Standard Methods for Verifying the Quality of Solid Biofuel
About this Guide:

1. The compilation of this Technical Guide has been facilitated by contributions and oversight of the relevant expert members 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 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.

5. 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.

6. 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 undertakes 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 pro’s 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 wood fuel markets and for Bioenergy Association accreditation of fuel suppliers. Also included are standard methods for sampling and testing. These methods are to be used where any question or dispute arises regarding the quality of solid biofuel. The methods presented build on version 1 of the Bioenergy Association Wood Fuel Classification Guidelines and subsequently reviewed by the solid biofuel supply sector.

Internationally there are a number of standards for sampling and testing the quality of solid biofuels. This document sets out the recommended standard most relevant to New Zealand. Discussion on the alternative standards that could be used is included in the CRL Energy report which is provided in Appendix 2.

In version 7 of The Wood Fuel Classification Guidelines the document has been widened so as to include a broader range of solid biofuels. As a consequence the Classification Guidelines are now referred to as the Bioenergy Association Solid Biofuel Classification Guidelines.
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1. Introduction

The ‘Bioenergy Association Wood Fuel Classification Guidelines’ were developed by the Bioenergy Association of New Zealand (Bioenergy Association) in partnership with the Energy Efficiency and Conservation Authority (EECA) and these were revised and widened in scope in 2013 to become the ‘Bioenergy Association Solid Biofuel Classification Guidelines’. These guidelines are voluntary standards developed for New Zealand and Australian conditions and wood fuel trading environment and they were based on existing quality standards for solid biofuel energy in Europe, New Zealand and Australia. The guidelines provide a means for wood fuel suppliers to classify their wood pellets, hog fuel, wood chips, firewood etc and to provide quality assurance to fuel users. A copy of the Guidelines can be found at http://www.usewoodfuel.org.nz EECA and the Bioenergy Association is promoting the Guidelines throughout the sector.

The initial version of the Bioenergy Association Wood Fuel Classification Guidelines included reference to testing standards and methodologies. When the Guidelines were widened to include other solid biofuels it was considered appropriate to move the verification sampling and testing methodologies into a separate Technical Guide.

To ensure an efficient solid biofuels (wood fuel) 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.

If market participants are to work with the Classification Guidelines then it is important for them 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 and 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 on wood. Provision is however made in this Guide for additional biomass fuels to be added at any time.

This document sets out what testing methods should be adopted by the solid biofuel industry to support the Solid Biofuel Classification Guidelines and 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 recognized 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

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1 Wood fuel is often used as a synonym for solid biofuel as the largest amount of solid biofuel is in the form of wood fuel.
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 are not the same and have been modified and simplified to allow solid biofuel operators to adopt a more pragmatic approach to fuel sampling, testing and reporting for accreditation purposes.

Discussion on the alternative standards that could be used is included in a report prepared by CRL Energy “Review of Wood Fuel Testing Standards” which is included in full in Appendix 2.

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 should be read in conjunction with the Bioenergy Association Technical Guide 1 “Solid Biofuel Classification Guidelines”.

Where additional testing methods need to be added, then this can occur during periodic updates of this document.

1.1 Scope

The testing and sampling methods are presented in two section sections, namely:

1. The recommended sampling and testing methods that comply with the requirements for the Bioenergy Association Wood Fuel Supply Accreditation Scheme. These have been simplified from the formal international standards and are recommended for everyday use in New Zealand and Australia.

and

2. The standard international sampling and testing methods which are the bench mark sampling and testing procedures from which the recommended methods were derived. These are to be used in any situation where there is a dispute or there is an issue with the recommended methods.

The methods presented relate to all solid biofuels, though it is expected that in most cases the testing will relate specifically to wood.
1.2 Document Outline

Section 2 considers the recommended sampling and assessment methods for the Bioenergy Association Accreditation scheme.

Section 3 provides the standard methods for sampling and testing of solid biofuels and these are included here for reference only.

2. Recommended Methods for Sampling and Assessment for Accreditation

2.1 Levels of 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, 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 supplier/owner as it will effectively define the type of fuel that can 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 by the Accreditation Scheme Administer or 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 delivery using simple methods. This is a simple form of compliance testing to validate the quantity of fuel supplied and ensure that the moisture content is within appropriate limits for efficient operation of the heat plant.
- **Level 2**: Limited laboratory 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 above) 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.

2.2 Recommended sampling methods

To support the different levels of testing suggested in 2.1 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 are most appropriate for type testing, special tests or level 3 testing (refer section 3).

For the purposes of accrediting solid biofuel suppliers a range of sampling and testing protocols are recommended. Three different 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 1.

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 1. Matrix of types of sampling and associated levels of testing

<table>
<thead>
<tr>
<th>Levels of Testing</th>
<th>Types of sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>1 (Measurement of moisture at the point of delivery using simple methods)</td>
<td>Low level sampling for day to operation</td>
</tr>
<tr>
<td>2 (Limited laboratory testing for particle size, moisture, % ash and calorific value)</td>
<td>Sampling for limited laboratory testing</td>
</tr>
<tr>
<td>3 (Full laboratory testing)</td>
<td>Sampling for full laboratory testing</td>
</tr>
</tbody>
</table>

* 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 simpler and more 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 EN 14778 (refer section 3). Types A and B sampling regimes will be assessed as part of the Bioenergy Association accreditation scheme.

2.2.1 Sampling

Sampling and testing is an important part of the Bioenergy Association Wood Fuel Supply Accreditation Scheme for suppliers as it ensures that there are appropriate standards to assess the quality assurance processes used by a fuel supplier.

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.

The following testing and sampling regimes are provided as a guide to “Approved Methods” for compliance with the Bioenergy Association Wood Fuel Supply Accreditation Scheme (refer Wood Fuel supply accreditation Scheme: Scheme Guidance Document for Applicants and Assessors (WFSAS01 2015) and “Contracting to Deliver Quality Wood Fuel to Customers, Bioenergy Association Technical Guide 6” (2015).

An overview of the sampling and the testing scheme is shown in Figure 1.
Figure 1. Sampling and testing regimes for different types of testing.
For verification 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 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 EN 14778 (see section 3) 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.

### 2.2.2 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.

#### 2.2.2.1 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 2.
Standard methods for verifying the quality of solid biofuel

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 3) and from the middle ½ of the heap as shown in Figure 4. A written record should be made of the location points where samples are taken.

Figure 2. Recommended sampling equipment for taking solid biofuel samples (From Burvall et al, 2010).

Figure 3. A B C Sample points in 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.

2.2.2.2 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 5).
Figure 5. Options for collecting samples from a fuel feed conveyor.

2.2.2.3 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.

2.3 Sample Storage

Keep the samples separate until you are required to reduce the total volume of sample 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 analysed within 5 days of collection.

2.4 Quartering Combined Samples for Sample Reduction

The quartering procedure is 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.

2.5 Assessment Methods

2.5.1 Determination of total moisture

2.5.1.1 Simple method

This is a simplified version of the drying and analysis method found in the draft standard for solid biofuel moisture content analysis published in the UK by the British Standards Institution (BSI) and is based on EN 14774 (Biomass Energy Centre UK). 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 an approved test centre.

Equipment requirements

<table>
<thead>
<tr>
<th>Sample containers</th>
<th>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.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oven</td>
<td>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.</td>
</tr>
<tr>
<td>Containers (for chip)</td>
<td>Should be corrosion resistant, non-combustible, and large enough to contain a complete sample (e.g. clean metal or ceramic roasting tin). <strong>You should weigh all containers before use.</strong></td>
</tr>
<tr>
<td>Scales/balance</td>
<td>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</td>
</tr>
<tr>
<td>Oven thermometer</td>
<td>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.</td>
</tr>
<tr>
<td>Heat proof mat</td>
<td>To provide insulation between hot samples and the scales.</td>
</tr>
<tr>
<td>Heat proof gloves</td>
<td>e.g. oven gloves.</td>
</tr>
</tbody>
</table>
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.

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.

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.

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).

**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.

\[
\text{MC}_{\text{wb}} = \left( \frac{\text{weight of water in a sample}}{\text{total initial weight of the sample}} \right) \times 100
\]

“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).

\[
\text{MC}_{\text{db}} = \left( \frac{\text{weight of water in a sample}}{\text{oven dry weight of sample}} \right) \times 100
\]

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

A microwave may be used to determine the moisture content of solid biofuels (as detailed in ASTM E1358-97). 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 endpoint 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.

2.5.1.3 Use of 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 wood and include capacitance, resistance, dialectrics, 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 [www.usewoodfuel.org.nz](http://www.usewoodfuel.org.nz).

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.

### 2.5.2 Particle sizing

Identifying the size of wood fuel is slightly more complicated than establishing its moisture content as it is difficult to ensure a whole load of woodchips are of the same size, just because of the way they are produced and subsequently handled. 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 systems can be designed to burn a variety of woodchip sizes many modern systems have been designed to deliver very high efficiencies in converting the energy stored in the wood into heat. To work well they need woodchips 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 European 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.](image)
3. **International Standard Sampling and Testing Methods**

This section is included as background and is of relevance in the case of dispute or where alternative methods are sought for diagnostic purposes.

### 3.1 Standard Sampling Methods

The standard method for sampling is EN 14778-1.

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 powder contained in a small sample container can represent, for example, a wood pellet shipment as large as 20,000 tonnes. The ISO sampling standard or the equivalent CEN (European), BS (British), AS (Australian), ASTM (US) or other standard is an important prerequisite before individual wood fuel tests are undertaken. Most of these standards have been derived from the European Standard.

EN 14778 part 1 describes general sampling methods for solid biofuels and part 2 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.

EN 14778-1 Table B1 offers guidelines for truck sampling that illustrate the significance of particle size. 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.

CEN/TS 14780 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.

The methods are not intended to be applied to the very large samples required for the testing of bridging properties.
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.

Using EN 14780 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. EN 14780’s Table 1 specifies 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 Appendix 1 also 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 EN 14780.

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 for coal 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.

### 3.2 Standard Sampling Methods

The recommended methods for testing and verifying the quality and compliance with the solid biofuel classification specifications are presented in Table 1.

