on test methods for the determination of essential physical properties of wood chips. These tests can be performed on a regular basis at the site of the wood chip fuel producer, fuel supplier or energy facility. Sampling and sample preparation are also described in Clause 5. A calculation tool, covering the properties described in Clause 5, is available as an MS Excel document[1)] to assist users in recording, calculating and reporting test results in a consistent manner. Clause 6 provides practical information on essential tests that are carried out by external laboratories. Annex A gives an empirical formula to calculate energy content of wood chips. Annex B gives an example of a sampling plan and sampling report. Annex C includes examples of data logging tables that can be used in reporting test results. Annex D shows key information expected to be found in a laboratory report of graded wood chips.

The sampling techniques and test methods described in this document are aligned with the methods given in the corresponding International Standards, with minor modifications to some steps, such as sample size, sampling frequency, number of replicates, or measurement time. This is done to make them more practical for routine testing. As such, the methods described in this document can lead to minor differences in the results when compared with the corresponding International Standards. These differences will not impact the reliability of assessing changes to the properties of wood chips when measured on a relative, day-to-day basis. Boiler operators, owners and fuel producers are encouraged to incorporate them into their regular quality monitoring and control routines.

1) Accessible at: https://standards.iso.org/iso/ts/17595/ed-1/en

Solid biofuels — Characterization of wood chip fuels — Essential information for producers, suppliers and users

1 Scope

This document provides guidance on the characterization of wood chips produced from raw materials, as defined in ISO 17225-4, for the following aspects:

— quality classes and specifications;

— sampling, sample preparation and test methods for physical characteristics which can be conducted on site;

— practical information about testing to be carried out by external laboratories.

This document provides additional information about the type and frequency of testing at an energy plant site, starting from the planning and start-up stages of a project and throughout its regular operation.

This document is applicable for assessing changes in properties on a relative basis when testing is done routinely. This document is not applicable for demonstrating conformance with the referenced International Standards.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes the 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 16559, *Solid biofuels — Vocabulary*

3 Terms and definitions

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

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

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

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

4 Quality specifications for wood chips

4.1 General

Successful operation of a wood chips based bioenergy facility strongly depends on ensuring a good match between wood chips quality, fuel handling equipment and the conversion technology.

Before investing in a boiler or gasifier, it is essential to determine key characteristics of the fuel intended to be used, such as its origin and sources, typical moisture content, particle size distribution, ash content and bulk density. This information will help equipment suppliers make appropriate recommendations on the type and design of boilers and of equipment for fuel handling and storage.

Table 1 summarizes the generalized relationship between wood chips quality, installation types and sizes. The size ranges used for grouping the applications in Table 1 are meant for illustrative purposes only and in

practice some overlap between the applications and the scales is expected. Wood chips quality requirements and tolerance to variance in fuel quality depend on the size and type of energy conversion technology and the design specifications of the equipment as defined by Original Equipment Manufacturers. For example, medium to large scale boilers and heaters can typically accept wood chips with higher moisture content and chip size as well as higher variance in the wood chip fuel quality from minute to minute with almost no impact on operation; whereas small-scale gasification combined heat and power (CHP) systems demand stricter fuel quality requirements with low moisture content and narrow particle size distribution and cannot tolerate almost any variance in the wood chip fuel quality from minute to minute without upsetting the process. It is considered a best practice for each facility to implement a wood chip fuel quality management plan [2].

Similarly, the particle size distribution of wood chips has an impact on the selected type and sizing of feeding systems. For example, fuel feeding systems such as augers are sensitive to oversized particles and need to be sized properly.

Table 1 — Typical association between wood chips quality and applications

Installation size and type	Range of Moisture content (M) % in mass, as received	Particle size (P)	Production processes
Boilers up to 100 kW	15 % – 35 %	P16s, P16, P31s Maximum length of 120 mm	Sieving and drying are typically needed
Boilers from 100 kW to 500 kW — firing system: underfed, grate etc.	< 40 % depending on the conversion system	P 31s, P45s Maximum length of 120 mm or 200 mm, depending on the feeding system	Seasoning is preferred; sieving and drying are sometimes needed
Gasification based CHP systems up to 500 kW — updraft gasifier — downdraft gasifier	> 30 % < 15 %	P45s Sensitive to fines and long particles	Drying and sieving of fines and large particles are typically needed
Boilers from 500 kW to 1,5 MW — firing system: underfed, grate etc.	< 45 % depending on the conversion system	P45, P63 depending on the feeding system	
Boilers and CHP systems from 1,5 MW to 5 MW — firing system: fluidized bed, grate etc.	< 55 % depending on the conversion system	P45, P63 depending on the feeding system	

