Solid Biofuels Testing

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Who is Pentarch Technical Services (PTS)?

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- PTS is part of the Pentarch group of companies.

- Pentarch has two main divisions which are Pentarch Agricultural (export of agricultural feed stocks) and Pentarch Forestry (PTS, wood sales, woodchip exports and wood processing).

- Pentarch has five laboratories in New Zealand and Australia that specialise in testing woodchip and agricultural products.

- PTS has provided a range of wood and agricultural testing services for clients throughout New Zealand for over 25 years.

Pentarch laboratories are in:

- Burnie, Tasmania, Australia (woodchip testing).
- Eden, New South Wales, Australia (woodchip testing).
- Mallee, New South Wales, Australia (agricultural products testing).
- Narrogin, Western Australia, Australia (agricultural products testing).
- Kawerau, New Zealand (agricultural products, woodchip and biofuel testing).

What is the difference between biomass and biofuel?

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- Biomass is a residue of unknown quality.

- Biofuel is a material which has been tested and its quality defined:
  - Its properties are defined and within an agreed specification.
  - It is much more valuable than biomass to the end user.

"As this market emerges there is a need for sellers and buyers of solid biofuels to be confident with respect to the description and quality of the fuel sought or supplied. Confidence in terms of the fuel characteristics will increase the value to both buyers and sellers."

Examples of solid biomass.

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Raw biomass becomes a **biofuel** when it is tested, and its properties are known. This allows it to be burnt in boilers and furnaces to generate heat or raise steam.

Examples of solid biofuels?

Fuel Type	Features	Example
Woodchips	Chipped woody biomass in the form of pieces, with a defined particle size produced by mechanical treatment with sharp tools such as knives.	
Hog Fuel	Fuel wood in pieces of varying size and shape produced by crushing with blunt tools such as rollers, hammers, or flails. These fuels are typically of a lower quality compared to woodchip.	
Wood Pellets	Wood that has been pulverised and pelletised under heat and high pressure to produce a cylindrical wood derived fuel of consistent size.	
Urban Wood Fuels	Wood residues derived from urban activities including packaging materials, off-cuts from manufacturing, construction and demolition wood residues, yard trimmings, urban tree residues and from land clearing	

Examples of solid biofuels?

Compressed Firelogs and Briquettes	A briquette or fire log is a block of flammable matter used as fuel to start and sustain a fire. Common types of briquettes are fuel logs, charcoal briquettes and biomass briquettes.	
Torrefied wood/ bio coal	"Torrefied wood is thermally modified wood and completely desiccated, with devolatilised hemicellulose, which has not yet reached the point of "char". These fuels may be compressed, fine or chunky.	
Herbaceous Wood Fuels	These are woody derived fuels sourced from Miscanthus, Switchgrass, other grasses and straw and may be in the form of chip, hogged, pelletised, or baled fuels.	
Firewood	Larger piece sizes of wood used for kindling or for sustaining combustion in domestic solid wood fire appliances.	

Biofuel trade in New Zealand and Australia.

Table 2. Most common forms of traded solid biofuel.

Fuel Type	Delivered Form	Typical Particle size	Preparation Method
Woodchips		5 mm to 100 mm	Cut with sharp tools
Hog fuels		Varying	Crushed with blunt tools
Pellets		< 25 mm	Mechanical compression
Urban solid fuels		10mm – 200mm	Chopped during collection
Firelogs and briquettes		25mm	Mechanical compression
Torrefied wood		<100 mm	Heat treatment
Herbaceous biofuels		10 mm to 200 mm	Chopped
	Small square bales	$0.1m^3$	Compressed and bound to squares
	Big square bales	$3.7m^3$	Compressed and bound to squares
	Round bales	$2.1\ m^3$	Compressed and bound to squares
Firewood	Trailer or truck load	100 mm to1000mm	Cutting to size with sharp tools

Table 2 is from BANZ technical guide 1

Why do biofuels need to be tested?

