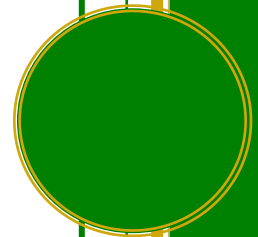


Standard Methods for Verifying the Quality of Solid Biofuel

Bioenergy Association Technical Guide 05

Version 2
May 2023



About this Guide:

1. The compilation of this Technical Guide has been facilitated by contributions and oversight of the expert members of the Solid Biofuels Interest group of the Bioenergy Association.
2. The aim of the Association's Technical Guides is to encourage delivery of high quality and consistent best practice bioenergy solutions. These Guidelines are voluntary but essentially provide a regulatory framework for the New Zealand bioenergy and biofuels sector.
3. The Guide is an outcome of industry discussion and collaboration. It captures the collective technical knowledge of a range of relevant leading bioenergy sector personnel. In addition, it benefits from the collective review and use by relevant asset owners, guide users, policy makers and regulators.
4. This version of the Guide is based on international standards and best practice.
5. This guide is provided in good faith as an addition to the ongoing body of knowledge relating to the bioenergy and biofuels sector in New Zealand and Australia. However, as the Guide is general and not specific to any application, the Association and none of those involved with its preparation accept any liability either for the information contained herein, or its application.
6. As with all Bioenergy Association technical guidance documents, this guide is a 'living document' and will be revised from time to time and reissued, as new information comes to our attention. If you have suggested additions to this Guide please contact admin@bioenergy.org.nz.
7. This Version 2 of the Guide has been updated to include the latest international standards and recognized best practice.
8. Any enquiries regarding these guidelines should be referred to:
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CAVEAT

Bioenergy Association recommends that any party undertaking a project to upgrade or replace a bioenergy facility should undertake a full evaluation of all possible options prior to fixing on a specific new project solution.

As a decision maker, it's important to understand the pros and cons of each option and have them set out by an appropriate expert in a way that ensures they are easily comparable. Too often a client rushes into a solution without properly evaluating all the options.

These Technical Guides are only a guide and users should ensure that they have engaged appropriate expert to consider their specific application.

EXECUTIVE SUMMARY

This document provides the recommended methods for determining the quality of solid biofuels for the New Zealand and Australian biomass energy markets, and for Bioenergy Association accreditation of suppliers of solid biofuel. Also included are recommended standard methods for sampling and testing. These methods are to be used where buying and selling solid biofuels, or when any question or dispute arises regarding the quality of solid biofuel. The methods presented build on the solid fuel classifications set out in the Bioenergy Association Solid Biofuel Classification Guidelines¹.

Internationally there are a number of standards for sampling and testing the quality of solid biofuels. This document sets out the recommended standards and best practices most relevant to buying and selling solid biofuels in New Zealand and Australia

Having standards as set out in the Guidelines provides a language which allows solid biofuels to be described in an accurate and unambiguous way for both buyers and suppliers. While petrol and diesel may appear superficially to be very similar, if you put the wrong one in your car you won't get home and you'll receive an expensive repair bill. Similarly, if you put biofuel of the wrong moisture content or chip size in your chip boiler that too will stop working, you'll get cold and receive an expensive repair bill! Or if you use unseasoned firewood on a wood burning stove you will also get cold, and spend more money on fuel, maintenance and replacing the boiler earlier than you need to.

Quality assurance that the biofuel supplied meets the contract specification ensures that both buyers and sellers are happy, and heat plant in which the fuel is to be combusted operates with optimal performance.

The key parameters that need to be specified in an unambiguous way for solid biofuel are:

- Moisture content – because water doesn't burn!
- Dimensions – to make sure it fits the appliance and its fuel handling system
- Origin – where does it come from and what does it consist of
- Ash content
- Energy density – with high density biofuel you need less trucks for delivery

This document should be read in conjunction with:

- *Technical Guide 1 - Solid Biofuel Classification Guidelines*, and
- *Technical Guide 6 – Contracting to deliver Quality Solid Biofuel to Customers*².

¹ <https://www.usewoodfuel.org.nz/resource/tg01-solid-biofuel-classification-guidelines>

² <https://www.usewoodfuel.org.nz/resource/tg06-contracting-deliver-quality-wood-fuel-customers>

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1 Introduction

The sale and purchase of solid biofuels is generally based on the energy content of the fuel. Boiler systems are designed for specific types of solid biofuel and with specified characteristics related to combustion, storage or handling. These requirements will be set out in a fuel sale and purchase contract.

To calculate energy content of the fuel the moisture content and calorific value are the most significant characteristics. The weight or volume of fuel delivered is critical for calculating total energy supplied. Size and degree of fines in the fuel are important for efficient fuel handling and storage.

The 'Bioenergy Association Solid Biofuel Classification Guidelines'³ set out descriptions of fuel types and were developed by the Bioenergy Association as voluntary best practice standards for New Zealand and Australian biomass fuel trading markets. The Guidelines provide a means for wood fuel suppliers to classify their wood pellets, hog fuel, wood chips, firewood etc and to provide clarity to fuel sellers and users of the solid biofuels traded. The Guidelines are based on international quality standards for solid biofuel energy.

Previous versions of this and other Technical Guides only referred to wood fuel. The biomass energy market has widened in recent years to include a wide range of other biomass fuels, these are referred to as solid biofuels. However, in New Zealand wood fuel is by far the largest form of solid biofuel so these terms should be considered as interchangeable. Where any text uses the term wood fuel it should be considered as solid biofuel.

This document sets out recommended verification sampling and testing methodologies so that buyers and sellers of solid biofuels will have confidence that the fuel traded is what it is specified to be.

To ensure an efficient solid biofuels supply market, it is important that suppliers and end users understand the range of biomass fuels that are being traded and to ensure that purchasers of solid biofuels can be confident that they are receiving what they ordered. Each boiler system will have been designed for a specific fuel and the specification for this fuel will be included within a sale and purchase contract. Solid biofuels must be manufactured to meet that specification.

If market participants are to sell and buy specified biofuel then it is important for both parties to have consistently agreed methods for verification of quality. This requires agreed standards and methodologies on sampling and testing of the fuel. They also need to be able to access facilities or laboratories that have been approved to undertake an agreed standard set of tests to ensure the quality of the fuels.

While this Technical Guide covers all solid biofuels the primary focus in New Zealand is, and is likely to be for some time, on wood so many examples or discussions will be wood focused. Generally, the same advice will apply to other solid biofuels.

³ <https://www.usewoodfuel.org.nz/resource/tg01-solid-biofuel-classification-guidelines>

Biofuel suppliers should have a well-documented quality assurance (QA) protocol which assures the fuel purchaser that the fuel delivered is as per the specification in the sale and purchase contract. A fuel suppliers quality assurance system will be based on fuel sampling and testing methods as set out in the Guide. Having a sound QA system ensures a fuel supplier is well protected should there be any allegation of the fuel causing difficulties when combusted.

This document sets out what sampling and testing methods should be adopted by solid biofuel suppliers to verify the quality of solid biofuel being delivered to customers. These testing standards are provided to encourage consistency and predictability among fuel suppliers and to provide the framework for accrediting fuel suppliers. It is recognised that alternative testing methods do exist and, in some circumstances, can be used – but in such cases evidence should be provided to validate the use of such alternatives. The Bioenergy Association is open to receiving recommendations for inclusion of these alternative methods into these Guidelines.

Internationally there are a number of standards for sampling and testing the quality of solid biofuels. This document sets out the recommended methods that should be used for sampling and testing solid biofuels and which will be compliant with the Bioenergy Association's Fuel Supply Accreditation Scheme. These standard methods are applicable to New Zealand and Australian conditions and have been developed with input from the solid biofuel supply sector.