**Table 2. Recommended testing and verification methods for solid biofuels (from CRL Energy, 2010).**

<table>
<thead>
<tr>
<th>Property</th>
<th>Verification Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Sample</td>
<td>Solid biofuels – Methods for sample preparation -EN 14780</td>
</tr>
<tr>
<td></td>
<td>EN 14780 details the methods for sample preparation to ensure that biases are</td>
</tr>
<tr>
<td></td>
<td>avoided in reducing large quantities of solid biofuels (perhaps with a wide</td>
</tr>
<tr>
<td></td>
<td>particle size range) down to small samples of consistent size for repeatable</td>
</tr>
<tr>
<td></td>
<td>laboratory measurements.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Method</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Moisture in Laboratory Sample</td>
<td>Solid Biofuels - Determination of moisture content – Oven dry method – Part 3: Moisture in general analysis sample EN 14774-3</td>
</tr>
<tr>
<td>Field Moisture Content</td>
<td>CRL Energy recommends that the low cost instruments may be useful for an indication of wood fuel moisture but results would not provide adequate certainty for fuel supply contracts. Some more expensive instruments might provide adequate certainty but it is likely to be cheaper to conduct basic oven moisture tests on-site for quality control (as some suppliers do) with occasional tests from an independent laboratory for auditing and verification purposes.</td>
</tr>
<tr>
<td>Ash Content</td>
<td>Solid Biofuels - Determination of ash content (EN 14775).</td>
</tr>
<tr>
<td>Volatile Matter Content</td>
<td>Solid Biofuels - Determination of the content of volatile matter (EN 15148).</td>
</tr>
<tr>
<td>Net calorific value</td>
<td>Solid biofuels - Determination of calorific value (EN 14918).</td>
</tr>
<tr>
<td>Particle size distributions&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Solid Biofuels - Determination of particle size distribution - Part 1: Oscillating screen method using sieve apertures of 1mm and above (CEN/TS 15149-1) or Solid Biofuels - Determination of particle size distribution - Part 2: Horizontal screen method using sieve apertures of 3.15mm and below (CEN/TS 15149-2) or Solid biofuels - Determination of particle size distribution - Part 3: Rotary screen method (CEN/TS 15149-3).</td>
</tr>
<tr>
<td>Quantifying the amount of fines</td>
<td>Solid Biofuels: Methods for the determination of particle size distribution. Part 2: Vibrating screen method using sieve apertures of 3, 15 mm and below (CEN/TS 15149-2).</td>
</tr>
<tr>
<td>Particle density</td>
<td>Solid Biofuels: Methods for the determination of particle density (BS EN 15150: 2011).</td>
</tr>
<tr>
<td>Bulk density</td>
<td>Solid biofuels - Determination of bulk density (EN 15103).</td>
</tr>
<tr>
<td>Mechanical durability of</td>
<td>Solid Biofuels: Methods for the determination of mechanical durability of pellets</td>
</tr>
</tbody>
</table>

<sup>2</sup> Refer Appendix 2.
pellets and briquettes | and briquettes, to be published (BS EN 15210-2009: Pellets or Briquettes).
---|---
Water soluble chloride (Cl) content, sodium (Na) and potassium (K) | Solid biofuels methods for determination of the water soluble content of chloride, sodium and potassium (CEN/TS 15105)
Sulphur (S) and chlorine (Cl) content | Solid biofuels - Determination of total content of sulfur and chlorine (CEN/TS 15289)
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 (CEN/TS 15290)
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 - As, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sb, V and Zn (CEN/TS 15297)
Carbon, Hydrogen and Nitrogen Content (Ultimate analysis) | Solid biofuels - Determination of total content of carbon, hydrogen and nitrogen - Instrumental methods (CEN/TS 15104)

Note these recommended methods are the same as proposed in the Bioenergy Association Wood Fuel Classification Guidelines July 2010 (Bioenergy Association Technical Guide 1 version 5).

### 3.3 Determination of Total Moisture


This EN standard is applicable to all solid biofuels and describes the reference method for determining the total moisture content of a sample by drying in an oven. It should be used when high precision is required for the determination of moisture. A sample with the minimum mass of 300 grams is dried at a temperature of 105°C±2°C and in which the air atmosphere changes between 3 and 5 times per hour, until constant mass is achieved. Moisture percentage is calculated from the loss in sample mass. Procedure for the correction of buoyancy effects is included in the method. The dried sample has to be weighed while still hot, which gives a buoyancy effect which has to be compensated for when the highest precision is needed. The apparatus, sample preparation, procedure and calculation methods are also described.

Method based on 14774-2 Solid biofuels - Methods for the determination of moisture content - Oven dry method-Part 2: Total moisture - Simplified method.

The principal of this EN standard is similar to EN 14774-1, and it may be used when the highest precision is not needed, for example routine production monitoring and quality control on site. The difference compared to Part 1 is that there is no allowance for buoyancy compensation. The sample with a minimum mass of 300 grams is dried at a temperature of 105°C ± 2°C in an air...
atmosphere until constant mass is achieved and moisture percentage is calculated from the loss in sample mass.

Method based on EN 14774-3 Solid biofuel - Methods for the determination of moisture content - Oven dry method - Part 3: Moisture in general analysis samples.

This EN standard is applicable to all solid biofuels and it describes the method for determining the moisture in the analysis of samples by drying the sample in an oven. It is to be used for general analysis samples as described in EN 14780. General analysis samples are defined as sub-samples of a laboratory sample having a nominal top size of 1 mm or less (i.e. has been ground) and used for a number of chemical and physical analyses. The analysis sample is dried either in air atmosphere or in nitrogen atmosphere at a temperature of (105 ± 2 °C) and the moisture percentage is calculated from the loss in the test sample mass. The apparatus, sample preparation, procedure and calculation are described. A minimum of two determinations shall be carried out on the test sample.

For fuel suppliers to be Bioenergy Association accredited it is recommended that they have on-site capability to undertake moisture content analyses using an oven.

4. **References and Relevant Literature**


Appendix 1  Recommended Testing Laboratories

Note that there may be biosecurity issues with sending wood samples to and from Australia and New Zealand.

Recommended Laboratories in New Zealand

CRL Energy Ltd, Grant Murray, PO Box 31244, Lower Hutt 5040, 04 5703717, g.murray@crl.co.nz (also for Greymouth lab)

SGS New Zealand Ltd, Minerals Division - Ngakawau Laboratory, Hugh McMillan, PO Box 240, Westport 7866, 03 7828261, Hugh.McMillan@sgs.com (also for Waihi lab)

Veritec Forest Nutrition Laboratory, Kaye Eason, Scion, Private Bag 3020, Rotorua 3046, 07 3435400, Kaye.Eason@veritec.co.nz

Wood Industry Technical Services, Alistair Coulter, 64 Paul Rd, RD2 Whakatane, 07 3228020, witsl@orrcom.co.nz

Recommended Laboratories in Australia

A selection of Australian laboratories (many more available on www.nata.asn.au)

ACIRL, ALS Laboratory Group, Ipswich, Queensland, Andrew White, 00617 3810 5200, Andrew.White@alsglobal.com

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

SGS Australia Pty Ltd, Coal and Technical Services, Newcastle Laboratory, NSW, 00612
Appendix 2  Review of Wood Fuel Testing Standards

Author(s): Wayne Hennessy
CRL Ref: Report No: 10-11013
Title: Review of Wood Fuel Testing Standards
Client Name: EECA
Client Address: P O Box 37444
Auckland 1151
Attention: Chris McArthur
Date of Issue: 31 May 2010

Approved By: Dr T W Matheson
Name & Designation: General Manager Operations

Confidentiality Clause: This document and any accompanying attachments are confidential to the intended recipient. The document may contain information that is subject to legal privilege.

ISO 9001
Summary

The Wood Fuel Classification Guidelines have been developed by the Bioenergy Association of NZ (BANZ) in partnership with EECA. They are voluntary standards developed for New Zealand conditions based on existing quality standards for wood energy in Europe, New Zealand and Australia. The guidelines provide a means for wood fuel suppliers to classify their wood pellets, hog fuel, wood chips, firewood etc. and to provide quality assurance to fuel users.

The purpose of this study is to review existing wood fuel testing standards and to make recommendations as to which testing standards should be adopted within the wood fuel industry to support the Wood Fuel Classification Guidelines. BANZ will incorporate the recommended testing standards into the Wood Fuel Classification Guidelines and then liaise with stakeholders and work with EECA to encourage industry use and adoption of the guidelines.

In this report, sampling issues and each wood fuel property are considered in terms of the standards available, the laboratories that can offer the service and the costs of the service. A recommendation is made at the end of each section regarding the most appropriate standard. For every property in Table 1, the relevant EN standard (or technical specification that is proposed as a standard) is recommended because it appears to have been subjected to detailed consideration of the relevant variables.

Table 1 – List of technical specifications to determine fuel properties.

<table>
<thead>
<tr>
<th>Wood Fuel Property</th>
<th>Recommended Testing Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling</td>
<td>Solid biofuels - Methods for sampling (CEN/TS 14778-1)</td>
</tr>
<tr>
<td>Preparation of Sample</td>
<td>Solid biofuels - Methods for sample preparation (CEN/TS 14780)</td>
</tr>
<tr>
<td>Total Moisture</td>
<td>Solid Biofuels - Determination of moisture content – Oven dry method – Part 2: Total moisture – Simplified method (EN 14774-2)</td>
</tr>
<tr>
<td>Moisture in Laboratory Sample</td>
<td>Solid Biofuels - Determination of moisture content – Oven dry method – Part 3: Moisture in general analysis sample (EN 14774-3)</td>
</tr>
<tr>
<td>Ash Content</td>
<td>Solid Biofuels - Determination of ash content (EN 14775)</td>
</tr>
<tr>
<td>Volatile Matter Content</td>
<td>Solid Biofuels - Determination of the content of volatile matter (EN 15148)</td>
</tr>
<tr>
<td>Gross (or Net) Calorific Value</td>
<td>Solid biofuels - Determination of calorific value (EN 14918)</td>
</tr>
<tr>
<td>Carbon, Hydrogen and</td>
<td>Solid biofuels - Determination of total content of carbon, hydrogen</td>
</tr>
<tr>
<td>Nitrogen Content (ultimate analysis)</td>
<td>and nitrogen - Instrumental methods (CEN/TS 15104)</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Sulphur (S) and Chlorine (Cl) Content</td>
<td>Solid biofuels - Determination of total content of sulfur and chlorine (CEN/TS 15289)</td>
</tr>
<tr>
<td>Major Elements</td>
<td>Solid biofuels - Determination of major elements - Al, Ca, Fe, Mg, P, K, Si, Na and Ti (CEN/TS 15290)</td>
</tr>
<tr>
<td>Trace or Minor Elements</td>
<td>Solid biofuels - Determination of minor elements - As, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sh, V and Zn (CEN/TS 15297)</td>
</tr>
<tr>
<td>Ash Fusion Temperature</td>
<td>Solid biofuels - Determination of ash melting behaviour - Part 1: Characteristic temperatures (CEN/TS 15370-1)</td>
</tr>
<tr>
<td>Particle Size Distribution (including amount of fines)</td>
<td>Solid Biofuels - Determination of particle size distribution - Part 1: Oscillating screen method using sieve apertures of 1mm and above (CEN/TS 15149-1) or Solid Biofuels - Determination of particle size distribution - Part 2: Horizontal screen method using sieve apertures of 3.15mm and below (CEN/TS 15149-2) or Solid Biofuels - Determination of particle size distribution - Part 3: Rotary screen method (CEN/TS 15149-3)</td>
</tr>
<tr>
<td>Bulk Density</td>
<td>Solid biofuels - Determination of bulk density (EN 15103)</td>
</tr>
</tbody>
</table>

Section 16 summarises some other CEN technical specifications that have been developed and may be relevant for some specific customer requirements.