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Physical properties of solid biofuels vary:

- Solid biofuels properties are determined by chemical composition and physical properties. These will affect the heating value and performance of the biofuel.
- % Ash content varies depending on the source of the biofuel. Bark is often high in silica from soil contamination and can form a glass like residue in the boilers.
- % Moisture content of wood varies significantly. Raw woodchip in New Zealand varies from 40 to 60% moisture. At these levels, the wood has approximately half the calorific value (energy density).
- Bulk density effects fuel durability, energy density, storage and handling costs.

Properties that need to be regularly tested in solid biofuels are:

- % Moisture content.
- % Ash content.
- Bulk density (kg/m^3)
- Size classification.
- Calorific value - energy output on burning in MJ/kg (energy density).

Description of biofuel properties.

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Size (P)

Particle size is an important parameter for biofuels and is affected by the technology used to produce the biofuel such as chippers, hoggers, hammer mills and grinders. It is desirable to have a consistent biofuel fuel particle size. Particle size affects:

- Boilers fuel feed and distribution systems.
- Heating performance. Too many fine particles or too long a particle will reduce the boiler performance.

Moisture (M)

Boilers are generally specified to be used with biofuels of defined % moisture content. In some regions of New Zealand only dry biofuel (approx. 12%) is permitted to be used in biofuel heated plants.

Description of biofuel properties.

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Ash (A)

Some boilers and regional councils require specific % ash content limits in biofuel. Excessive ash reduces the fuel heating value and increases maintenance and ash disposal costs.

Bulk density (BD)

Combining % moisture content and bulk density allows biofuels to be sold on an energy basis. In some cases, it is more practical to measure the volume of biofuel for sale rather than weighing it.

Energy density (ED)

Is important for consumer confidence that fuels being sold have a consistent energy content rather than one that varies. Large variations in bulk density, % moisture or % ash contents are unacceptable.

How is boiler fuel described in a specification.

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P16 M35 A1 BD200 ED15 is one example of how woodchip is described:

- 16 mm sized chip (3.15≤P16≤16mm).
- % Moisture content of 35% (M35≤ 35%).
- % Ash content of 1% (A1≤ 1%).
- Bulk density of 200 kg/m^3 (BD 200+/-10%).
- Energy density of 15 MJ/kg (ED15+/-10%).

From BANZ technical guide 1

Specification for woodchips as a biofuel.

Each traded type has its own specification:

Table 3 – Specification of properties for woodchips

Size specification	Previous size classification[3]	Main fraction (minimum, 75 w-%mm)[4] P = particle size W= weight	Fines fraction w-% (< the specified minimum mm)	Coarse fraction, (w-%), max length of particle, mm
P16A[5]	S30	3.15≤P≤16mm	≤12%	≤3%.>16mm and all ,< 31.5mm
P16B		3.15≤P≤16mm	≤12	≤3%.>45mm and all ,< 120mm
P45A	S50	8≤P≤45mm	≤8	≤6% >63mm and maximum 3.5%>100mm, all < 120mm
P45B		8≤P≤45mm	≤8	≤6% >63mm and maximum 3.5%>100mm, all < 350mm
P63	S100	8≤P≤63mm	≤6	≤6% > 100mm,all <350mm
P100		16≤P≤100mm	≤4	≤6% >200mm,all < 350mm

Moisture properties % by weight (wet basis)	
M20	≤ 20%
M30	≤ 30%
M35	≤ 35%
M40	≤ 40%
M55	≤ 55%
M55+	≤ 55+%

Table 3 is from BANZ technical guide 3

Specification for woodchips as a biofuel.

Each of the traded types has its own specification.

Ash properties % by weight (dry basis)	
A.5 A1 A3 A5 A6+	≤ 0.5% ≤ 1% ≤ 3% ≤ 5% > 6% - Actual Value Stated
Bulk Density	
Kg/m^3	Actual value stated
Energy Density	
MJ/kg	Actual Value Stated – If sold by weight

Table 3 is from BANZ technical guide 3

Who should do biofuel testing and how often?