The recommended methods provided in this document are based on the standard international methods, but they have been modified and simplified to allow solid biofuel operators to adopt a more pragmatic approach to fuel sampling, testing and reporting for sale or accreditation purposes.

A list of appropriate testing laboratories in both New Zealand and Australia is also included in this document. This list will be periodically updated and posted on the Bioenergy Association website: www.usewoodfuel.org.nz

This document covers only fuel quality and should be read in conjunction with:

1. *Technical Guide 1 - Solid Biofuel Classification Guidelines*, and
2. *Technical Guide 6 – Contracting to deliver Quality Solid Biofuel to Customers*⁴.

Technical Guide 6 suggests that for the purpose of selling and buying solid biofuels that only the following fuel characteristics are important:

- Moisture content
- Particle size
- Calorific value
- Bulk density
- Ash content

This Guide recommends the methods for sampling and testing for these characteristics but for completeness also indicates the testing methods for other characteristics which may need to be known for diagnostic or dispute resolution.

⁴ <https://www.usewoodfuel.org.nz/resource/tg06-contracting-deliver-quality-wood-fuel-customers>

2 Scope

The guide is presented in two parts, namely:

1. The recommended sampling methods. These have been simplified from the formal international standards and are recommended for the sale and purchase of solid biofuels in New Zealand and Australia.
2. The recommended testing methods for each level of quality assurance. These are derived from the international standards and are limited to the five important characteristics for the sale and purchase of solid biofuels.

The methods presented relate to the buying and selling of all solid biofuels, though it is expected that in most cases the testing will relate specifically to wood.

Where in depth testing is required, specifically for diagnostic activities, the referenced formal international standards should be referred to.

3 International Sampling and Testing Standards

This Guide is a simplification of international standards for sampling and testing solid biofuels being sold and purchased in the New Zealand and Australian bioenergy markets. For most sale and purchase of solid biofuels it is not necessary to refer to the full standards, however there are key methods and practices which should be followed as part of a fuel suppliers quality assurance system. Reference to the full standards are necessary for diagnostic or dispute situations.

The standard methods for sampling of solid biofuels are set out in:

- ISO 21945:2020 *Solid biofuels -- Simplified sampling method for small scale applications*, and
- ISO 18135:2017: *Solid Biofuels -- Sampling*.

Table 1: International solid biofuel testing standards

Field Moisture Content – fuel delivery testing	Low-cost instruments may be useful for an indication of wood fuel moisture but results would not provide adequate certainty for fuel supply contracts without being supported by verification testing. The verification testing is necessary for fuel delivery auditing purposes.
Total Moisture – Site testing	Solid biofuels – Determination of moisture content-Oven dry method-Part 2 Total moisture- Simplified Method ISO 18134-2: 2017. Some inexpensive instruments such as basic oven moisture tests on-site for processing quality control at a fuel suppliers processing site might provide adequate certainty but these should be supported by regular verification tests from an independent laboratory.
Moisture in Laboratory verification testing	Solid Biofuels - Determination of moisture content – Oven dry method – Part 3: Moisture in general analysis sample ISO 18134-3:2015
Ash Content	Solid Biofuels - Determination of ash content ISO 18122:2015.
Ash Fusion Temperature	Solid biofuels -- Determination of ash melting behaviour ISO 21404:2020

Volatile Matter Content	Solid biofuels -- Determination of the content of volatile matter ISO 18123:2015
Net calorific value	Solid biofuels -- Determination of calorific value ISO 18125:2017
Particle size distributions ⁵	<p>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 17827-1:2016</p> <p>Solid Biofuels -- Determination of length and diameter of pellets ISO 17829:2015</p> <p>Solid biofuels -- Particle size distribution of disintegrated pellets ISO 17830:2016</p>
Quantifying the amount of fines	<p>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 17827-2:2016</p> <p>Solid biofuels -- Determination of fines content in quantities of pellets ISO 18846:2016</p> <p>Solid biofuels -- Determination of fines content in quantities of pellets -- Part 2: Simplified method ISO/CD 18846-2 [Under development]</p>
Particle density	Solid biofuels -- Determination of particle density of pellets and briquettes ISO 18847:2016
Bulk density	Solid biofuels -- Determination of bulk density ISO 17828:2015
Mechanical durability of pellets and briquettes	<p>Solid biofuels -- Determination of mechanical durability of pellets and briquettes -- Part 1: Pellets ISO 17831-1:2015</p> <p>Solid biofuels -- Determination of mechanical durability of pellets and briquettes -- Part 2: Briquettes ISO 17831-2:2015</p>
Water soluble chloride (Cl) content, sodium (Na) and potassium (K)	Solid biofuels -- Determination of the water-soluble chloride, sodium and potassium content ISO 16995:2015
Heavy extraneous materials	Solid biofuels -- Determination of content of heavy extraneous materials larger than 3.15 mm ISO 19743:2017
Sulphur (S) and chlorine (Cl) content	Solid biofuels -- Determination of total content of sulphur and chlorine ISO 16994:2016
Major elements (Al, Si, K, Na, Mg, Fe, P and Ti)	Solid biofuels -- Determination of major elements -- Al, Ca, Fe, Mg, P, K, Si, Na and Ti ISO 16967:2015
Minor elements (As, Ba, Be, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Pb, Se, Te, V and Zn)	Solid biofuels -- Determination of minor elements ISO 16968:2015
Carbon, Hydrogen and Nitrogen Content (Ultimate analysis)	Solid biofuels -- Determination of total content of carbon, hydrogen, and nitrogen ISO 16948:2015

5

4 Levels of sampling and testing

For the purposes of assessing and verifying the consistency and quality of solid biofuels being delivered to a site, a range of different levels of testing is recommended according to the application. The appropriate level of testing will depend on whether it is a type test, verification test, or a special test and the nature and scale of the supply.

A 'type' test is undertaken to fully describe the origin, source and type of solid biofuel. The test results will be of particular interest to a heat plant owner/operator as it will effectively define the type of fuel that will be supplied so that they can check the fuel suitability for the design specific to a particular heat plant.

A 'verification test' is typically undertaken repeatedly at predetermined intervals and effectively serves to confirm that the solid biofuel being regularly supplied corresponds to the type-tested product (i.e. that it complies with a contracted fuel specification).

A 'special test' will be carried out to assess non-compliance with agreed specifications, when production has been suspended for a period of time (6 months), or is required for diagnostic purposes by another third party.

The recommended levels of testing for a verification test are:

- Level 1: Measurement of volume and moisture at the point of processing or delivery using simple methods such as a bin moisture meter or processing site testing. This is a simple form of moisture compliance testing to validate the quantity of fuel supplied and ensure that the moisture content is within contractual limits for efficient operation of the heat plant and compliance to contract specifications. This test will also provide data for calculation of the energy content of the quantity of fuel delivered.
- Level 2: Limited laboratory verification testing of size, moisture, % ash, and calorific value. This level of testing would be selected for verification testing with the frequency being agreed between the supplier and end-user.
- Level 3: Full laboratory testing necessary for diagnostic purposes. This level of testing would apply to type-tests and in many cases special tests. It is expected a full suite of fuel parameters (as referred to in Table 1 below) would be considered for this level of testing.

These levels of testing are provided as a pragmatic means for solid biofuels to be evaluated for compliance with a contract on a regular 'monitoring' basis.

Sampling and testing of solid biofuels needs to take into account the following:

- Selection of appropriate methods to suit the specific purpose of sampling and testing
- The cost of sampling and testing and taking into account the frequency and range of parameters to be assessed.
- The logistical aspects of collecting samples from specific solid biofuel preparation, distribution and fuel handling systems.
- The range of factors that will influence the representativeness of a sample and the potential risk of contamination.