ASTM standards have been developed for a number of wood fuel properties and these are discussed in each section. There are notable temperature differences for the determination of ash content and volatile matter content and comparison tests would need to be carried out if they were used instead of the EN tests.

In general, because there is no demand for accredited services dedicated to wood fuel testing in New Zealand (and apparently none in Australia), adaptations of coal testing methods are currently the services available for wood fuel testing. Coal sampling and testing according to various standard methods are well established in New Zealand for all the relevant analyses for wood fuels. Comments are made in each section as to whether the equivalent coal tests would provide adequate assurance of the wood fuel property for contractual purposes.

As the demand for wood testing services develops, testing laboratories are likely to ensure that their coal testing methods meet the recommended standards for wood testing, with adaptations where necessary. Contact details for a selection of New...
Zealand and Australian laboratories currently accredited for the sampling and testing of coal are summarised in the Appendix.

A field moisture tester may be a useful instrument for assessing the moisture content of firewood in large chunks but may be of limited use for wood chips or pellets. CRL Energy assesses that the low cost instruments may be useful for an indication of wood fuel moisture but results would not provide adequate certainty for fuel supply contracts. The more expensive instruments might provide adequate certainty but it is likely to be cheaper to conduct basic oven moisture tests on-site for quality control (as some suppliers do) with occasional tests from an independent laboratory for contractual purposes.

The final section summarises some comments from wood fuel suppliers and users and officials on the BANZ wood fuel classifications.

1. Introduction

The Wood Fuel Classification Guidelines have been developed by the Bioenergy Association of NZ (BANZ) in partnership with EECA. They are voluntary standards developed for New Zealand conditions based on existing quality standards for wood energy in Europe, New Zealand and Australia. The guidelines provide a means for wood fuel suppliers to classify their wood pellets, log fuel, wood chips, firewood etc. and to provide quality assurance to fuel users. A copy of the Guidelines can be found at http://www.bioenergy.org.nz. EECA and BANZ are working on promotion of the Guidelines throughout the sector.

The Guidelines currently refer briefly to Testing Standards. If market participants are to work with the Guidelines then ultimately it will be important for them to be able to access facilities or laboratories that have been approved to undertake an agreed and standard set of tests to ensure quality. The purpose of this study is to review existing wood fuel testing standards and to make recommendations as to which testing standards should be adopted within the wood fuel industry to support the Wood Fuel Classification Guidelines.

Once the review of the wood fuel testing guidelines is complete, BANZ will incorporate the recommended testing standards into the Wood Fuel Classification Guidelines. BANZ will then liaise with stakeholders and work with EECA to encourage industry use and adoption of the wood fuel classification guidelines.

The scope of the review is to undertake the following:

- Review existing standards for wood fuel testing as applicable to the Wood Fuel Classification Guidelines, considering ease of testing, capacity for the testing to be undertaken within NZ, cost of testing, ability of tests to be undertaken within the field, bulk sampling methodology and any other relevant issues.
- Consider which tests present the most cost effective options.
• Make recommendations as to which tests are best applied to the EECA/BANZ
  Wood Fuel Classification Guidelines. For example, identify which tests are
currently available in New Zealand, the reason they have been established (if
not for wood fuel quality testing); the equipment they require as part of the
testing process.

In the following sections, sampling issues and each wood fuel property are considered
in terms of the standards available, the laboratories that can offer the service and the
costs of the service. A recommendation is made at the end of each section regarding
the most appropriate standard.

New Zealand is fortunate that CEN, the European standards organisation, has done
extensive work on developing technical specifications (effectively draft standards)
over the last decade. Development in the European market will be one driver for
wood fuel classification in New Zealand, especially for any wood pellet exports to
Europe. This year Europe-wide standardised wood pellets are available to consumers.
Under the EU ENplus standard, three quality classes have replaced the previous
country-specific regulations, including Germany’s DINplus and Austria’s ÖNORM
standard (DEPI 2010).

ENplus-A1 wood pellets must have an ash content of under 0.5% when using wood
from conifers and under 0.7% when using other types of wood. Class ENplus-A2
covers the wider spectrum of raw materials with an ash content of up to 1%
(integrating the slightly wider requirements of heating systems which are used, in
particular, in the southern European pellets countries). The previously undefined
category of industrial pellets has finally been settled. The new Class EN-B wood
pellets have a higher ash content (up to 3%) and expanded raw material potential such
as bark contents. These were previously called “industrial pellets” and were mostly
burned in large installations like power plants. All three classifications must have a
moisture content up to 10% and a fines content (<3mm) of up to 1%.

Details on the certification procedure, internal/external control and documentation
modalities, costs and sanctions are presented in a handbook (DEPI 2010). Pellet
quality requirements are based on proposed EN standard 14961-2 with only one
difference: chemically treated material is not allowed in any quality class.

There are also some US ASTM standards for wood fuel testing. Australia and New
Zealand do not have any specific standards for wood fuel testing and so the equivalent
coil tests are generally used1. This review discusses the similarities with the solid fuel
testing standards commonly used in New Zealand and some significant differences that
will need to be noted by testing laboratories.

In general, because there is no demand for accredited services dedicated to wood fuel
testing in New Zealand (and apparently none in Australia), adaptations of coal testing
methods are currently the services available for wood fuel testing. Coal sampling and
testing according to various standard methods are well established in New Zealand for
all the relevant analyses for wood fuels. As the demand for wood testing services

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1 AS/NZS 4014.6.2007 was designed as a means of minimising wood pellets fuel variability for testing
appliances rather than a practical means of classification for the wood fuel market.

CRI Energy Limited
develops, testing laboratories are likely to ensure that their coal testing methods meet the recommended standards for wood testing, with adaptations where necessary.

IANZ (International Accreditation NZ) has a procedure for accrediting laboratories by checking regularly that their methods follow various standards or appropriate in-house methods and ensuring they have the appropriate technical skills and calibrated equipment. Similarly, NATA has 31 Australian laboratories currently accredited for the sampling and testing of coal. Contact details for a selection of these laboratories are summarised in the Appendix.

It is not CRI Energy’s role to comment on whether the chosen wood quality classifications for each parameter are appropriate for the New Zealand market. The final section summarises some comments from wood fuel suppliers and users and officials on those classifications.

2. Standards on Wood Fuel Definitions and Quality Assurance

CEN/TS 14588 for terminology, definitions and descriptions has evolved to a proposed standard under approval. This is a useful summary of terms used in the wood fuels industry.

Fuel specifications and classes for solid biofuels were set out in CEN/TS 14961:2005, which defined certain parameters and property classes and this was used as the basis for New Zealand’s Wood Fuel Classification Guidelines (BANZ 2009).

This technical specification has now been split into a CEN finalised standard EN 14961:2010 Part 1 - General requirements and 5 proposed standards:

- Part 2: Wood pellets for non-industrial use (under approval)
- Part 3: Wood briquettes for non-industrial use (under approval)
- Part 4: Wood chips for non-industrial use (under approval)
- Part 5: Firewood for non-industrial use (under approval)
- Part 6: Non woody pellets for non-industrial use (under development)

CEN/TS 15234:2006 Fuel quality assurance has similarly been split into 6 proposed standards with Part 1 under approval and Parts 2 to 6 under development. Informative Annexes A and B appear to have been published as CEN/TS 15569:2009, a general guide for a quality assurance system. This may provide a useful guide for wood fuel suppliers or users in New Zealand wishing to implement such a system:

- Step 1: Document the steps in the process chain.
- Step 2: Define specifications for the biofuels (considering any emissions limits).
• Step 3: Analyse factors influencing the fuel quality and performance (including the preliminary inspection of fuel sources and incoming raw materials, care of storage and processing, and competence of staff).

• Step 4: Document any Critical Control Points for compliance with the fuel specification (points where properties can most readily be assessed and points that offer the greatest potential for quality improvement).

• Step 5: Select appropriate measures to give confidence to customers that the specifications are being realised (including allocation of responsibilities, training of staff, work instructions, establishing quality control measures, documenting processes, test results and complaints).

• Step 6: Document routines for separate handling of non-conforming biofuels.

3. Assessing Wood Fuel Properties

For any solid fuels testing, it is important to understand how the various properties are assessed and reported.

Solid fuels are mixtures of organic matter (the source of combustion heat), mineral matter (usually minimal for wood) and moisture. 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). The measurements of moisture and ash (together with volatile matter and fixed carbon) are collectively known as proximate analysis.

Wood ash content varies according to the amounts of inherent mineral matter within the wood and from any associated impurities (e.g. bark can contain relatively high amounts of dirt from dragging logs). Moisture content varies according to the tree species, transport and storage methods (including any drying treatment).

The proximate analysis and calorific value (expressed on an “as received basis” or “wet basis”2) are useful for wood fuel users and suppliers to understand the combustion heat that can be obtained from a particular consignment of wood fuel.

For most wood fuels, expressing the calorific value on a “dry ash free basis” can act as a useful check because removing the variability of the ash content and the moisture content usually leaves a consistent quantity that represents the heat content of the organic matter alone.