There are three fuel specification standards relevant to wood chips quality in the ISO 17225 series, namely ISO 17225-1 which specifies general requirements, ISO 17225-4 on graded wood chips and ISO 17225-9 on graded hog fuel and wood chips for industrial use.[3] ISO 17225-1 describes the fuel quality classes for a broad range of solid biofuels produced from raw and processed materials originating from forestry, agricultural and aquaculture activities and forms the basis for subsequent parts in the ISO 17225 series. Quality properties and classes for wood chips suitable for residential and commercial space heating applications are described in ISO 17225-4. ISO 17225-9 defines the fuel quality classes and specifications of graded hog fuel and wood chips for industrial use. Compared to ISO 17225-4, ISO 17225-9 encompasses a wider range of raw materials and allows higher threshold values for various property classes.

4.2 Classification of raw material

The origin and source of raw materials for wood chips production, as per the classification in ISO 17225–4, are summarized in Table 2. Those interested in the full list of all raw materials for solid biofuels and wood chips can refer to Table 1 in ISO 17225-1.

Table 2 — Origin and source of raw materials for graded wood chips (based on ISO 17225-4)

1.1 Forest, plantation and other virgin wood	1.1.1 Whole trees without roots 1.1.3 Stemwood 1.1.4 Logging residues 1.1.7 Segregated wood from gardens, parks, roadside maintenance, vineyard, fruit orchards and driftwood from freshwater
1.2 By-products and residues from wood processing industry	1.2.1 Chemically untreated wood by-products and residues 1.2.2 Chemically treated by-products and residues, fibres and wood constituents (excluding fibres and wood constituents)
1.3 Used wood	1.3.1 Chemically untreated used wood

Drying and/or screening of raw materials may be needed when producing wood chips from materials such as logging residues, short rotation coppice and wood from gardens, parks, roadside maintenance, vineyards, fruit orchards and driftwood from freshwater. These processes can reduce bark and fines contents and remove heavy extraneous materials (such as stones, sand, solid etc) ensuring the intended quality class according to ISO 17225-4 are achieved.

Bark and chemically treated used wood are not suitable as raw material for use in energy conversion systems that are specifically designed for residential, commercial, and institutional applications.

4.3 Normative and informative properties of graded wood chips

For fuels classes defined in ISO 17225-4, the properties that are mandatory to determine are defined as normative properties. Informative properties are those that are voluntary to determine, and they can be a useful tool for effective communication between the seller and buyer. Table 3 describes normative and informative parameters for wood chips according to ISO 17225-4. Even though the property of heavy extraneous materials is neither normative nor informative, it is included in this document as it can be an important quality parameter to take into consideration.

Table 3 — Normative and informative properties for graded wood chips

Properties	Standard	Graded wood chips (ISO 17225-4)	
		Class A1/A2	Class B1/B2
Origin and source	ISO 17225-4	normative	normative
Particle size (P)	ISO 17827-1	normative	normative
Moisture content (M)	ISO 18134-2	normative	normative
Ash content (A)	ISO 18122	normative	normative
Content of nitrogen (N), sulfur (S) and chlorine (Cl)	ISO 16948	---	normative
Minor elements (such as Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni) and Zinc (Zn))	ISO 16968	---	normative
Net calorific value (Q)	ISO 18125	informative	informative
Bulk density (BD)	ISO 17828	informative	informative
Heavy extraneous materials (EM)	ISO19743	---	---

4.4 Classification of particle size classes and fines fractions

Raw woody biomass can be comminuted to wood chips or hog fuel. Wood chips consist of sub-rectangular shape pieces with a typical length of 5 to 50 mm and are produced by sharp tools such as knives. Graded wood chips are suited for automatically fed energy conversion installations. Hog fuel, on the other hand, is comprised of pieces with varying sizes and shapes as it is produced using blunt tools such as crushers/grinders, which break the raw woody biomass.[3] Hog fuel is much more fibrous and undefined in size; therefore, it is better suited for large installations (> 5 MW) with an appropriate fuel handling system.

Particle size and fines classifications for wood chips according to ISO 17225-4 are shown in Tables 4 and 5, respectively. A sample can only belong to one size class, which is always the lowest possible class based on the main fraction. Ps-classes additionally limit fines content and maximum length of particles.

Wood chips belonging to one of the Ps-classes are intended to be used in residential and small-scale commercial applications while the other P-classes are for larger scale applications.