5 Sampling

The aim of correct sampling is to obtain a representative sample (samples) from the whole quantity (generally a delivered truck load) to which it will apply. Every particle in the delivered truckload represented by the sample should have an equal probability of being included in the sample. In order to do so, a sampling plan should be agreed by the buyer and seller of the fuel and set out in the fuel sale and purchase contract.

To support the different levels of testing suggested in Section 4 there is a need for pragmatic approaches to sampling that can be used for day to day operations by a solid biofuel supplier.

The more detailed methods of sampling as set out in the international standards are most appropriate for type testing, special tests or level 3 testing.

For Level 2 and 3 testing three different sampling approaches are provided with each approach being considered for a specific purpose and to align with particular level of testing. The levels of testing and their associated type of sampling are briefly described in Table 2. The applications for the recommended types of sampling are:

Type A: Low level sampling for the day to day operation and trading of solid biofuels;

Type B: Sampling for limited laboratory testing; and

Type C: Sampling for full laboratory testing and for complete fuel type descriptions and special analyses.

Table 2. Matrix of types of sampling and associated levels of testing

Levels of Testing	Types of sampling		
	A	B	C
	Low level sampling for day to operation	Sampling for limited laboratory verification testing	Sampling for full laboratory diagnostic testing
1 (Measurement of moisture at the point of delivery using simple methods)			
2 (Limited site laboratory testing for particle size, moisture, % ash and calorific value)			
3 (Full external laboratory testing)			



Approved* sampling regime and regarded suitable for purpose



Approved* sampling though a more simple method is available



Non approved* sampling regime for the specific type of fuel testing

* Approved for purposes of accreditation under the Wood Fuel Supply Accreditation Scheme

Although types A and B sampling regimes provide simple cost effective options for sampling, it is critical that for any sampling approach that the overall objective is to obtain a representative sample and therefore best practice principals should always be deployed and the default specification is as described in ISO 21945:2019. Sampling for Type C situations should follow ISO 181345:2017.

The main purpose of sample preparation is that a sample is reduced to one or more test portions that are in general smaller than the original sample. The main principle for sample reduction is that the composition of the sample as taken on site shall not be changed during each stage of the sample preparation. Each sub sample shall be representative of the original sample. To reach this goal every particle in the sample before sample division shall have an equal probability of being included in the sub-sample following sample division. Two basic methods are used during the sample preparation. These methods are: sample division and particle size-reduction of the sample. The Standard also gives information on suitable apparatus for sample division. A guideline for minimum masses to be retained after each sample division stage, depending on the nominal top size of the material are provided also in the Standard.

5.1 Standard Sampling Methods

Incorrect sampling of solid biofuels to determine their characteristics can introduce significant bias into the analysis of properties of fuels. The most important steps in solid biofuel fuel testing are ensuring that correct sampling and preparation procedures have been used so that the wood particles contained in a small sample container can represent, for example, a wood pellet shipment as large as 20,000 tonnes.

ISO 181345:2017 describes general sampling methods for solid biofuels including sampling particulate material transported in lorries. The most important feature of the sampling standards is the calculation of the size and number of increments (based on nominal top particle size) that must be sampled in a systematic manner from a conveyor belt or truck load or stockpile etc. to ensure that a representative sample is taken.

The fuel supplier should develop a sampling plan according to the type of fuel being delivered and the significance of particle size. A suggested sampling for truck loads is:

- For shavings or sawdust, a load of <30 tonnes should have a minimum of 6 increments while a consignment of 240 tonnes (several truckloads) should have 11 increments (but a minimum of 2 per truckload).
- For a homogeneous fuel like wood chips or pellets, there should be 11 increments for <30 tonnes and 20 for 240 tonnes.
- For a heterogeneous fuel like bark, there should be 22 increments for <30 tonnes and 34 for 240 tonnes.

The sampling tool must have a minimum capacity in litres of 0.05 times the nominal top size (mm) with a minimum of 0.5 litres.

ISO 14780:2017 *Solid biofuels -- Sample preparation* describes methods for reducing combined samples (or increments) to laboratory samples and laboratory samples to sub-samples and general analysis samples and is applicable to solid biofuels. The methods described in this standard may be used for sample preparation, for example, when the samples are to be tested for calorific value, moisture content, ash content, bulk density, durability, and particle size distribution, ash melting behaviour, chemical composition, and impurities.

Using ISO 14780:2017 ensures that biases are avoided in reducing large quantities of wood fuels (perhaps with a wide particle size range) down to small samples of consistent size for repeatable laboratory measurements. The challenge is to ensure the sample amount reduction is carried out in a systematic manner with a minimum sample weight according to the nominal top size. It is suggested that for an initial bulk density of 200-500kg/m³, the minimum weight for >100mm top size is 15kg (or 20kg if >500kg/m³) but for 10mm top size it is 0.25kg (or 0.5kg if > than 500kg/m³).

The sampling methods described in ISO14780:2017 provide approaches for size reduction for the different types of sampling. These methods descriptions are provided as a pragmatic approach to lower-level testing and sampling.

Where fuel type testing or special testing is required then the default method is ISO 181345:2017.

Reducing the particle size (and consequently the minimum sample weight to be handled) involves initial crushing of an often moist sample to typically up to 3mm particle size samples, though this size can be difficult to achieve for fibrous wood samples. Care must be taken to minimise moisture loss during the crushing process before a total moisture sample is determined. Such size reduction preparations are best undertaken in a laboratory.

For product testing (Type A: that are typically undertaken on a day-to-day basis to validate the quality of delivered fuel) it is recommended that the following sampling procedures based on ISO 21945:2020 are used:

- Where the fuel has maximum particle size ≤ 60 mm and the quantity of solid biofuel being tested is ≤ 30 tonnes, then 3 samples of the fuel should be taken each of a minimum volume of 1 litre. The 3 samples should then be placed on a clean surface into one pile, mixed thoroughly using a trowel and then quartered (The process for quartering is provided in section 2.4).

If the sample is of suitable size for the analytical tests to be undertaken (i.e. Level 1 or Level 2 tests) then proceed to analysis. If the sample size is regarded as being too big then another quartering can be undertaken. Keep quartering the sample until an appropriate volume is available for testing (approximately 500 grams of sample for Level 1 testing and 300 grams for Level 2 & 3 testing). Note final sample size needs to take into account the required quantity of sample for the analyses required.

- Where the fuel has a maximum particle size ≥ 60 mm and the quantity of solid biofuel being tested is ≤ 30 tonnes then take 6 samples of the fuel of 2 litres each. To reduce the amount of sample for analysis then use the same quartering procedure as presented above.

- Where a fuel has maximum particle size of ≤ 60 mm, but the total quantity of solid biofuel being tested is $>$ than 30 tonnes, then collect a minimum of 6 samples of 1 litre. To reduce the amount of sample for analysis then use the same quartering procedure as presented above.
- Where a fuel has a maximum particle size of > 60 mm and the total quantity of solid biofuel being tested is $>$ than 30 tonnes then 12 samples of 2 litres each are to be collected. To reduce the amount of sample for analysis then use the same quartering procedure as presented above.

Type B sampling applies where samples are taken for either Level 1 or Level 2 testing and the number of samples collected is more than the minimum. This type of sampling is recommended where samples are collected for the purposes of Level 2 testing.