Another measurement that is sometimes useful for the assessment of different wood species is the ultimate analysis, particularly the carbon content expressed as a

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2 There is a useful note that frequency of testing can be greatly reduced if there is evidence of continuous compliance to specifications with no significant changes.

3 All moisture references in this report are on an as received, wet basis.
percentage (usually on a “dry basis”). Again, removing the variability of the ash content and the moisture content usually leaves a consistent quantity that represents the carbon content of the organic matter alone.

The most common basis for reporting laboratory analyses is the “as analysed basis” (also known as “air dried basis”). The moisture loss is measured after a crushed sample is conditioned to the laboratory atmosphere and this process minimises the risk that the moisture content of the sample will change during sample fine grinding, weighing and measurement for different properties. To ensure that moisture variability is accounted for, the moisture content of the laboratory sample is re-measured if, for example, the ultimate analysis is conducted on a different day from the proximate analysis.

A useful reference is CEN/TS 15296:2006 “Solid Biofuels - calculation of analyses to different bases”, which has a table of formulae to convert “as analysed”, “as received”, “dry” and “dry ash free” bases to one another. It also contains the formula for calculating net from gross calorific value (i.e. converting higher to lower heating value).

The NZ Energy Information Handbook (NZEIH 2008) summarises the properties of a wide range of wood fuels for different tree species.

4. Sampling and Preparation Methods for Wood Fuels

For any solid fuels testing, testing laboratories generally acknowledge that the greatest source of testing variability (and potential measurement errors) is in the sampling methodology. High measurement precision can not make up for any bias in the sampling regime.

The most important steps in wood fuel testing are ensuring that correct sampling and preparation procedures have been used so that the wood powder contained in a small bottle can represent, for example, a wood pellets shipment as large as 20,000 tonnes. The ISO sampling standard or the equivalent CEN (European), BS (British), AS (Australian), ASTM (US) or other standard is an important pre-requisite before individual wood fuel tests are considered.

CEN/TS 14778 part 1 describes general sampling methods for solid biofuels and part 2 sampling particulate material transported in lorries. Specific methods are detailed for finer materials like wood pellets and sawdust (using a scoop or pipe) and coarser materials such as wood chips (using a fork or shovel) as well as various other forms of biomass fuels. While the details differ, the overall principles are similar to those used for the commonly known ISO 18283 used for coal sampling in New Zealand.

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 over a conveyor belt or truckload or stockpile etc. to ensure a representative sample is taken.
For example CEN/TS 14778-1 Table B1 offers guidelines for truck sampling that illustrate the significance of particle size. 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 litre.

CEN/TS 14779 relates to the preparation of biofuel sampling plans and sampling certificates and may become relevant for large scale production for say wood pellet shipments.

CEN/TS 14780 details the methods for sample preparation to ensure 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. 14780’s Table 1 specifies 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 [0.5kg].

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 for coal 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 weighed.

Methods are specified ( riffle boxes, rotary dividers etc.) to ensure that sample weight reduction is free of bias, which is particularly important for heterogeneous samples (containing say bark chunks or stones). Once the crushed sample is dried, it is more easily handled in a grinder or ring mill to produce a homogeneous powder (typically up to 0.2mm for non-fibrous samples).

A key quantity determined during solid fuel preparation is the loss on air drying (see next section) to determine the moisture loss when a crushed sample is equilibrated in the laboratory atmosphere before grinding it to a powder.

IANZ currently has one laboratory accredited for its solid fuels sampling/preparation method: CRL Energy (Gracefield, Wellington) follows ISO 18283:2006 for hard coal sampling. The SGS (Ngakawau, Westport) quality manager stated that they follow an ISO sampling standard but they are not accredited for this. An expert in coal quality systems (Daly 2009) highlighted that both CRL Energy and SGS labs follow standard methods for sample preparation but only some sampling methods in some situations could be accredited. Many samples received by all laboratories are sampled by the coal mining companies or wood fuel suppliers so the sampling quality assurance (and degree to which the sample is representative) lies with those companies.
Costs

Most laboratories offer sampling services on an hourly rate with travel costs that would be dependent on location of a shipment or stockpile. For NZ labs, sample preparation costs for CRL Energy and SGS are $23-25 (ex. GST) while Vertec and Wood Industry Technical Services include this cost in the analysis price.

ACIRL in Ipswich (Queensland) estimates approximately $550 per sample and Bureau Veritas in Wollongong (NSW) would quote on an hourly rate ($75/hr). SGS in Newcastle (NSW) would negotiate its rates with individual clients.

Conclusion

Sampling and preparation methods are very important (to avoid bias in the test sample) and the recommended methods for wood fuel sampling and preparation are CEN/TS 14778-1 and 14780 respectively. Without reviewing differences in detail, CRL Energy considers any of the following coal standards (among others) would give assurance of adequate wood fuel sampling and preparation for contractual purposes: AS 4264.1 or 4264.3, ASTM D2013, ISO 5069-1 or 5069-2 or 13909 or 18283.

5. Moisture Testing for Wood Fuels

Moisture content is the most important test for determining wood fuel properties because the organic matter properties are usually consistent (for a given tree species on a dry basis) and ash content is usually low. There is a small range of analysis methods, including oven drying (air or nitrogen atmosphere), microwave drying and a field tester.

According to standard methods, the “loss on air drying” for a crushed sample is added to the laboratory measurement of air dried “moisture content” to give “total moisture”, which is used for calculating properties on an “as received basis” for a solid fuel consignment. The purpose of this stage process is to minimise bias or systematic errors in the sample preparation as discussed in the last section.

Total moisture can also be measured by a direct method of weight loss in a drying oven.

CEN’s EN 14774 part 1 describes the reference method for total moisture in solid biofuels. A 300-500 gram sample (up to 30mm thickness) is dried at 105 ± 2°C in an air oven with 3 to 5 volume changes per hour. The tray is re-weighed hot after heating for a few hours then re-heated and re-weighed until constant weight is achieved; defined as a relative change of less than 0.2% of the weight loss (so <0.1% difference for a 50% weight loss) over one hour. A method is described to allow for buoyancy effects (balance pan heating) and the drying time should not exceed 24 hours to avoid unnecessary losses of volatile compounds. EN 14774 part 2 is described as the simplified method because it does not include a buoyancy correction procedure but is otherwise the same.
EN 14774 part 3 is for moisture analysis in the laboratory sample. A 1g sample (up to 1mm particle size) is dried in an unlined dish at 105 ± 2°C in an air oven but a nitrogen atmosphere is recommended for samples (like coal) susceptible to oxidation. The dish is lidless while still hot and weighed after cooling to room temperature. Constancy in weight is considered to be a change of <1mg between successive reheating and weighings. This normally takes 2-3 hours.

Coal methods are very similar but laboratory sample moisture determination is conducted in a nitrogen atmosphere to avoid oxidation. For hard coal, ISO 589 measures oven dried total moisture (typically 16hr) while ISO 11722 measures moisture in the laboratory analysis sample (typically 2hr). For lignite (brown coal), ISO 5068 Parts 1 and 2 measure total moisture and laboratory sample moisture respectively. ISO 17246 is for proximate analysis of coal (including these moisture methods).

ASTM E871 measures oven dried moisture in particulate wood fuels. ASTM D2961 and D3302 are similar methods for measuring total moisture in coal while D3173 measures moisture in the laboratory analysis coal sample. ASTM E870 is a general standard for test methods for wood fuels (including the moisture method) while D3172 and D5142 are general standards for proximate analysis of coal samples (including moisture).

AS 1038.1 specifies the test method for oven dried total moisture in hard coals and AS 2434.1 for brown coals (with AS 2434.7 for moisture in the laboratory sample). AS 1038.3 is for the proximate analysis (including moisture in the lab sample) of hard coals.

Cost

For LANZ accredited labs, total moisture costs (extra to the sample preparation) for CRL Energy (accredited for ISO 5068) and SGS are $10 per sample (ex GST). Veritec follows ASTM E871 on a 4-6 litre sample and charges $9 while Wood Industry Technical Services follows a Scandinavian pulp and paper industry method using at least 0.25kg and charges $7.50. Proximate analysis (moisture, ash volatile matter) is $23-28 for CRL Energy and SGS (which is accredited for ASTM D5142 - modified). For sample preparation, moisture, ash and calorific value, Veritec charges $150 for the first sample and $83 each for subsequent samples in the same batch.

ACIRL (Queensland) charges $220 per sample for total moisture and $330 for proximate analysis, Bureau Veritec (NSW) would charge $222 and $330 respectively. SGS (NSW) would negotiate its rates with individual clients.

Conclusion

It is recommended that EN 14774-2 should be used for total moisture determination and EN 14774-3 for moisture determination of wood fuel laboratory samples.

ASTM E871 is specifically designed for total moisture determination of wood fuels. CRL Energy considers accredited laboratories using any of the following coal standards (among others) would give assurance of adequate total moisture
measurement of wood fuel samples for contractual purposes: AS 1038.1 or 2434.1, ASTM D2961 and D3302, ISO 589 or 5068-1.

Similarly, CRL Energy considers any of the following coal standards would give adequate moisture measurements for wood fuel laboratory samples: AS 1038.3 or 2434.7, ASTM D3173, ISO 5068-2, 11722 or 17246.

**Microwave method for moisture**

ASTM E1535 describes the rapid determination of moisture content in wood fuel samples within 10 minutes rather than the E871 method that takes a minimum of 18hr. A 50 gram sample is weighed onto tared paper towels and heated in a typical microwave oven for a few minutes before removing and weighing. After stirring the sample, it is re-heated and re-weighed for a few cycles until the difference between successive weighings is less than 0.5g. A table of suggested cycle times for different tree species and approximate moisture levels is a useful guideline. E.g. For pine chips (about 48% moisture), a 4 minute cycle (full power) followed by a 1 minute and then 30 second cycles is suggested.

There is no comparison made with results from the E871 method nor is there any discussion of how to minimise the buoyancy problem of balance drift as the balance pan heats up.

Repeatability limits state that results should be considered suspect if duplicate measurements in the same laboratory differ by more than 1%. (This appears to mean an absolute rather than relative difference, e.g. 46% and 47% results would be acceptable.) Reproducibility limits state that results should be considered suspect if results from this method from a different laboratory differ by more than 1.5%

This method appears to be a very useful means of spot checking lots of wood fuels but it would be prudent to undertake a comparison with the E871 method if the microwave method is to be used for quality control.