Table 4 — Classification of particle size distribution of graded wood chips (based on ISO 17225-4)

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	Max. length of particles (L), 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	values from F-classes in Table 5	value to be reported
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		

Table 5 — Classification of fines fraction for graded wood chips (based on ISO 17225-4)

Fines fraction, F (< 3,15 mm, % in mass)			
F02	≤ 2	**F20**	≤ 20
F05	≤ 5	**F25**	≤ 25
F10	≤ 10	**F30**	≤ 30
F15	≤ 15	**F30+**	> 30 (maximum value to be reported)

4.5 Specifications of graded wood chips in accordance with ISO 17225-4

In the ISO 17225 series , graded means that solid biofuel used in a particular application (household, commercial, public-sector buildings, or industrial) meets specified properties expressed by quality classes like A1, A2, B1 or B2. Key specifications for graded wood chips, in accordance with ISO 17225-4, are presented in Figure 1. Bulk density and calorific values, though important, are not captured in Figure 1; their typical ranges can be found in Table 6.

Class A1 represents wood chips with lower ash content, indicating no or very little bark, and lower moisture content. If the moisture value is below 10 % in mass, it needs to be reported explicitly. Some technologies, such as small downdraft gasification-based CHP (up to 500 kW), often require Class A1 wood chips with moisture level below 20 % in mass. Wood chips in Class A2 may have a higher moisture content. Threshold values for N, S, Cl and minor elements are not required for Class A1 and A2 wood chips as these classes of fuels are produced from virgin material and chemically untreated wood residues.

Class B1 extends the origin and source of class A to include other materials, such as short rotation coppice, wood from gardens and plantation, and chemically untreated by-products and residues from the wood processing industry. Class B2 further extends the raw material to include chemically treated wood from the wood processing industry, by-products and residues from the aforementioned industry and chemically untreated used wood. Class B2 does not allow chemically treated raw materials containing halogenated organic compounds or heavy metals exceeding virgin wood levels.

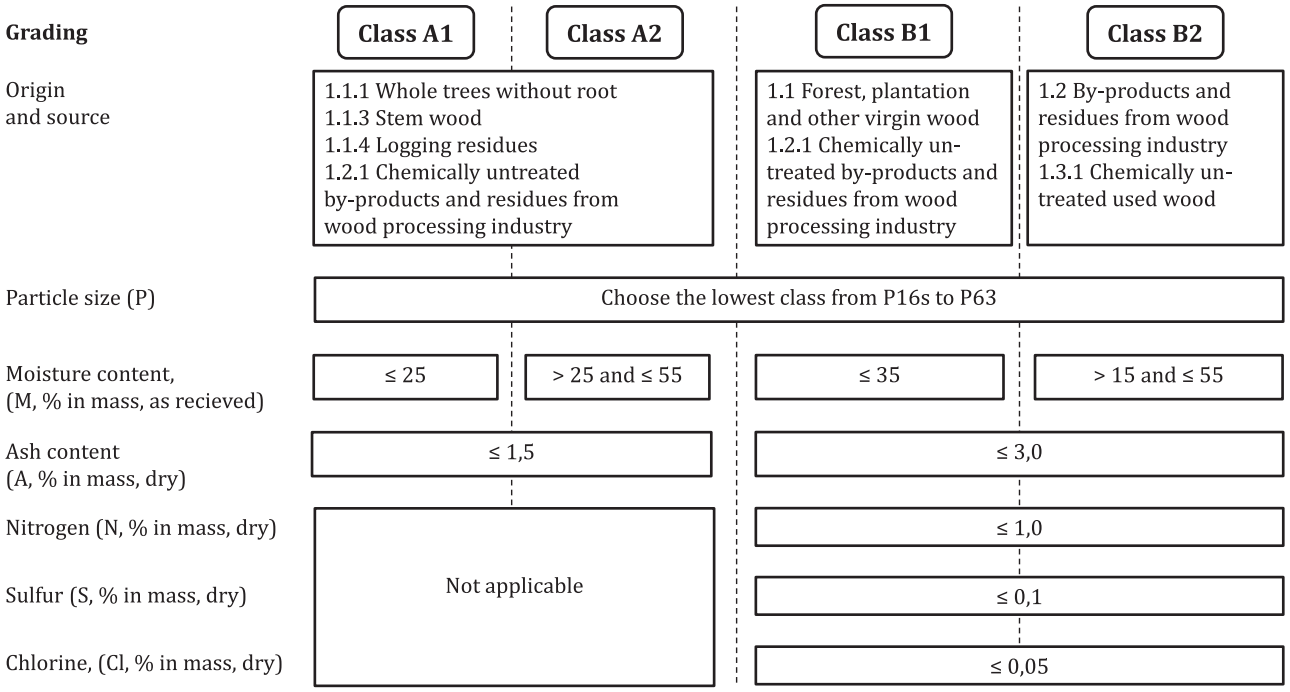

Figure 1 — Key specifications of graded wood chips (based on ISO 17225-4)

4.6 Typical ranges for key quality properties

Typical values for a selected number of key properties of wood chips are shown in Table 6. The values presented in Table 6 are for two sources of wood chips covering opposite ends of the spectrum, i.e. wood with no or insignificant amounts of bark, needles and leaves vs logging residues. Additional values for a broader range of solid biofuels can be found in ISO 17225-1:2021, Annex B.

