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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.

Wood Fuel Property	**Recommended Testing Standard**
Sampling	Solid biofuels - Methods for sampling (CEN/TS 14778-1)
Preparation of Sample	Solid biofuels - Methods for sample preparation (CEN/TS 14780)
Total Moisture	Solid Biofuels - Determination of moisture content – Oven dry method – Part 2: Total moisture – Simplified method (EN 14774-2)
Moisture in Laboratory Sample	Solid Biofuels - Determination of moisture content – Oven dry method – Part 3: Moisture in general analysis sample (EN 14774-3)
Ash Content	Solid Biofuels - Determination of ash content (EN 14775)
Volatile Matter Content	Solid Biofuels - Determination of the content of volatile matter (EN 15148)
Gross (or Net) Calorific Value	Solid biofuels - Determination of calorific value (EN 14918)
Carbon, Hydrogen and	Solid biofuels - Determination of total content of carbon, hydrogen

Nitrogen Content (ultimate analysis)	and nitrogen - Instrumental methods (CEN/TS 15104)
Sulphur (S) and Chlorine (Cl) Content	Solid biofuels - Determination of total content of sulfur and chlorine (CEN/TS 15289)
Major Elements	Solid biofuels - Determination of major elements - Al, Ca, Fe, Mg, P, K, Si, Na and Ti (CEN/TS 15290)
Trace or Minor Elements	Solid biofuels - Determination of minor elements - As, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Sb, V and Zn (CEN/TS 15297)
Ash Fusion Temperature	Solid biofuels - Determination of ash melting behaviour - Part 1: Characteristic temperatures (CEN/TS 15370-1)
Particle Size Distribution (including amount of fines)	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)
Bulk Density	Solid biofuels - Determination of bulk density (EN 15103)

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, 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.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. Developments 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 coal tests are generally used[1]. 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

[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.

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 CRL 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/TR 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[2], 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"[3]) 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

[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/m^3, the minimum weight for >100mm top size is 15kg [or 20kg if >500kg/m^3] 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 Veritec and Wood Industry Technical Services include this cost in the analysis price.

ACIRL in Ipswich (Queensland) estimates approximately A$50 per sample and Bureau Veritas in Wollongong (NSW) would quote on an hourly rate (A$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 two 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 $\pm$ 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 unlidded dish at 105 $\pm$ 2°C in an air oven but a nitrogen atmosphere is recommended for samples (like coal) susceptible to oxidation. The dish is lidded while still hot and weighed after cooling to room temperature. Constancy in weight is considered to be a change of <1mg between successive re-heating 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 IANZ 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 A$20 per sample for total moisture and A$30 for proximate analysis. Bureau Veritas (NSW) would charge A$22 and A$30 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 E1358 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 loads of wood fuels but it would be prudent to undertake a comparison with the E871 method if the microwave method was to be used for quality control.

Field testing for moisture

George Escort of Scion's Veritec laboratory described the use of field meters for moisture testing (Escort 2010). He regularly uses a Carrel 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 $\pm$ 3%, but above 30%, it might only be accurate to as much as $\pm$ 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.

CEN'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 17246) 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 $83 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 lidded 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 IANZ 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[4]. 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 pelletising 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

[4] Based on figures for a range of softwoods and hardwoods (Harris 1966), CRL Energy considers that dry ash free figures of 6.0% hydrogen and 43% oxygen can be used to calculate the as received hydrogen and oxygen content for the net CV calculation.

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 out 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 coals, 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 A$25 for total sulphur and A$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 say 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 00335063) 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. ACIRL (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 slagging) 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. ACIRL (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.

14. Bulk Density Testing of Wood Fuels

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, baled 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 Veritas 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/m^3 for A1 and A2, >600kg/m^3 for B and >550kg/m^{3}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 clinker 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 (sticking to wet logs in winter) while sandy and pumice 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 (Escort 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

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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, Ca, 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

DEPI (2010) Certification of Wood Pellets for the End Consumer Market - Manual for Germany and Austria - Based on prEN 14961, Part 2, German Pellet Institute, www.enplus-pellets.de/downloads/ENplus_Manual_10-03.pdf

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

Harris, J. M. (1966) The properties of wood waste, NZ Forest Research Institute.

ISO 334:1992 Solid mineral fuels - Determination of total sulfur - Eschka method.

ISO 351:1996 Solid mineral fuels - Determination of total sulfur - High temperature combustion method.

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 609:1996 Solid mineral fuels - Determination of carbon and hydrogen - High temperature combustion method.

ISO 625:1996 Solid mineral fuels - Determination of carbon and hydrogen - Liebig method.

ISO 1171:1997 Solid mineral fuels - Determination of ash.

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 5068-1:2007 Brown coals and lignites – Determination of moisture content - Part 1: Indirect gravimetric method for total moisture.

ISO 5068-2:2007 Brown coals and lignites – Determination of moisture content - Part 2: Indirect gravimetric method for moisture in the analysis sample.

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 11722:1999 Solid mineral fuels - Hard coal - Determination of moisture in the general analysis test sample by drying in nitrogen.

ISO 12902:2001 Solid mineral fuels - Determination of total carbon, hydrogen and nitrogen - Instrumental methods.

ISO 17246:2005 Coal - Proximate analysis (incorporating specific ISO moisture and ash standards above).

ISO 17247:2005 Coal - ultimate analysis (incorporating methods above).

ISO 18283:2006 Hard coal and coke - Manual sampling

ISO 23499:2008 Coal - Determination of bulk density

NZEIH (2008) New Zealand Energy Information Handbook – Third edition, NZ Centre for Advanced Engineering, Private Bag 4800, Christchurch 8140.

ÖNORM M7133 (1998) Chipped wood for energetic purposes – requirements and test specifications, Osterreichisches Normungsinstitut (Austrian Standards Institute).

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@irl.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@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

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