**Field testing for moisture**

George Escott of Scion’s Vetitec laboratory described the use of field meters for moisture testing (Escott 2010). He regularly uses a Carret and Carrel (NZ made) instrument for testing the moisture content of firewood. It consists of a meter measuring the resistivity between two probes that is corrected for the tree species for different wood fuel sources. He estimated that in the 10-30% moisture range (as received, wet basis), the measurement could be accurate to ± 3%, but above 30%, it might only be accurate to as much as ± 10%.

This instrument cost about $2000 but the manufacturer also produces a more basic model (dry, marginal and wet readings) for about $100. An internet search showed numerous models are available overseas for as little as NZ$50. Product reviews appear to be readily available to compare the performance of the more accurate meters.

ASTM D4444 offers a standard means of calibrating hand-held meters. It says that as well as the actual moisture content of the wood sample, measurements are influenced by a number of other wood variables, environmental conditions, geometry of the measuring probe circuitry, and design of the meter. The maximum accuracy can only
be obtained by an awareness of the effect of each parameter on the meter output and correction of readings as specified by using the standard test method.

**Conclusion on field testing**

A field moisture tester may be a useful instrument for assessing the moisture content of firewood in large chunks but one supplier commented it would be of limited use for wood chips or pellets. CRL Energy assesses that the low cost instruments may be useful for an indication of wood fuel moisture but results would not provide adequate certainty for fuel supply contracts. The more expensive instruments (like the one used by Veritec) might provide adequate certainty but it is likely to be cheaper to conduct basic oven moisture tests on-site for quality control (as some suppliers do) with occasional tests from an independent laboratory for contractual purposes.

6. **Ash Testing for Wood Fuels**

Ash content is another important test for determining wood fuel properties. Ashing temperature for wood fuel standards is a significant point of difference with coal ashing standards.

CEP's EN 14775 describes the method for ash content of solid biofuels. A 1g sample is initially ashed at 250°C until volatiles are burnt off slowly (to avoid losing entrained particles with fast burning) and then a heating regime is followed to finish with an ashing temperature of 550 ± 10°C for at least 2 hours.

ASTM D1102 for ashing wood samples follows a similar method (without prescribed times) to a final ashing temperature of 580-600°C. The sample is re-ashed for 30 minute periods until constant weights are recorded. It is not clear why there is a separate ASTM E1534 for ashing particulate wood fuels (and E1755 for ashing biomass) but E1534 also has a final ashing temperature of 580-600°C.

Coal ashing methods (such as AS 1038.3 or 2434.8, ASTM D3174 or D5142, ISO 1171 or 1724s) are very similar but the final ashing temperature is 815°C. The EN 14775 standard explains that the difference in the ash content determined for wood at 815°C compared to 550°C can be explained by the loss of volatile inorganic compounds, further oxidation of some inorganic compounds and the decomposition of carbonates.

**Cost**

For IANZ accredited labs, proximate analysis (moisture, ash volatile matter) is $23-28 for CRL Energy and SGS (ex GST). CRL Energy is accredited for ISO 1171 for coal samples but uses for wood samples ASTM D1102 (580-600°C). SGS is accredited for ASTM D5142 (modified) for proximate analysis of coal samples and uses the same method for wood samples (815°C).

For sample preparation, moisture, ash and calorific value, Veritec charges $150 for the first sample and $85 each for a subsequent sample in the same batch. Veritec uses an in-house method based on ASTM D1102 with a final ashing temperature of 525°C.
Wood Industry Technical Services follows a method with a final ashing temperature of 860°C and charges $25 including sample preparation.

ACIRL (Queensland) and Bureau Veritas (NSW) both charge A$30 for proximate analysis and SGS (NSW) would negotiate its rates with individual clients.

**Conclusion**

It is recommended that EN 14775 should be used for the determination of ash content of wood fuel samples. ASTM D1102 and E1534 are specifically designed for wood fuels with final ashing temperatures (580-600°C) somewhat higher than the EN standard (550°C).

CRL Energy recommends if coal standards (at 815°C, such as AS 1038.3 or 2434.8, ASTM D3174 or D5142, ISO 1171 or 17246) are to be used for ash measurement of wood fuel samples for contractual purposes, comparisons must be done to test if there are significant differences from the wood fuel standard.

7. **Volatile Matter Testing for Wood Fuels**

Volatile matter content is not a significant measurement for wood fuel compared with its importance for coal properties.

CEN’s EN 15148 describes the method for volatile matter of solid biofuels. A 1g sample in a folded silica crucible (prescribed dimensions) is placed in a 900 ± 10°C furnace for 7 minutes and weighed when cooled.

ASTM E872 for volatile matter of wood samples follows a similar method in a 950 ± 20°C furnace for 7 minutes.

Coal volatile matter methods (such as AS 1038.3 or 2434.2, ASTM D3172 or D3175 or D5142, ISO 562 or 17246) are very similar to the wood fuel ones described above.

**Cost**

For LANZ accredited labs, proximate analysis (moisture, ash volatile matter) is $23-28 for CRL Energy and SGS (ex GST).

ACIRL (Queensland) and Bureau Veritas (NSW) both charge A$30 for proximate analysis and SGS (NSW) would negotiate its rates with individual clients.

**Conclusion**

It is recommended that EN 15148 should be used for the determination of volatile matter content of wood fuel samples. ASTM E872 is designed for volatile matter of wood fuels but the 950 ± 20°C temperature is somewhat higher than the EN’s 900 ± 10°C and the difference should be tested if the ASTM method is to be used.

CRL Energy considers coal standards (such as AS 1038.3 or 2434.2, ISO 562 or 17246) would provide adequate volatile matter measurements of wood fuel samples
for contractual purposes. If ASTM D3172 or D3175 or D5142 coal standards were to be used, the temperature difference should be tested.

8. **Calorific Value (Specific Energy) Testing for Wood Fuels**

Calorific value measurement is an important test for determining wood fuel properties. It can sometimes be accurately estimated for a particular tree species if the sample moisture and ash content are known. For most wood fuels, expressing the calorific value on a “dry ash free basis” can act as a useful check because removing the variability of the ash content and the moisture content usually leaves a consistent quantity that represents the heat content of the organic matter alone.

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). Some fuel users prefer net CV as the more practical indicator of available energy (especially in Europe). Testing standards include the formula for calculating net from gross calorific value (i.e. converting higher to lower heating value), which requires the moisture and hydrogen content of the sample and an estimate of the oxygen content.

As an approximate indication, net CV for dry Pinus radiata wood waste (12% moisture) is 8% lower than gross CV while it is 15% lower than the gross CV for 40% moisture (NZEIH 2008).

By accounting for the energy required to vaporise water, net CV is often considered a more useful measure than gross CV, but the convention in New Zealand is usually to deal with gross CV.

It can be difficult to achieve consistent results from bomb combustion so the testing standards emphasise the importance of calibration and procedures to facilitate orderly combustion.

CEN’s EN 14918 describes the method for determining gross calorific value of solid biofuels and calculating net calorific value. A 1g sample of wood fuel powder is pressed to produce an unbreakable pellet (or the powder must be placed in a special combustion bag or capsule) in order to limit the speed of combustion. Various procedures are prescribed to determine the increase in bomb temperature compared with the temperature rise for combusting a standard substance. Small corrections are made for the heat of formation of nitric and sulphuric acids formed during combustion.

Coal calorific value methods (such as AS 1038.5, ASTM D5865, ISO 1928) are very similar but do not require pelleting the coal powder because (unlike wood) the combustion speed does not need to be limited.

Cost

For IANZ accredited labs, calorific value costs $32-38 (ex GST) for CRL Energy and SGS (both accredited for ISO 1928). For sample preparation, moisture, ash and

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*Based on figures for a range of softwoods and hardwoods (Harris 1966), CRL Energy considers that dry ash free figures of 6% hydrogen and 43% oxygen can be used to calculate the as received hydrogen and oxygen content for the net CV calculation.

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calorific value, Veritec charges $150 for the first sample and $83 each for subsequent samples in the same batch. Veritec uses an in-house method based on ASTM E711 for refuse derived fuel.

ACIRL (Queensland) and Bureau Veritas (NSW) both charge A$40 for calorific value and SGS (NSW) would negotiate its rates with individual clients.

**Conclusion**

It is recommended that EN 14918 should be used for the calorific value determination of wood fuel samples, CRL Energy recommends if coal standards (AS 1038.5, ASTM D5865, ISO 1928) are to be used for calorific value determination of wood fuel samples for contractual purposes, the testing laboratory should be accredited for the method and precautions must be taken (as in the wood fuel standard) to limit the speed of combustion.

9. **Ultimate Analysis of Wood Fuels**

Ultimate analysis (mainly for carbon content) is relatively uncommon compared with proximate analysis and calorific value. Most analytical techniques provide carbon, hydrogen and nitrogen (CHN) analyses. When these analyses are combined with sulphur and chlorine analyses (and moisture and ash), the oxygen content of the organic matter can be calculated by difference. Estimates of hydrogen and oxygen content are required to convert gross to net calorific value.

CEN/TS 15104 describes the instrumental method for determining CHN in solid biofuels. A sample of wood fuel powder (about 0.1g) is burnt in an oxygen/carrier gas mixture under conditions that ensure complete combustion (and conversion of some by-products) to carbon dioxide, water vapour and nitrogen for gas analysis. Duplicate determinations and calibration techniques are essential to ensure consistency of results.

Coal ultimate analysis methods (such as AS 1038.6.1 or 1038.6.4 or 2434.6, ASTM D5373, ISO 609 or 625 or 12902 or 17247) have a similar emphasis on calibration techniques to give consistent results.

**Cost**

Neither of the laboratories accredited for coal analysis in New Zealand (CRL Energy and SGS) offers a service to measure carbon. CRL Energy has a carbon analysis instrument and is investigating the possibility of upgrading its in-house method to a prescribed standard.