Table 6 — Typical values of selected properties for various sources of wood chips (partly based on ISO 17225-1:2021, Table B.1 and B.3)[a]

Origin and source		Wood without or with insignificant amounts of bark, needles/leaves from				Logging residues from			
		Coniferous wood		Broad-leaf wood		Coniferous wood		Broad-leaf wood	
Parameter	**Unit, dry basis**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Ash content	% in mass	0,3	0,1 to 1,0	0,3	0,2 to 1,0	3,0	< 1 to 10	5,0	2 to 10
Gross calorific value	MJ/kg	20,5	20,0 to 20,8	20,1	19,4 to 20,4	20,5	19,5 to 21,5	19,7	19,5 to 20,0
Net calorific value	MJ/kg	19,1	18,5 to 19,8	18,9	18,4 to 19,2	19,2	18,5 to 20,5	18,7	18,3 to 18,5
Nitrogen (N)	% in mass	0,1	< 0,1 to 0,5	0,1	< 0,1 to 0,5	0,5	0,3 to 0,8	0,5	0,3 to 0,8
Sulfur (S)	% in mass	< 0,02	< 0,01 to 0,02	0,02	< 0,01 to 0,05	< 0,02	< 0,02 to 0,06	0,04	0,01 to 0,08
Chlorine (Cl)	% in mass	0,01	< 0,01 to 0,02	0,01	< 0,01 to 0,02	0,01	< 0,01 to 0,04	0,01	< 0,01 to 0,04
Calcium (Ca)	mg/kg	900	500 to 1 000	1 300	600 to 3 000	5 000	2 000 to 8 000	4 000	3 000 to 5 000

[a] Typical values for Ca and Cl were collected from European laboratories and provided by BEA (Austria). Values marked by < are below determination limits.

Table 6 *(continued)*

Origin and source		Wood without or with insignificant amounts of bark, needles/leaves from				Logging residues from			
		Coniferous wood		Broad-leaf wood		Coniferous wood		Broad-leaf wood	
Parameter	**Unit, dry basis**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Potassium (K)	mg/kg	400	200 to 500	800	500 to 1 500	2 000	1 000 to 4 000	1 500	1 000 to 4 000
Magnesium (Mg)	mg/kg	150	100 to 200	200	100 to 400	800	400 to 2 000	250	100 to 400
Sodium (Na)	mg/kg	20	10 to 50	50	10 to 200	200	75 to 300	100	20 to 200

[a] Typical values for Ca and Cl were collected from European laboratories and provided by BEA (Austria). Values marked by < are below determination limits.

The values in Table 6 do not take into account variations caused by the method of harvesting and/or storage. For example, the ash content can be substantially higher for wood chips containing extraneous materials such as soil, or the net calorific values can be lower for biologically degraded wood chips.

4.7 Principles for assessing the quality of wood chip fuel

The types and frequency of wood chips quality assessment vary depending on the stages of a project, i.e., planning, start-up and regular operation, as shown in Table 7.

At the planning stage, it is essential to define the origin and sources and key attributes of the wood chips that will be used, including its typical range for moisture content, particle size distribution, ash content, bulk density and heavy extraneous materials. These values, which must be determined by an external laboratory, will form the baseline for later comparison, and will help equipment suppliers determine the type and design of fuel handling, storage and boiler or gasification system.

At the start-up phase, it is not necessary to repeat the aforementioned analyses, except moisture content determination, unless it is suspected on visual inspection that the wood chips quality differs from those previously determined at the planning phase.

Table 7 — Typical frequency of analysis of graded wood chips for the end-user

Properties	Frequency at		
	Planning phase [a]	**Start-up phase**	**Regular operation [b]**
Moisture content	2-3 times	Every lot	Every lot
Bulk density	Once	If a change expected or suspected	Once a year
Particle size distribution	Once	If a change expected or suspected	Once a year
Ash content	Once	If a change expected or suspected	Once a year
Calorific value	Once	If a change expected or suspected	If a change is expected or suspected
Heavy extraneous materials	Once	If suspected	If suspected

[a] Fuel analysis during planning stage is typically performed by external laboratories

[b] It is recommended to send samples to external laboratory to verify baseline and compare with daily results