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- The key is to ensure any biofuel sample is representative of the bulk shipment of biofuel.
- The biofuel manufacturer should get their biofuel tested to characterize it against the specification they intend to sell against.
- Once they have set the specification, they should monitor the % moisture content and the particle size to ensure it is consistent.
- Purchaser and supplier should agree on acceptance testing process.
- Third party laboratory should be used to regularly verify the results.

% Moisture in biofuel is measured by oven dry method.

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- Tested by drying woodchip/ biofuel at 105^{0}C for 24 hours.
- Expressed as the % moisture content over the total mass of wood (biofuel) taken.
  - In the wood adhesives industry, it is expressed as the % moisture content in oven dry wood.
- Affects the calorific value of radiata pine woodchips.
  - Woodchip with 0% moisture has a calorific value of 20MJ/kg.
  - Woodchip with 50% moisture has a calorific value of 9MJ/kg.

% Ash content of biofuel.

- % Ash content is obtained by burning dry, ground biofuel in a furnace at 580^0C for at least 4 hours. Ash content is expressed as a percentage of the oven dry biofuel.
- Ash is an inorganic material in chip/ biofuel that does not burn, such as:
  - Clay.
  - Silica.
  - Metals.
  - Rocks & sand.
- Ash has no calorific value.
- Can cause significant damage to plant and equipment.

% Ash content being determined in biofuel.

Amount of ash and its composition varies widely in biofuels.

Bulk Density in kg/m^3.

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- Is a measure of the kilograms of biofuel that fits in a m^3 of space.
- Gives an indication of the space required to store 1000kg of the biofuel.
  - Higher bulk densities reduce transport cost.
  - Lower bulk densities can lead to blockages when feeding the fuel.
  - Lower bulk densities can smother fires in boilers.

Biofuel size classification - and biofuel inspection.

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- Size classification is a measure of the distribution of particle sizes in the biofuel.
  - Large particles can lead to blockages in handling equipment.
  - Small particles can smother the flame and block handling equipment.
- Visual inspections pick up materials in biofuels which will cause issues, such as:
  - Sand.
  - Rocks and stones.
  - Plastic.
  - Metal.
  - Other contaminants.

Inspection for unwanted contaminants.

Unwanted stones

Biofuel size classification and inspection.

- Biofuels can vary significantly in size.

Boiler (hog) fuel size classification.

Size classification of biofuel- a typical set of results.

				Sieve Analysis				
			Gross	% Retained on Round Hole Screen				
Date	Source	Grade	oversize	> 50 mm	50 - 4.8 mm	Fines	Stones %	Comment
29/01/1900	A	A		58.2	40.0	1.7		
29/01/1900	A	A		58.2	40.0	1.7		
5/01/2021	A	B		16.5	69.0	14.4		
5/01/2021	A	B		23.3	60.3	16.4		
6/01/2021	A	B		8.5	74.2	17.3		
6/01/2021	A	B		21.7	51.5	26.7	0.8	small stones
6/01/2021	A	C		4.5	50.9	44.6		
7/01/2021	A	C		11.3	49.3	39.4	1.8	stones
7/01/2021	A	C		14.5	49.5	36.0		
8/01/2021	A	C		8.9	45.2	45.9		
9/01/2021	A	C		2.1	81.1	16.8	0.9	small stones
10/01/2021	A	C		3.1	74.8	22.1		

Calorific values.

Calorific value is the amount of energy produced when a combustible material undergoes complete combustion. It is an important quality indicator of fuels, measured in MJ/kg.

Bomb calorimeters are used to determine the calorific value of solid or liquid materials.

Calorific value produced by the bomb calorimeter when using an **oven-dried sample** is the **Gross Calorific Value (GCV)**, or **Higher Heating Value (HHV).** When using a **wet sample,** the **Gross Heating Value (GHV)** is produced.