Most CHN analyses in recent years have come through CRL Energy from ACIRL in Queensland, who charge A$100 per sample and use an accredited in-house method that is said to be equivalent to the AS 1038.6.4 for instrumental carbon analysis. There are at least two other laboratory chains in Australia (SGS and Bureau Veritas) that are accredited for AS 1038.6.4.
Conclusion

It is recommended that CEN/TS 15104 should be used for carbon, hydrogen and nitrogen determination of wood fuels. CRL Energy considers coal testing standards (such as AS 1038.6.1 or 1038.6.4 or 2434.6, ASTM D5373, ISO 609 or 625 or 12902 or 17247) would provide adequate results for wood fuels.

10. Analysis of Sulphur and Chlorine in Wood Fuels

Sulphur and chlorine levels in wood fuels are important as indicators for potential corrosion in fuel burning equipment. Normally these levels are relatively low in wood fuels but they may be relatively high in chemically treated wood or in sulphur containing additives used for pellets and briquettes.

CEN/TS 15234 (for quality assurance) states that if a wood fuel supplier suspects serious contamination of land or if planting has been used specifically for the sequestration of chemicals, analysis should be carried out to identify chemical impurities such as halogenated organic compounds and heavy metals.

CEN/TS 15289 sets two digestion methods (bomb combustion and peroxide digestion) for sulphur and chlorine in solid biofuels and allows a variety of detection methods. CEN/TS 15105 describes the determination of water soluble chloride, sodium and potassium content in solid biofuels.

There are several methods for determination of total sulphur in coal samples. Standards AS 1038.6.3.1 or 6.3.2 or 6.3.3, ASTM D4239, ISO 334 or 351 are based on the Eschka method (combustion with an alkaline chemical to capture acidic gases) or high temperature combustion or an instrumental method. Similarly for chlorine determination in coal, AS 1038.8.1 is an Eschka method and AS 1038.8.2 is a high temperature combustion method.

Cost

CRL Energy and SGS (both accredited for ASTM D4239) charge $22-23 for a total sulphur analysis.

CRL Energy charges $80 per sample for two different in-house methods for chlorine. One uses bomb combustion digestion with measurement by ion selective electrode and the other is measured by X-ray fluorescence on a pressed coal powder disc.

ACIRL (Queensland) charges $25 for total sulphur and $75 for chlorine.

Conclusion

It is recommended that CEN/TS 15289 should be used for determination of total sulphur and chlorine in wood fuels. CRL Energy considers any of the coal standards for sulphur (AS 1038.6.3.1 or 6.3.2 or 6.3.3, ASTM D4239, ISO 334 or 351) or for chlorine (AS 1038.8.1 or 8.2) could be adequately used for determination of wood fuel samples for contractual purposes. The laboratory should be accredited for each
method and precautions must be taken (as in the wood fuel standard) to limit the speed of combustion if bomb digestion is used.

If a relatively high chlorine content was measured in a wood fuel, before expensive organics tests were carried out, it would be prudent to check if the chlorine was in the form of soluble chloride salts by using the CEN/TS 15105 test method.

11. Analysis of Major and Minor Elements in Wood Fuels

The determination of major elements of solid biofuel ashes may be helpful to predict the melting behaviour and slagging of the ashes. Also, contamination of fuels with sand or soil is indicated by high values of certain elements.

The presence of relatively high levels of minor (trace) elements can be of environmental concern. e.g. Some energy crops will concentrate cadmium and in polluted areas other toxic elements may be found at elevated concentrations. This can be a problem if the ash is to be put back in the forest as fertiliser.

CEN/TS 14961 Annex C is a useful compilation of major and trace element ranges for various solid biofuels.

CEN/TS 15290 is a method for determination of major elements by acid digestion of the biofuel itself or of a 550°C ash of the biofuel. Aluminium, calcium, iron, magnesium, phosphorus, potassium, silicon, sodium, titanium (and perhaps barium and manganese) are measured by one of four spectrometric methods.

CEN/TS 15297 is a method for determination of minor (trace) elements by acid digestion of a biofuel taking care not to lose volatile trace elements and to avoid contamination from for instance the milling process. Arsenic, cadmium, cobalt, chromium, copper, mercury, manganese, molybdenum, nickel, lead, antimony, vanadium and zinc are measured by a variety of spectrometric methods (mercury, arsenic and others require very specialised methods).

Alternatively, X-ray fluorescence may be used for many major and trace elements when validated with suitable biomass reference materials. There is a proposed CEN standard (current reference 00355065) for this.

There are several standard methods for measuring major and trace elements in coal samples. Examples are AS 1038.14.1 for major elements by borate fusion of ash and flame atomic absorption spectrometry and AS 1038.10.1 for 11 trace elements.

Cost

CRL Energy charges $86 per sample (ex GST) for determining the major elements in a coal or wood ash by X-ray fluorescence on a borate fused disc. 22 trace elements can be measured for $244 on a coal or wood 550°C ash after microwave acid digestion. Mercury can be analysed for $70 on combustion bomb washings using cold vapour atomic absorption spectrometry.
Several Australian labs can conduct major and trace element analysis based on coal standard methods. ACIRC (Queensland) charges A$100 for major elements.

**Conclusion**

It is recommended that CEN/TS 15290 and 15297 should be the methods used for determination of major and minor (trace) elements respectively in solid biofuels. Alternatively, X-ray fluorescence may be used for many major and trace elements when validated with suitable biomass reference materials. There are several standard methods for measuring major and trace elements in coal samples (such as AS 1038.14.1 and 1038.10.1). CRL Energy considers any coal standard would also provide adequate results for wood fuel samples. It would be prudent for the method to be validated with suitable biomass reference materials.

### 12. Ash Fusion Temperatures of Wood Fuels

Ash melting is a complex process that can involve sintering, shrinkage or swelling of the ash. It is important to avoid slag deposits in the combustion equipment (unless it is designed to encourage slugging) so an ash fusion test helps predict the melting behaviour of an ash.

CEN/TS 15370-1 sets out the determination of melting behaviour of ashes from combusting solid biofuels. As for various similar coal ash fusion standards (AS 1038.15 or ASTM D1857 or ISO 540), the test can be carried out in a reducing or oxidising atmosphere depending on the combustion equipment conditions that need to be simulated.

**Cost**

CRL Energy and SGS charge $70 per sample (ex GST) for an ash fusion temperature test (reducing and oxidising atmospheres would count as two tests).

Several Australian labs can conduct ash fusion temperature tests. ACIRC (Queensland) charges A$100 per test.

**Conclusion**

It is recommended that CEN/TS 15370-1 should be the method for the determination of melting behaviour of ashes from combusting solid biofuels. CRL Energy considers this would give the same results as various coal ash fusion standards (AS 1038.15 or ASTM D1857 or ISO 540).

### 13. Particle Size Testing of Wood Fuels

Particle size distribution is one of the most important properties for classifying wood fuels. There are a number of difficulties to overcome to obtain consistent tests within and between laboratories, mainly because of the shape and fibrous nature of many wood particles.
CEN/TS 15149-1 is an oscillating screen method for solid biofuels (one or two dimensions for shaking) with sieve apertures 1mm or more. 15149-2 is a vibrating screen method (three dimensions for shaking) with sieve apertures 3mm or less. 15149-3 is a rotary screen method (gravity separation rather than shaking). 15149-1 can be used for either manual or mechanical shaking while 15149-2 must be mechanical because it is explained that small sieve holes may easily be clogged during manual sieving. Sieve geometry, thickness and hole distances and diameters must be in accordance with an ISO standard. It is accepted that some thin particles that are longer than the hole diameter will pass the sieve and mix with smaller size fractions.

For 15149-1, sieves with hole diameters of 3mm, 16mm, 45mm and 63mm are recommended (with the preferable addition of a 8mm sieve to avoid overloading). Mechanical sieving must be continued for 15 minutes and it is cautioned that longer shaking periods can cause abrasion and a higher portion of the fine fraction.

For 15149-2, the sieving operation must be continued until the weight changes between two sequential sieves do not exceed 0.3% of the total sample weight per one minute of sieving operation. For sawdust sizing, sieve sizes of 3.2mm, 2.8mm, 2.0mm, 1.4mm, 1.0mm, 0.5mm and 0.25mm are recommended.

For all three methods, pre-drying may be needed because the sample must be sieved at a moisture content below 20% (wet basis) to prevent particles sticking together or losing moisture during sieving. Particles larger than 100mm (maximum dimension) must be hand sorted into one or more fractions.

There is also a range of particle size tests for coal samples among the various standards such as AS 3881, ASTM D4749 and ISO 1953.

Cost

CRL Energy (using a 3 dimension ‘Rotap’ shaker) and SGS charge $60-80 per sample (ex GST) for coal size analysis (or much more for a large number of sieve sizes). However, manual sieving wood pellets for just 3mm fines determination (together with caliper measurement of 10 randomly selected particles) can cost less than $30. Wood Industry Technical Services charges $20-30 depending on the number of sieve trays with their manual sieving method.

Australian labs charge by hourly rates depending on requirements.

Conclusion

It is recommended that one of the three CEN methods should be used for particle size testing of wood fuel samples. CEN/TS 15149-1 is a manual or mechanical shaking method for solid biofuels with sieve apertures 1mm or more, while 15149-2 is a vibrating screen method with sieve apertures 3mm or less and 15149-3 is a rotary screen method. Many factors influence the consistency of particle size tests so if a coal sieving method is to be used for wood fuels, CRL Energy recommends it would be prudent to undertake comparative tests with an equivalent CEN method.

Bulk density is an important measure for wood fuel deliveries on a volume basis and together with the gross calorific value it determines the energy density (although some fuel users prefer net CV as the more practical indicator of available energy). Energy density is a necessary measure to be able to estimate required storage or transport volumes to meet a certain energy demand.

Bulk density is subject to variation due to vibration, shock, pressure, biodegradation, drying and wetting so conditions for its determination must be standardised in order to gain comparative measuring results. Nevertheless, measured bulk density can deviate from practice conditions during transport or storage because of these factors.

CEN's EN 15103 sets out the method for determination of bulk density of solid biofuels with a nominal top size (for 95% of the fuel) of 100mm. Two standard measuring containers with volumes of 5 litres and 50 litres were chosen but these limited volumes meant that some fuels are excluded from the scope of the standard e.g. chunk wood, unbroken bark pieces, haled material or larger briquettes. The 5 litre container may be used for fuels with a nominal top size up to 12mm or for pellet fuels up to 12mm in diameter.