For fuel type or special testing, (Type C) then the sampling method should follow ISO 181345:2017 summarized as:

- Where a fuel has a maximum particle size ≤ 100 mm and the total quantity of solid biofuel being tested is ≤ 30 tonnes, then collect 6 samples of minimum size of 0.5 litres. To reduce the amount of sample for analysis then use the same quartering procedure as presented above.
- Where a fuel has a maximum particle size > 100 mm and the total quantity of solid biofuel being tested is ≤ 30 tonnes, then the sampling must consist of 22 samples with a minimum of 2 L per sample. To reduce the amount of sample for analysis then use the same quartering procedure as presented above.
- Where a fuel has a maximum particle size of ≤ 100 mm and the total quantity of solid biofuel being tested is > 30 tonnes, then a minimum of 20 samples of 0.5 litres must be collected. To reduce the amount of sample for analysis then use the same quartering procedure as presented above.
- Where a fuel has a maximum particle size of > 100 mm and the total quantity of solid biofuel being tested is > 30 tonnes, then a minimum of 34 samples of 2 litres must be collected. To reduce the amount of sample for analysis then use the same quartering procedure as presented above.

5.2 Collecting a Sample of Solid Biofuel

The method used to take the samples of solid biofuel will depend on the nature of the fuel preparation, loading, unloading, method of delivery and fuel feed systems. This section provides guidance on how to specifically collect samples from different situations.

For any sampling system it is important that appropriate health and safety procedures are established and that operator safety is paramount. The measures required will be dependent on the site-specific situation and the nature of the fuel being sampled. Operators must not be exposed to potential dust hazards and strict precautions must be adhered to regarding explosion and fire risks.

5.2.1 Sampling a Solid Biofuel Stack

Where the fuel is prepared or unloaded as a stack then the process for collecting a sample should be as follows.

The critical factor in taking a sample is that it should be representative of the whole stack. The same distribution of particle sizes in the sample as exists in the stack or storage area should be represented in the sample, and this should have the same moisture content as the represented material. (When sampling and testing chip (or other fuel type) in a large stack of fuel, there will be variations in the moisture content throughout the stack and you will need to take a sample from more than one place to ensure that the sample to be tested is representative. In addition, segregation of particle size can occur with large pieces flowing to the outside of the stack, depending on how the stack is created.) Samples should be taken from the upper, middle and lower parts of the fuel stack. Ignore any material from the lowest 30cm of the stack as this is likely to pick up additional moisture and other contamination from the ground and take samples at least 30 cm from the stack surface (outer layers of the stack may not be representative of the all the material in the stack). To access 30 cm into a stack, scoop away the material to expose the sampling zone. Take the sample as soon as possible following exposure of the sampling layer.

Samples should be collected using a trowel or shovel with a repeatable sampling volume. Typical tools used for sampling are shown in Figure 1.

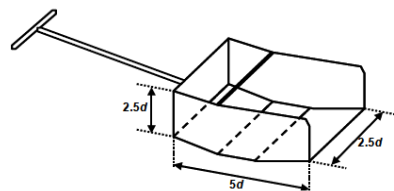


Figure 1. Recommended sampling equipment for taking solid biofuel samples (From Burvall et al, 2010).

Obtaining samples from large stacks for fuel are clearly difficult so the following should be treated as an ideal guide. Dig through the heap and take samples of at least 1 litre each from different points (as shown in Figure 2) and from the middle $\frac{1}{2}$ of the heap as shown in Figure 3. A written record should be made of the location points where samples are taken.

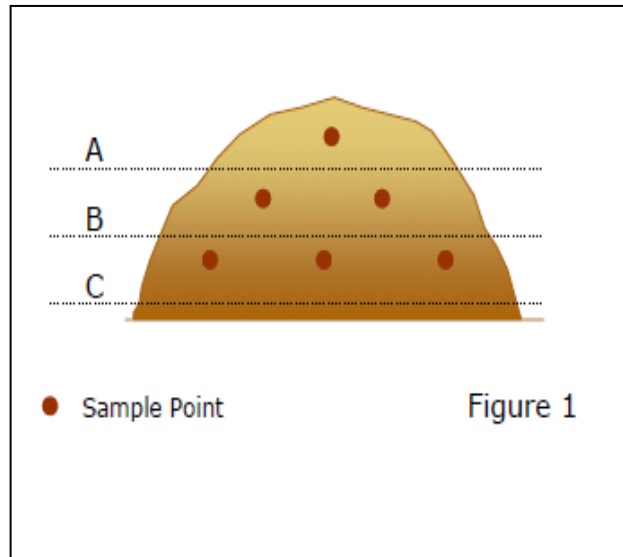


Figure 2. A B C Sample points in a fuel stack.

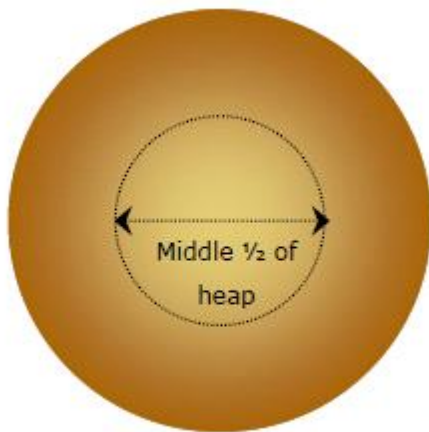


Figure 3. Middle half of a fuel stack.

The samples should all be the same size and include the same proportions of over and undersized pieces as the area they are taken from. If there is a large amount of observable variation through the stack, then you will need to collect more samples to take account of this. All samples should then be sealed in pre-weighed airtight containers (e.g. plastic food containers) as soon as you have collected them. Do not mix the samples at this stage. Samples are only mixed at the sample size reduction stage.

5.2.2 Sampling fuel from a truck after loading from a hopper or bin system

If the fuel is accessible once loaded onto a truck, then essentially treat the load as though it is a fuel stack and sample accordingly.

Sampling may need to be undertaken from a permanently installed platform which is arranged to provide good access to the load of fuel from the sides and top.

Where the fuel is not accessible (i.e. the fuel has been loaded directly into a container/bin or a hopper), then samples will need to be collected from the hopper either by using a purpose built sampling port or alternatively dropping samples onto the ground (taking care to avoid contamination) and sub-sampling the 'small' resulting stack. However, it is often more practical to sample contained loads of fuel at the point of delivery as the fuel is discharged from the container.

Where a truck is loaded by a conveyor, then samples can be collected directly off the conveyor (Figure 4).

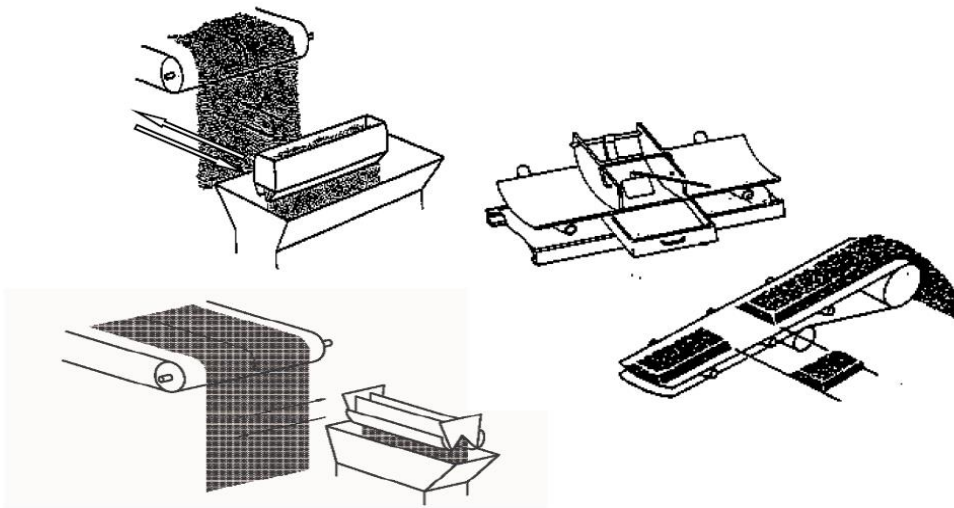


Figure 4. Options for collecting samples from a fuel feed conveyor.