The container is filled by pouring the sample from a height of 20-30cm above the rim. The filled container is dropped from a height of 15cm onto a wooden board on a hard floor three times. Empty space is refilled and the top skimmed off before weighing. The measurement must be repeated to compare duplicate results.

ASTM E873 for wood fuels and ISO 23499 for coal samples operate similarly. ASTM E873 uses a 30cm sided cubic box (~27 litres) that is also dropped from a height of 15cm five times onto a non-resilient surface.

Cost

CRL Energy (using ASTM E873) charges $60 per wood or coal sample for bulk density determination and needs a minimum of 40-50kg. Veritec charges $9 for a small scale measuring cylinder estimate and Wood Industry Technical Services charges about $10 for the 'Tappi' method using an 11 litre container. At least two wood fuel suppliers conduct their own ASTM E873 bulk density tests.

Australian labs charge by hourly rates depending on requirements, with Bureau Veritus estimating A$140 per sample.

Conclusion

It is recommended that EN 15103 should be used as a bulk density test for solid biofuels. CRL Energy considers any wood or coal standard method would provide an adequate test for wood fuels for contractual purposes. If a method is not a published standard, a comparison should be done with a standard method to test for bias.
15. Miscellaneous tests of wood fuels

CEN has published several other technical specifications - some may be of general interest but most will be relevant for some specialised situations.

CEN/TS 15150 is for the determination of particle density in solid biofuels. Also AS 1038.26 is used for the determination of apparent relative density in coal samples.

CEN’s EN 15210-1 and proposed standard CEN/TS 15210-2 are for the determination of mechanical durability of pellets and briquettes respectively. Mechanical durability influences the stability and amount of fines in pellets and briquettes during handling and transport.

A proposed CEN standard 16126 is for the determination of particle size distribution of disintegrated pellets and a related one (current reference 00335066) is for the determination of particle size distribution by image analyses.

A proposed CEN standard 16127 is for the determination of length and diameter for pellets and cylindrical briquettes.

A proposed CEN standard (current reference 00335088) is for determination of bridging (or arching) properties of particulate biofuels in feed systems.

AS 1038.19 measures the abrasion index of a coal, which describes its ability to wear away machinery during grinding. While organic matter in coal and wood is relatively soft, quartz and other mineral constituents are quite abrasive.

16. Feedback on Wood Fuels Testing and Classification

Opinions were sought on the BANZ Wood Classification Guidelines and on wood fuels testing from a range of users and suppliers, equipment manufacturers and an air quality official. In the following discussion all comments refer to moisture content on the as received basis.

An official offered some comments on the Australia/New Zealand standards committee that established the moisture limits for wood pellet fuels in clean air zones that led to the current A1 category. Industry representatives on the committee argued that a 8% moisture limit and 0.5% ash limit for this category would be relatively easy to maintain. A 1% ash limit has been chosen for the BANZ A1, A2 and B category pellets and a 5% limit for C industrial grade pellets. He said most consent applicants offer the 8% pellet moisture limit and there is no reason why they could not request a departure from that limit in a consent change application.

Moisture, energy content, particle diameter (>6mm for A1 and A2, <10mm for B and C), bulk density and fines content are the other key differences in pellet categories. Moisture for A1 pellets are <8%, <10% for A2 and B, <15% for C, which relate to the energy content limits of >17MJ/kg for A1, A2, B and >10MJ/kg for C. Bulk density limits are >650kg/m³ for A1 and A2, >600kg/m³ for B and >550kg/m³ for C. Fines content limits are <1% for A1 and A2, <4% for B and <10% for C.
A major pellet manufacturer is generally pleased with the BANZ classifications but is concerned that the A1 moisture limit is very stringent because it was designed for minimising variability in appliance equipment testing rather than for normal quality assurance purposes. He stated that European officials encountered a backlash from pellet fuel suppliers that slowed the development of EN 14961 because it was proposed as a fuel control measure rather than focusing on emissions limits. The company’s product meets the 8% limit but the market would grow if it was a more realistic 10%.

This company has regular comprehensive testing to ensure quality control. It has found ash composition is an issue for clinker deposits prevention even when ash content is less than 1%.

Another smaller manufacturer of pellets considered the stringent A1 moisture limit is anti-competitive. The company’s Douglas fir derived products easily meet the moisture limit but it is not practical because kiln dried sawn timber sources for pellet manufacture can not stay below 8% moisture. However, there are insufficient checks on A grade pellets so if there are some unscrupulous suppliers in the market, the reputation of every supplier may suffer. Staff have a moisture meter and measure their own bulk density with a fortnightly sample sent to a laboratory for quality checking.

The company also has a major concern regarding the requirement for no bark instead of simply relying on the 1% ash limit. In reality, no manufacturer can manage to achieve a no bark requirement.

Another smaller manufacturer of pellets considered that before BANZ got involved, Environment Canterbury and Nelson City Council acted inappropriately by trying to create a more stringent pellet standard than the European one. He considered there is evidence that all manufacturers struggle to meet the A1 requirements. If few suppliers can meet these requirements, A1 pellet prices will remain too high to encourage conversion from higher emission appliances.

He also stated that there is considerable European demand for lower grade industrial pellets for power station obligations for renewable fuels. Australia is installing major plants to supply the European market and if NZ also becomes a significant supplier, it will “suck the NZ market dry”. The higher ash limits for industrial pellet grades are associated with potential handling problems and ash melting problems in combustion equipment.

A wood chips supplier of industrial plants stated his customers are not too concerned about quality issues. The company measures moisture content only because dirt contamination is not an issue for them. Using a 50mm screening process avoids the need for particle size analysis.

Another wood chips supplier produces 3 screened grades and advertises them using the BANZ classification guidelines. The relatively low grade fuel (up to 50% moisture) is suited to constant load plant. The medium grade (35% moisture cap) is geared for electrical ignition systems while the dry grade (up to 25% moisture) is more suited to equipment that is regularly in shutdown mode. He believes warranties provided by equipment installers will increasingly be linked to critical aspects of fuel quality.

The firm finds a moisture meter is not useful for wood chips and does its own moisture tests, so it sees no need for testing by external labs. It is considering installing a drying
plant for wood chips to create a high quality fuel that would be equivalent to pellets in terms of emissions. The supplier considers that schools should be a ready market for such a product but there is insufficient incentive for fuel savings because it is the Ministry of Education that manages boiler installations.

Another wood chips supplier for small industrial and commercial equipment produces 5 screened grades and customers do not require fuel testing.

One major industrial plant uses a variety of wood fuel sources for its steam raising, including offcuts, sander wood dust and sometimes screened slash from log processing (where excessive dirt levels can give boiler chinker problems). The plant laboratory does its own moisture measurements on different sources and sends samples to a coal testing laboratory for ash determination. Plant operators use a previously established correlation to estimate calorific value from the moisture and ash content. Their products must meet a Japanese Industrial Standard that has no requirements regarding fuel quality.

Another major industrial plant uses a range of wood fuel sources with over half coming from operations within its own company (requiring only spot quality checks). The firm has moisture, ash, size and fines requirements for its external suppliers but does not have a regular testing programme for all of these properties. Payment is according to some moisture limits and a check is made for ash content of a composite sample every three days. Because they have their own plant requirements, the BANZ guidelines are not used.

A wood fuel combustion equipment installer said that wood chip boilers with underfeed grates needed 2% ash and 35% moisture limits whereas reciprocating grates could handle 6% ash and 55% moisture limits. He disagrees with the perception of some that reciprocating grates are ‘fussy’ with regard to particle size and fines content.

Shavings can have excessive fines problems but generally they fall within the EU category of <20% fines. Mineral content can be an issue when whole logs are chipped because entrained stones damage the chipping knives. Normally whole logs are shredded using hammer mills to produce hog fuel and these high powered mills can handle stones and dirt well. Higher ash levels can be a seasonally varying problem in locations with high clay soils (stickling to wet logs in winter) while sandy and peumice soils do not adhere so readily to skid logs.

Another equipment installer has found the customer has usually done the research on energy needs so it is up to them to dictate any fuel requirements. They deal with many handling systems and these have technical requirements for good operation.

A manufacturer of small industrial and commercial equipment believes that moisture is always the key fuel quality issue. Problems can arise above 30% moisture although some equipment can handle up to 40% moisture (or even more in some situations). Size is generally not an issue unless there is an auger feed that will have a top size limit. There can be problems with contamination by dirt and occasionally stones. Underfeed grates require a fuel moisture limit of just 20% for irregular loads and 30% for high heating loads while reciprocating grates are more ‘forgiving’ with regard to moisture and particle size.
He considered the most important issue was for NZ to have its own fuel standard rather than rely on the EU ones because they are based on hardwoods rather than the Pinus radiata and Douglas fir that are dominant here. Hardwoods are easier to burn and fuel moisture levels of 60% can be handled in the EU where power plants operate at very high heating loads. Some efficiency tests were needed in NZ to confirm which fuel quality limits are appropriate here.

A manufacturer of large industrial equipment said for their purposes (design and warranties etc.) as well as the obvious ones like CV, size, moisture and ash content they may need to know fuel carbon content and macro- and micro-nutrients from ash disposal like potassium, calcium, phosphorus, magnesium, sulphur, iron, boron, manganese, copper and zinc. Chlorine, silicon and sodium are important for understanding ash properties and linking to the results of ash fusion tests. Sulphur and chlorine content are useful for the assessment of corrosion risk. Some major and trace elements can indicate contamination of the fuel by heavy metals, sand or pumice.

An expert in wood fuels quality (Eskor 2010) considers there needs to be a specification to identify old, partly rotten wood, which usually has low moisture but also has a low energy density. He agreed with the view expressed by one pellet manufacturer that a zero bark level was inappropriate when an ash limit is specified; some pellet manufacturers currently include small amounts of bark. He considered a durability specification might be necessary to place limits on pellet degradation.

17. Acknowledgements

The author is grateful to the industry stakeholders, laboratory staff and others who have given information and advice that have contributed to this report. Brian Cox of the Bioenergy Association of NZ and Glenys Lloyd of the Energy Library have been particularly helpful in providing information on standards and technical specifications.

18. References

AS 1038.1-2001 Coal and coke - Analysis and testing - Higher rank coal - Total moisture

AS 1038.3-2000 Coal and coke - Analysis and testing - Proximate analysis of higher rank coal

AS 1038.5-1998 for calorific value (black and brown coal).