5.2.3 Sampling a fuel delivery when the fuel is removed pneumatically directly to a fuel bin

Where fuel is to be sampled after delivery and is not directly accessible either as a discrete stack or from the delivery truck, then samples will need to be collected from the bin as it is being filled or from a specifically designed sampling port in the pneumatic delivery system. Where operators are sampling from a bin, site specific safety procedures must be established and enforced.

If the fuel feed to the heat plant is to be sampled, then the same procedures as outlined above will apply. In some circumstances purpose-built sampling ports may be required if the fuel feed system is fully enclosed from a day or working bin to the heat plant.

5.2.4 Sampling logs or firewood

Correct sampling practice is important when testing logs and firewood blocks. If the wood has been seasoned in long (eg 2m) lengths there will be a significant difference between the middle of the length (high MC) and the ends (low MC) and this can give rise to significant variation in measured values between logs. Block firewood will have similar differential moisture content according to the size of block and length of drying time.

To measure the moisture content of a firewood log using a resistance type handheld moisture meter, it must be freshly split and then three measurements taken on the freshly split surface: 5cm in from each end of the log and in the middle of the split surface with sufficient contact. It is recommended that you test at least 5 logs from each 2m³ batch. You should then calculate the average (mean) MC over all of the readings.



The resistance type of moisture meter can give a good indication of the moisture content of logs and firewood but they will only ever give an approximate indication. For a more accurate measurement of logs or when assessing wood chip, you should assess moisture content using the methodology contained here. If you wish to conduct an analysis for marketing fuel, or assessment of compliance to standards or specifications you should get a complete verification analysis conducted by an approved test laboratory.

As with chip, you should choose logs to give a representative section of the load. Bear in mind that there is potentially a much greater variability between and within logs and firewood blocks than with other wood fuels.

Moisture content is likely to vary between logs with different:

- size,
- species,
- number of split faces and cracks,
- as well as where they occur in the stack.

You should pick a minimum of two logs to test per cubic metre. The logs should be chosen from the middle of the stack and not have been in contact with the ground.

Remove all bark from the logs and cut one 2.5cm thick slice 2.5cm in from each end and one from the center of the log. Make sure that your sample is representative as any areas that have been split or have been stored with the bark already stripped will be drier than logs which still have bark on.

When you have cut your sample sections from the logs, you should place them in an airtight container immediately (eg sealable plastic bags) and test as soon as possible.

5.2.5 Sampling Firewood from a stockpile or store

This method is based on the sampling standard BS EN 14778:2011

To make sure the sample is representative, random samples should be taken from around the pile/lorry/bag/sack. Where a sample is being taken following a dispute, please ensure all parties witness the sample collection.

- From a stockpile of firewood, randomly select a minimum of 8 samples from different areas of the stock, ideally taking samples from different drying batches and cross species;
- If the sample is to be site tested and verification tested by an external testing laboratory split the samples into two batches. One to be submitted to testing laboratory and the other to be site tested. Put identification on both samples so that they can be cross referenced test reports are prepared;
- If taking directly from a kiln, ensure the product has cooled before sampling;
- If gathering samples from different drying methods ie. seasoned and kiln dried then two separate sets of samples will need collecting;
- Note the weather conditions.

5.3 Sample Storage

Keep the samples separate until you are required to reduce the total volume of samples prior to analysis.

Store samples out of direct sunlight to prevent deterioration of the samples and, if possible, place in a cool store (below 4°C) to prevent bacterial spoilage. Samples should be in sealed containers so that there is no loss of moisture.

Samples should be analysed for moisture content as soon as possible after collection or at least within 5 days of collection.

5.4 Sample Reduction

The main purpose of sample preparation is that a sample is reduced to one or more test portions that are in general smaller than the original sample. The main principle for sample reduction is that the composition of the sample as taken on site shall not be changed during each stage of the sample preparation. Each sub-sample shall be representative of the original sample. To reach this goal, every particle in the sample before sample division shall have an equal probability of being included in the sub-sample following sample division.

Full instruction of sample preparation is set out in ISO 14780:2017.

Two basic methods are used during the sample preparation. These methods are:

- sample division;
- sample size-reduction.

Avoid loss of moisture and fine particles during milling and other operations. Because of the risk of changes in the moisture content (loss of moisture), a sub-sample (moisture analysis sample) shall be separated at the earliest possible stage of the sample preparation procedure. As an alternative, a separate moisture analysis sample may be taken. The sample reduction shall be carried out by a procedure that does not conflict with the requirements of ISO 18134-1 or ISO 18134-2. For materials that have to be examined for moisture content, care should be taken to avoid any significant heat build-up and risk of drying.

Sample reduction can be achieved by the quartering procedure as follows:

- 1) Place the sample on a hard, clean, level surface where there will be neither loss of material nor the accidental addition of foreign material;
- 2) Using a large trowel, shovel, or other suitable tool, turn the entire sample over at least 3 times and form the entire sample into a conical pile by depositing individual lifts on top of the preceding lift;
- 3) Flatten the pile until the diameter is approximately equal to four to eight times the thickness of the pile;
- 4) With a large trowel or other suitable tool, divide the sample in half by vertically passing the tool through the centre of the pile. In a similar manner divide each of these halves into two parts, thus “quartering” the sample; and
- 5) Combine diagonally opposite quarters into two samples. All fine materials shall be included by brushing the surface clean. Store one of these two halves. If the remaining material still weighs too much, repeat the entire quartering process until the final test sample size is obtained.

6 Testing Methods

6.1 Testing for sale and purchase of solid biofuels

For regular sale and purchase of solid biofuels not every fuel characteristic needs to be specified in a sale and purchase contract and tested. Fuels sourced from different locations may have different properties and thus require specific testing. In many cases, unless there is a reason to suspect that it might be otherwise, typical values can be assumed. Situations where this might not be acceptable are where biomass has been grown on land treated with sewage sludge, on geology that includes metal ores, or where it has been grown sufficiently near the sea that spray borne salt may be present in the bark potentially giving elevated chlorine (and sodium) levels unless the bark is removed.

Some parameters, such as moisture content, may well need to be measured periodically and chip size distribution should also be checked regularly to ensure that factors such as degrading of the condition of the chipper blades has not led to sub-standard chips. When feedstock is being sourced consistently from the same supply, and there is no reason to believe that any important parameter is

likely to have changed or be outside the normal range, then it may be sufficient simply to rely on typical values for many of the parameters, or test only occasionally to ensure compliance.

Just as there is currently no absolute requirement to produce fuel to a particular standard unless demanded by the customer, there is equally no absolute requirement to have any testing performed by any particular test laboratory. If the customer is happy for in-house testing then that should suffice, though any measurement should be either according to the standard procedure, or calibrated to it. However, where independent verification of a property is required, a recognised test laboratory should be used. There is a list of Bioenergy Association recognised test laboratories in New Zealand and Australia in Annex A.

6.2 Determination of total moisture

6.2.1 Simple method

This is a simplified version of the drying and analysis method as set out in ISO 18134-2:2017 *Solid biofuels -- Determination of moisture content -- Oven dry method -- Part 2: Total moisture -- Simplified method*. The methodology contained here is designed to give an approximate figure using the minimum of specialist equipment and should not be used for marketing purposes or as a substitute for a complete analysis conducted by a recommended test laboratory.

6.2.2 Equipment requirements

Sample containers	These must be airtight sealable containers appropriate to the type of fuel. Plastic food containers are appropriate for chip but for logs sealable airtight plastic bags may be used. You should weigh all containers before use.
Oven	An electric oven will work best. You need to check the oven's specifications for the maximum length of time that it can be run continuously. Fan ovens may not be appropriate for testing chip as the air circulation may blow fine particles out of the sample container.
Containers (for chip)	Should be corrosion resistant, non-combustible, and large enough to contain a complete sample (e.g. clean metal or ceramic roasting tin). You should weigh all containers before use.
Scales/balance	Must be accurate to the nearest 1g, should have a "re-zero" or "tare" button to allow for the weight of containers, and be able to weigh several kg
Oven thermometer	In-oven thermometers are widely available from kitchen stores. Should be accurate to nearest 2°C, adjustable and must have a waterproof sensor for calibration.
Heat proof mat	To provide insulation between hot samples and the scales.
Heat proof gloves	e.g. oven gloves.

6.2.3 Calibration

The process of heating wood removes the water from your sample, but may also release other volatile compounds within the wood. This has been allowed for under the testing methodology, but it does mean that samples must be dried at a standardised temperature to avoid unreliable results. Domestic ovens are not precision instruments and frequently have a wide margin of error in terms of temperature control, so some form of calibration is often necessary.

6.2.3.1 Thermometer calibration

First you need to check the calibration of the oven thermometer. The most straightforward way of doing this is to place it in a large bowl of ice water. When the temperature of the water stops changing adjust the thermometer according to the manufacturer's instructions so that it reads 0°C. If the thermometer does not read low enough, then boiling water may be used to calibrate to 100°C, but bear in mind that this is more difficult to do safely.

6.2.3.2 Oven Calibration

To calibrate the oven, place the calibrated thermometer in the middle of the oven and set to 200°C (using the main oven control) when the oven has reached temperature check the reading on the thermometer against the oven setting. The oven manufacturer should provide instructions on any fine tuning of the temperature calibration possible.

When you have calibrated the oven, turn it down to 105°C (the working temperature for moisture testing) and check it against the thermometer. Some oven models only allow calibration in 5°C or even 10°C increments and it may be that even with calibration you still need to set the oven control higher or lower to achieve an accurate temperature, using the calibrated thermometer as your guide.

6.2.4 On-site testing the Sample

- Preheat the oven to the point marked during calibration for an internal temperature of 105°C. You should use the thermometer used during calibration to double check the actual drying temperature;
- Weigh the samples in the airtight container before opening. This provides an accurate weight of the sample before any material or water is lost from the sample;
- Weigh the heatproof container that you will be using to heat the sample;
- If you are testing more than one sample, remember to label the containers so that you know which results apply to each sample;
- Transfer each sample from the airtight container to a labeled heatproof container;
- Put all of the samples in the oven at the same time;

- Log each sample weight every two hours (you should make sure that you have a heat proof mat between your samples and the scales.) when the weight of a sample remains unchanged (to within 10g) for two consecutive measurements it can be considered to be oven dry;
- This process can take a long time, so make sure that you do not run the oven for longer than the manufacturer recommends. If the samples take longer than this (or you need to leave the samples) then switch off the oven leaving the samples inside and allow it to cool down and start heating again later.
- Meanwhile thoroughly dry the airtight containers on a radiator or similar and re-weigh (if any material has stuck to the inside).

6.2.5 Determining the moisture content

You should now have accurate weights for:

- The airtight container;
- The heatproof container (if used);
- The sample before drying;
- The sample after drying;
- The weight of any moisture left inside the airtight container after transfer to the oven; and
- The weight of any other material left inside the airtight container after transfer to the oven.

You should be able to use these weights to determine the total weight of each sample before and after drying.

The moisture content (MC) of the solid biofuel is defined as the weight of water expressed as a percentage of the weight of the wood either the total (wet) sample weight (wet basis) or the dry wood weight (dry basis). All fuel calculations are carried out on a “wet basis”.

The wet basis moisture content is a measurement of the proportion of the sample which is water expressed as a percentage of the total sample. For example if the wood in a sample weights 50kg and the water in the sample also weight 50kg, then the total MC of the sample would be 50% as half of the sample is water.

$$\text{The } MC_{wb} = (\text{the weight of water in a sample} / \text{total initial weight of the sample}) \times 100$$

“Dry basis” is expressed as the percentage of the oven dry weight of the wood. For example, if the wood in the solid biofuel weights 50kg and the water also weighs 50kg then the dry basis moisture content is 100%. The main advantage of this method is that the oven dry weight of the wood remains constant. This method is the standard used by many of the organisations doing research on wood, as well as building surveyors and architects. (It is rare to use dry basis measurements in the context of solid biofuels).

$$\text{The } MC_{db} = (\text{Weight of water in a sample} / \text{oven dry weight of sample}) \times 100$$

6.2.5.1 Microwave method⁶

A microwave may be used to determine the moisture content of solid biofuels (as detailed in *ASTM E1358-97(2019) Standard Test Method for Determination of Moisture Content of Particulate Wood Fuels Using a Microwave Oven*). The advantage of the procedure is that the test is relatively quick, typically requiring only about 10 to 15 minutes to perform. If this method is used then it should be calibrated with the other methods provided above and used as a regular monitoring method.

Disadvantages of this approach are:

- Only one sample can be dried at a time
- The drying of the sample needs to be closely supervised to ensure that it does not combust and no hazardous conditions arise.

The microwave can be a standard commercial microwave that has a power output of at least 600 W. The sample size should be around 50 grams, so the sensitivity of the balance (scales) that is being used to weigh the sample should have a minimum sensitivity of 0.01 grams. The 50 grams sample of solid biofuel to be tested is placed on 3 sheets of standard paper towel placed on top of each other, the weight of which has been recorded. The sample with the towels is weighed, then placed into the microwave oven and is heated on full power for a heating interval, it is then removed from the oven after the heating interval, reweighed and mixed and then returned to the oven for a further heating period. This process is continued until the end-point is reached, where the weight change after a drying interval is less than 0.5g. The weight of the sample minus the weight of the towels is the dry weight of the solid biofuel for the calculation, and the weight of the original sample and towel minus the weight of the towel is the wet weight of the sample for the moisture content calculation.

An appropriate schedule of intervals of heating times for relatively high moisture content fuel may be 2 minutes for the first heating interval, followed by two 1 minute intervals and then 30 second intervals thereafter. For low moisture content samples it is recommended to use a cycle of three 1 minute intervals and then 30 second intervals thereafter. The use of appropriate drying cycles is important to avoid over drying the samples. If a sample catches fire in the microwave extreme caution is required to remove it and ensure that the fire is fully extinguished before the sample is disposed of.

6.2.5.2 Electronic moisture meters

There is a range of different electronic devices available for measuring moisture content of solid biofuels in the field or as part of a process. These methods use different technologies to determine the moisture in samples of biomass and include capacitance, resistance, dielectrics, infrared, ultrasound, and microwave. The accuracy and usefulness of these systems is highly site and application specific. The Bioenergy Association provides information on these systems and technologies on the website <https://www.usewoodfuel.org.nz/solid-biofuel-testing> .

⁶ Determination of moisture content using a microwave (from Govett et al: Practical guide for the determination of moisture content).

Electronic moisture meters are reasonably priced, often portable, quick and easy to use and have been used widely in the forestry and wood processing sectors. Such meters are usually best over a select range of moisture contents so it is important to be aware of the accuracy and appropriateness of the type of meter being used. Furthermore, temperature, moisture distribution, species and the presence of any chemical treatment will affect the accuracy of these devices and advice should be obtained from the manufacturer or supplier regarding its suitability for the type of situation the meter is to be used for.

Electronic moisture meters should only be used for Type A testing.