AS 1038.6.1-1997 (high temperature combustion), AS 1038.6.4-2005 (instrumental) and (for brown coal) AS 2434.6-2002 for carbon, hydrogen content.

AS 1038.6.3.1-1997 Coal and coke - Analysis and testing - Higher rank coal and coke - Ultimate analysis - Total sulfur - Eschka method, (6.3.2 high temperature combustion and 6.3.3 infrared method).

AS 1038.10.0-2002 Coal and coke - Analysis and testing - Determination of trace elements - Guide to the determination of trace elements

AS 1038.10.1-2003 Coal and coke - Analysis and testing - Determination of trace elements - Coal, coke and fly-ash - Determination of eleven trace elements - Flame atomic absorption spectrometric method


AS 1038.15-1995 Coal and coke - Analysis and testing - Higher rank coal ash and coke ash - Ash fusibility

AS 1038.19-2000 Coal and coke - Analysis and testing - Higher rank coal - Abrasion Index

AS 1038.26-2005 Coal and coke - Analysis and testing - Higher rank coal and coke - Guide for the determination of apparent relative density

AS 2434.1-1999 Methods for the analysis and testing of lower rank coal and its chars - Determination of the total moisture content of lower rank coal

AS 2434.2-2002 Methods for the analysis and testing of lower rank coal and its chars - Lower rank coal - Determination of volatile matter

AS 2434.7-2002 Methods for the analysis and testing of lower rank coal and its chars - Lower rank coal - Determination of moisture in the analysis sample

AS 2434.8-2002 Methods for the analysis and testing of lower rank coal and its chars - Lower rank coal - Determination of ash

AS 3881-2002 Higher rank coal - Size analysis

AS 4264.1-1995 and (for brown coal) AS 4264.3-1996 Sampling methods

AS/NZS 4014.6-2007 Solid fuel burning appliances – test fuels. Part 6 – wood pellets


ASTM D2013-09 Standard Practice for Preparing Coal Samples for Analysis


ASTM D3174-04 Method for ash in the analysis sample of coal and coke.


ASTM D3178-02 Carbon and hydrogen in the analysis sample of coal and coke.


ASTM D5373-08 Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Laboratory Samples of Coal.


ASTM E711-96 Standard Test Method for Gross Calorific Value of Refuse-Derived Fuel by the Bomb Calorimeter


CEN/TS 14588:2004 Solid biofuels - Terminology, definitions and descriptions (also a prEN standard under approval)

CEN EN 14774-1:2009 Solid biofuels - Determination of moisture content - Oven dry method - Part 1: Total moisture - Reference method

CEN EN 14774-2:2009 Solid biofuels - Determination of moisture content - Oven dry method - Part 2: Total moisture - Simplified method

CEN EN 14774-3:2009 Solid biofuels - Determination of moisture content - Oven dry method - Part 3: Moisture in general analysis sample

CEN EN 14775:2009 Solid biofuels - Determination of ash content

CEN/TS 14778-1:2005 Solid biofuels - Methods for sampling (also a prEN standard under development)

CEN/TS 14778-2:2005 Solid biofuels - Sampling - Part 2: Methods for sampling particulate material transported in lorries

CEN/TS 14779:2005 Solid Biofuels - Sampling - Methods for preparing sampling plans and sampling certificates

CEN/TS 14780:2005 Solid biofuels - Methods for sample preparation (also a prEN standard under development)

CEN EN 14918:2009 Solid biofuels - Determination of calorific value

CEN EN 14961-1:2010 Solid biofuels - Fuel specifications and classes - Part 1: General requirements

CEN prEN standard under approval 14961-2 Solid biofuels - Fuel specifications and classes - Part 2: Wood pellets for non-industrial use

CEN prEN standard under approval 14961-3 Solid biofuels - Fuel specifications and classes - Part 3: Wood briquettes for non-industrial use

CEN prEN standard under approval 14961-4 Solid biofuels - Fuel specifications and classes - Part 4: Wood chips for non-industrial use

CEN prEN standard under approval 14961-5 Solid biofuels - Fuel specifications and classes - Part 5: Firewood for non-industrial use
CEN prEN standard under development 14961-6 Solid biofuels - Fuel specifications and classes - Part 6: Non woody pellets for non-industrial use

CEN EN 15103:2009 Solid biofuels - Determination of bulk density

CEN/TS 15104:2005 Solid biofuels - Determination of total content of carbon, hydrogen and nitrogen - Instrumental methods (also a prEN standard under approval)

CEN/TS 15105:2005 Solid biofuels - Determination of the water soluble chloride, sodium and potassium content (also a prEN standard under approval)

CEN EN 15148:2009 Solid biofuels - Determination of the content of volatile matter

CEN/TS 15149-1:2006 Solid biofuels - Determination of particle size distribution - Part 1: Oscillating screen method using sieve apertures of 1 mm and above (also a prEN standard under approval)

CEN/TS 15149-2:2006 Solid biofuels - Determination of particle size distribution - Part 2: Horizontal screen method using sieve apertures of 3.15 mm and below (also a prEN standard under approval)

CEN/TS 15149-3:2006 Solid biofuels - Determination of particle size distribution - Part 3: Rotary screen method (also a prCEN/TR under development)

CEN/TS 15150:2005 Solid biofuels - Determination of particle density (also a prEN standard under development)

CEN EN 15210-1:2009 Solid biofuels - Determination of mechanical durability of pellets and briquettes - Part 1: Pellets

CEN/TS 15210-2:2005 Solid biofuels - Methods for the determination of mechanical durability of pellets and briquettes - Part 2: Briquettes (also a prEN standard under approval)

CEN/TS 15234:2006 Solid biofuels - Fuel quality assurance - Part 1: General requirements

CEN prEN standard under approval 15234-1:2006 Solid biofuels - Fuel quality assurance - Part 1: General requirements

CEN prEN standard under development 15234-2 Solid biofuels - Fuel quality assurance - Part 2: Wood pellets for non-industrial use

CEN prEN standard under development 15234-3 Solid biofuels - Fuel quality assurance - Part 3: Wood briquettes for non-industrial use

CEN prEN standard under development 15234-4 Solid biofuels - Fuel quality assurance - Part 4: Wood chips for non-industrial use
CEN prEN standard under development 15234-5 Solid biofuels - Fuel quality assurance - Part 5: Firewood for non-industrial use

CEN prEN standard under development 15234-6 Solid biofuels - Fuel quality assurance - Part 6: Non-woody pellets for non-industrial use

CEN/TS 15289:2006 Solid biofuels - Determination of total content of sulfur and chlorine (also a prEN standard under approval)

CEN/TS 15290:2006 Solid biofuels - Determination of major elements - Al, Cu, Fe, Mg, P, K, Si, Na and Ti (also a prEN standard under approval)

CEN/TS 15296:2006 Solid biofuels - Conversion of analytical results from one basis to another (also a prEN standard under approval)

CEN/TS 15297:2006 Solid biofuels - Determination of minor elements - As, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sb, V and Zn (also a prEN standard under approval)

CEN/TS 15370-1:2006 Solid biofuels - Determination of ash melting behaviour - Part 1: Characteristic temperatures (also a prEN standard under development)

CEN/TR 15569:2009 Solid biofuels - A guide for a quality assurance system

CEN prEN standard under approval 16126 Solid biofuels - Determination of particle size distribution of disintegrated pellets

CEN prEN standard under approval 16127 Solid biofuels - Determination of length and diameter for pellets and cylindrical briquettes

CEN 00335063 (prEN standard under development) Solid biofuels - Determination of the chemical composition by XRF (X-ray fluorescence)

CEN 00335066 (prEN standard under development) Solid biofuels - Determination of particle size distribution by image analyses

CEN 00335088 (prEN standard under development) Solid biofuels - Determination of bridging properties of particulate biofuels


Escort, G. (2010) Personal communication with George Escort on Scion’s Veripec laboratory experience with wood fuels testing.


ISO 540:2008 Hard coal and coke - Determination of ash fusibility

ISO 562:1998 Hard coal and coke - Determination of volatile matter

ISO 589:2008 Hard coal - Determination of total moisture


ISO 1928:2009 Solid mineral fuels - Determination of gross calorific value by the bomb calorimetric method, and calculation of net calorific value.

ISO 1953:1994 Hard coal - Size analysis by sieving


ISO 5069-1:1983 Brown coals and lignites - Principles of sampling - Part 1: Sampling for determination of moisture content and for general analysis

ISO 5069-2:1983 Brown coals and lignites - Principles of sampling - Part 2: Sample preparation for determination of moisture content and for general analysis


ISO 23499:2008 Coal - Determination of bulk density

APPENDIX – Contact details for testing standards and laboratories

For information on standards and technical specifications:

Energy Library, PO Box 159, Wellington 6140, 04 8018465, www.energyinfo.co.nz

Industrial Research Library, PO Box 31310, Lower Hutt 5040, Alison Speakman, 04 9313356, A.Speakman@iri.cri.nz

Testing laboratories:

CRL Energy Ltd, Grant Murray, PO Box 31244, Lower Hutt 5040, 04 5703717, g.murray@crl.co.nz (also for Greymouth lab)

SGS New Zealand Ltd, Minerals Division - Ngakawau Laboratory, Hugh McMillan, PO Box 240, Westport 7866, 03 7828261, Hugh.McMillan@spg.com (also for Waihi lab)

Veritec Forest Nutrition Laboratory, Kaye Eason, Scion, Private Bag 3020, Rotorua 3046, 07 3435400, Kaye.Eason@veritec.co.nz

Wood Industry Technical Services, Alistair Coulter, 64 Paul Rd, RD2 Whakatane, 07 3228020, witsl@orrcom.co.nz

A selection of Australian laboratories (many more available on www.nata.asn.au)

[Veritec notes there may be biosecurity issues with sending wood samples to Australia]

ACIRL, ALS Laboratory Group, Ipswich, Queensland, Andrew White, 00617 3810 5200, Andrew.White@alsglobal.com

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

SGS Australia Pty Ltd, Coal and Technical Services, Newcastle Laboratory, NSW, 00612 4920 3611

CRL Energy Limited
Proposed distribution of woodchips size for P16B

- <120 mm
- ≤12%
- >75%
- ≤3%

<100 mm
- ≤12%

<45 mm
- ≤12%

<16 mm
- ≤12%

<8 mm
- ≤12%

<3.15 mm
- ≤12%