Biomass chip

The moisture content of biomass chip can be measured by placing a sample of chip into a bin moisture-meter, the water content is measured by determining the capacitance between two electrodes within the bin. The water content is indicated immediately after the quick-measuring electronic evaluation in percent. The measuring method is very accurate for the simple reason that the two materials to be measured (water and wood) have very different dielectric constants. Seeing as the dielectric constants are so different the species of wood does not affect the measuring.

Solid biomass

If you are using a resistance type moisture meter for a quick indication of moisture content of large pieces of solid biomass you should calibrate it first against biomass that has been checked using a method above. You should also be sure that you know whether the meter is giving a reading in wet or dry basis.

Correct sampling is important if testing logs as if the wood has been seasoned then there may be a significant difference in the reading between the middle of the length and the ends.

The resistance type of moisture meter can give a good indication of the moisture content of a large piece of biomass, but they will only ever give an approximate indication.

Firewood

Samples should be tested using the pin meter method, were the pin meter readings average over 25% then these should be forwarded to the lab for further analysis. Pin meter readings should be undertaken with the following method: -

1. From the selection of samples, a minimum of 3 random firewood blocks should be further selected.
2. Take the samples and split the log down the center with an axe
3. Measure the moisture by pressing the meters pins into the center of the log, across the grain.

Record the number of measurements of each split log. Measure for at least 6 readings from the sample then calculate the average.

$$\text{AVERAGE} = \frac{\text{SUM OF ALL READINGS TAKEN}}{\text{NUMBER OF READINGS TAKEN}}$$

Record this as the timber's average moisture content.

6.3 Particle size

Testing of the particle size of a fuel is generally only undertaken for level 3 testing.

Identifying the size of wood fuel is slightly more complicated than establishing its moisture content as it is difficult to ensure a whole truck load of woodchips are of the same size, just because of the way they are produced and subsequently handled. For example larger pieces may drift to the edges of a pile which smaller pieces remain higher up.

The dimensions of wood chips are specified in terms of the range of sizes for 75% of the sample, measured using sieves. While wood fuelled combustion systems can be designed to burn a variety of biomass particle sizes many modern systems have been designed for specific fuels to deliver very high efficiencies in converting the energy stored in the biomass into heat. To work well they need biomass particles of the correct size, generally with a low proportion of small, or fine, material which would reduce the efficiency of the combustion and a low proportion of larger pieces which could jam the feed system. The international standards use simple calibrated sieves to assess the range of composition of particular samples:

A common specification is likely to be P16 and this will comprise:

- Less than 12% of the total volume of woodchips will be less than 3.15mm in size; and
- For P16A no more than 3% will be more than 16mm and all will be less than 31.5mm; OR for P16B no more than 3% will be more than 45mm and all will be less than 120mm (refer to the Solid Biofuel Classification Guidelines for these details).

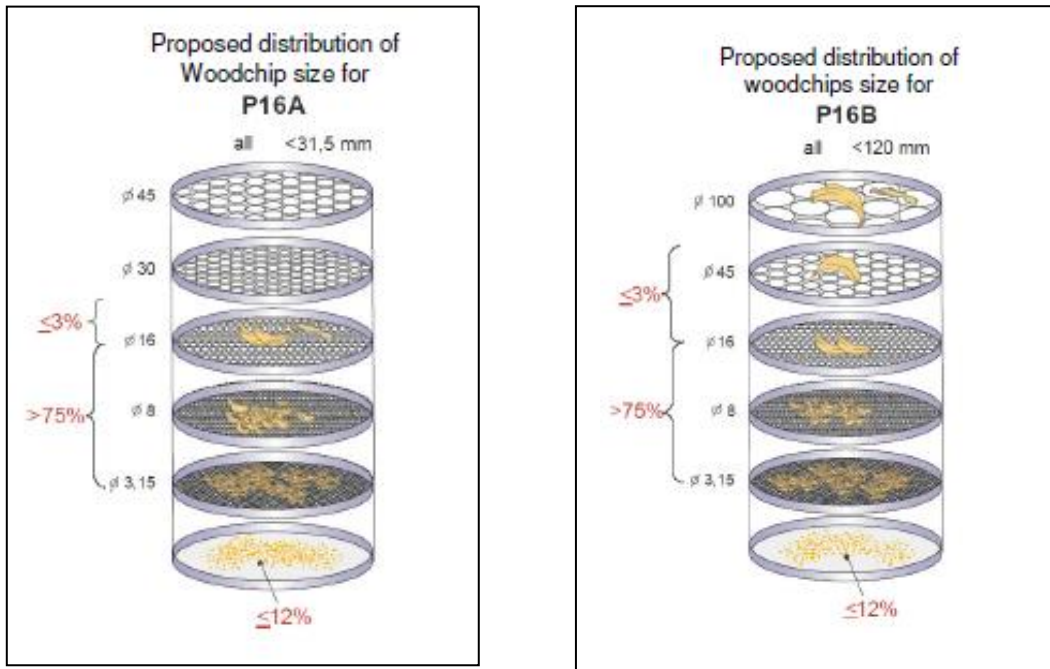


Figure 6. Particle size analysis for wood chips - 75% of the total volume of woodchips being between 3.15mm and 16mm.

6.4 Calorific value

Testing of the calorific value of a fuel is generally only undertaken for level 3 testing.

The heat of combustion of any solid fuel sample is usually measured in New Zealand as the gross calorific value, expressed in megajoules per kilogram of fuel (MJ/kg). The calorific value of the organic matter is effectively diluted by the quantities of mineral matter (expressed as percentage ash content) and moisture (expressed as a percentage).

Analysis of the calorific value of a fuel sample is covered by ISO 18125:2017 *Solid biofuels -- Determination of calorific value*.

6.5 Bulk density

Testing of the bulk density of a fuel is generally only undertaken for level 3 testing.

Understanding the bulk density of a delivered fuel may be important for fuel handling and storage. Bulk density is subject to variation due to the air gap between the solid particles. This can be affected by particle size and shape and how the bulk fuel has been handled or transported.

Analysis of the bulk density of a fuel sample is covered by ISO 17828:2015 *Solid biofuels -- Determination of bulk density*.

6.6 Ash content

Testing of the ash content of a fuel is generally only undertaken for level 3 testing.

Biomass ash content varies according to the amounts of inherent mineral matter within the biomass and from any associated impurities (e.g. bark can contain relatively high amounts of dirt from dragging logs).

Maintaining the ash content of a biomass fuel within specified levels is important for combustion efficiency and protection of the grate of the burner. As content is a key element of some burner designs. If the ash content is low the protection of the grate of the burner from the heat of combustion may be less because there is less ash covering the grate. On the other hand too high an ash content may also be detrimental because of solidification of the ash on the grate, reducing air flow through the grate.

Analysis of the ash content of a fuel sample is covered by ISO 18122:2015 *Solid biofuels -- Determination of ash content*.

7 Reporting

To allow clarity of the results of testing, reporting of results for the purpose of the sale and purchase of a solid biofuel should be by comparison against the client's contract specification.

Report of testing of sample of solid biofuel to meet contract specification.		
Name of testing laboratory		
Name of responsible tester		
Clients name		
Clients contact details		
Date of testing		
Fuel descriptor		
Sample identifier		
Date sample collected		
	Contract specification requirements	Actual results
Moisture content		
Particle size		
Calorific value		
Bulk density		
Ash content		
Contaminants		
Comments		

Figure 7: Representative testing report format

Appendix 1: Recommended Solid Biofuel Testing Laboratories

New Zealand



Pentarch Technical Services,

Tasman Mill Site, 1 Fletcher Ave, Kawerau 3192; Tel: (07) 323 6537

Manager: Sharmaine Walker

Email: pts-lab@pentarch.co.nz

Website:

http://www.pentarch.com.au/pentarch_forestry/forestry_au/analytical_laboratory_services.html

- Products tested: woodchip, biofuels, logs, standing trees, agricultural feedstock
- Type of tests: moisture content, density, ash, size classification, calorific value
- Operates seven days a week; 24-36 hr turnaround depending on test

Scion Analytical Chemistry Laboratory,

Private Bag 3020, Rotorua 3046, +64 7 343 5899,

testing@scionresearch.com

<https://www.scionresearch.com/services/laboratory-services>

SGS New Zealand,

50 Dole St, Ngakawau, Westport 7824, New Zealand. +64 275 108 462

wil.nicoll@sgs.com

Verum,

Mike Young, m.young@verumgroup.co.nz 027 471 3165

97 Nazareth Ave, Christchurch,

P.O. Box 29-415, Christchurch 8024,

0800 427536, or 03 341 2120

Provide biomass fuel core testing services and can also help in the diagnostic testing with CHN-S, Ash fusion temperatures and ash constituents.

Australia

Bureau Veritas International Trade Australia Pty Ltd, Wollongong Laboratory, 24 Glastonbury Avenue, Unanderra NSW 2526, www.ccipl.com.au, 00612 4272 4224

Pentarch Technical Services

SGS Australia Pty Ltd, Coal and Technical Services, Newcastle Laboratory, NSW, 00612

Appendix 2: International Solid Biofuels Standards

1. International organisation for standardisation

The International Organisation for Standardisation (ISO) develops and publishes international standards for the manufacture of products, operating practices etc. To develop a standard, international experts form a technical committee that is responsible for that specific subject area. They begin the process with the development of a draft that meets a specific market need. This is then shared for commenting and further discussion. Standards are developed in committee until ready for public consultation. After comments are received from the public the committee will produce a final document.

Individual countries have their own standards setting organisations and each of these may be a national member of the ISO. Committees may have participating or observing members in an ISO Committee.

Some countries have their own standards or they may have a mix of their own and adopted ISO standards. There are a number of joint Australian/New Zealand standards. Under the Australia–New Zealand Closer Economic Relations Trade Agreement, commonly known as Closer Economic Relations (CER) the presumption is that a AU or NZ standard will be joint unless there is good reason for it to be separate. An AU/NZ standard will only be produced if there is not an applicable international standard which could be adopted or referenced.

Solid Biofuel standards are the responsibility of the committee ISO/TC238. Bioenergy Association is the observing New Zealand representative on this committee.

2. What is a standard

A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose.

A regulatory body may reference as part of a regulatory regime a standard in whole or in part.

3. Solid biofuels standards for New Zealand, Australia and the South Pacific

The full suite of ISO solid biofuel standards are referenced in New Zealand and Australia and are listed on <https://www.usewoodfuel.org.nz/resource/tnsb32-solid-biofuel-standards> . There are no separate or joint New Zealand or Australian standards relevant to solid biofuels.

The current international standards relevant for sampling and testing for solid biofuels are:

ISO 14780:2017

Solid biofuels -- Sample preparation

ISO 14780:2017/DAmD 1: 2019

ISO 16559:2014

Solid biofuels -- Terminology, definitions and descriptions

ISO 16948:2015

Solid biofuels -- Determination of total content of carbon, hydrogen and nitrogen

ISO 16967:2015

Solid biofuels -- Determination of major elements -- Al, Ca, Fe, Mg, P, K, Si, Na and Ti

ISO 16968:2015

Solid biofuels -- Determination of minor elements

ISO 16993:2016

Solid biofuels -- Conversion of analytical results from one basis to another

ISO 16994:2016

Solid biofuels -- Determination of total content of sulphur and chlorine

ISO 16995:2015

Solid biofuels -- Determination of the water soluble chloride, sodium and potassium content

ISO/TS 16996:2015

Solid biofuels -- Determination of elemental composition by X-ray fluorescence

ISO 17225-1:2014

Solid biofuels -- Fuel specifications and classes -- Part 1: General requirements

ISO 17225-2:2014

Solid biofuels -- Fuel specifications and classes -- Part 2: Graded wood pellets

ISO 17225-3:2014

Solid biofuels -- Fuel specifications and classes -- Part 3: Graded wood briquettes

ISO 17225-4:2014

Solid biofuels -- Fuel specifications and classes -- Part 4: Graded wood chips

ISO 17225-5:2014

Solid biofuels -- Fuel specifications and classes -- Part 5: Graded firewood

ISO 17225-6:2014

Solid biofuels -- Fuel specifications and classes -- Part 6: Graded non-woody pellets

ISO 17225-7:2014

Solid biofuels -- Fuel specifications and classes -- Part 7: Graded non-woody briquettes

ISO 17225-8:2016

Solid biofuels -- Fuel specifications and classes -- Part 8: Graded thermally treated and densified biomass fuels

ISO 17225-9:2020

Solid biofuels -- Fuel specifications and classes -- Part 9: Graded hog fuel and wood chip for industrial use

ISOCD 17588 [Under development]

Solid Biofuels – Fuel quality assurance

ISO 17827-1:2016

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 17827-2:2016

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 17828:2015

Solid biofuels -- Determination of bulk density

ISO 17829:2015

Solid Biofuels -- Determination of length and diameter of pellets

ISO 17830:2016

Solid biofuels -- Particle size distribution of disintegrated pellets

ISO 17831-1:2015

Solid biofuels -- Determination of mechanical durability of pellets and briquettes -- Part 1: Pellets

ISO 17831-2:2015

Solid biofuels -- Determination of mechanical durability of pellets and briquettes -- Part 2: Briquettes

ISO 18122:2015

Solid biofuels -- Determination of ash content

ISO 18123:2015

Solid biofuels -- Determination of the content of volatile matter

ISO 18125:2017

Solid biofuels -- Determination of calorific value

ISO 18134-1:2015

Solid biofuels -- Determination of moisture content -- Oven dry method -- Part 1: Total moisture -- Reference method

ISO 18134-2:2017

Solid biofuels -- Determination of moisture content -- Oven dry method -- Part 2: Total moisture -- Simplified method

ISO 18134-3:2015

Solid biofuels -- Determination of moisture content -- Oven dry method -- Part 3: Moisture in general analysis sample

ISO 18135:2017

Solid Biofuels -- Sampling

ISO 18846:2016

Solid biofuels -- Determination of fines content in quantities of pellets

ISO/CD 18846-2 [Under development]

Solid biofuels -- Determination of fines content in quantities of pellets -- Part 2: Simplified method

ISO 18847:2016

Solid biofuels -- Determination of particle density of pellets and briquettes

ISO 19743:2017

Solid biofuels -- Determination of content of heavy extraneous materials larger than 3.15 mm

ISO 21404:2020

Solid biofuels -- Determination of ash melting behaviour

ISO/AWI 21596 [Under development]

Solid biofuels -- Determination of grindability -- Hardgrove type method for thermally treated biomass fuels

ISO 21945:2020

Solid biofuels -- Simplified sampling method for small scale applications

ISO/CD 23343-1 [Under development]

Solid biofuels -- Determination of water sorption and its effect on durability of thermally treated biomass fuels -- Part 1: Pellets

ISO NP 5370 [Under development]

Solid biofuels — Determination of fines content in pellets

Appendix 3: References and Relevant Literature

Hennessy, W, 2010: *Review of Wood Fuel Testing Standards*. Published by CRL Energy and EECA. Report No. 10-11013. Pp.33.

Burvall, J. et al: 2010: *Sampling and sample reduction for solid biofuels*. Power point presentation, Intelligent energy, Europe.

Jamie Hartley and John Marchant, *Methods of determining the moisture content of wood*, Research Division, State Forests of New South Wales, Sydney, 1995

<https://www.usewoodfuel.org.nz/resource/methods-of-determining-the-moisture-content-of-wood>

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