Net Calorific Value (NCV) and Lower Heating Value (LHV) can be calculated from the GCV. Different values assume different end states of water after combustion and initial sample % moisture contents.

Measuring calorific value

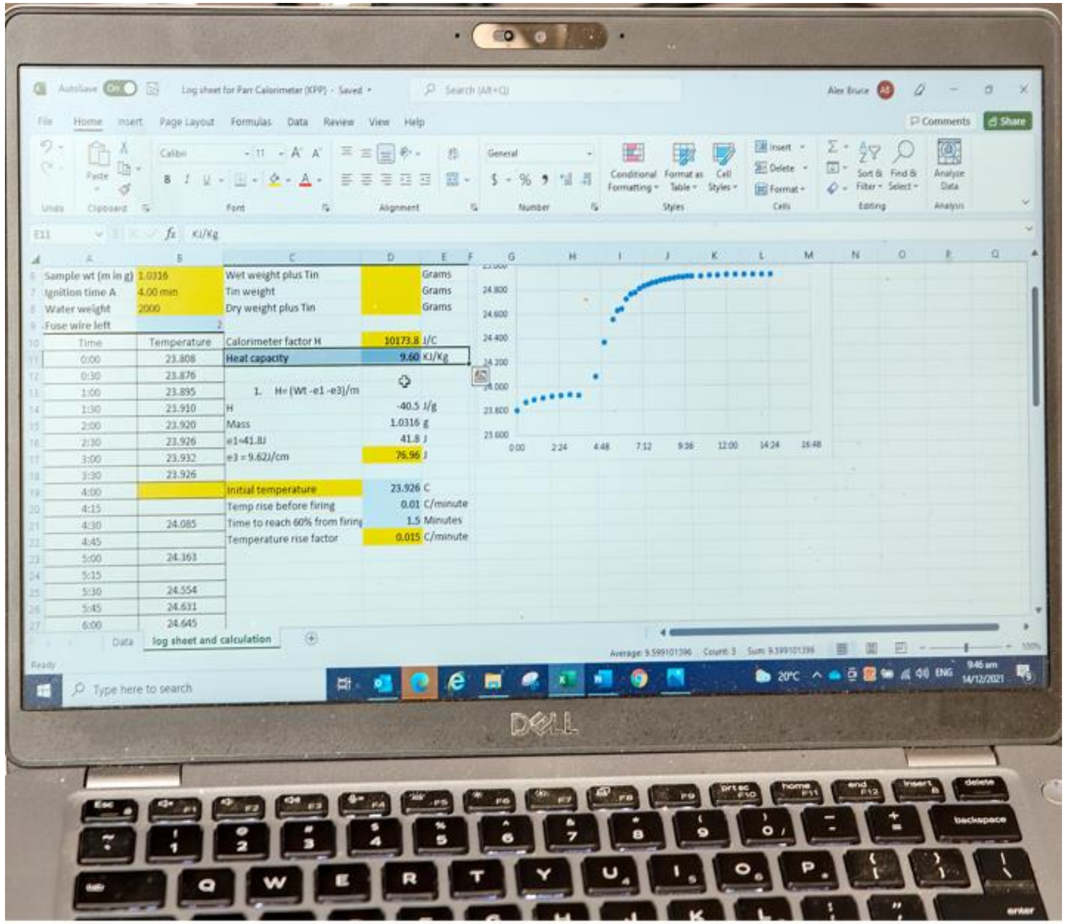
Key parts of a calorimeter

- Thermocouple.
- Water jacket with combustion vessel (Oxygen Bomb) in it.
- Stirrer and stirrer motor.
- Ignition box.

Determining calorific value?

Steps in the process

- Temperature and time data is used to calculate the temperature rise in combination with the:
  - Fuel mass (g).
  - Calibration factor for the Oxygen Bomb (MJ/C).
- Heat given out in MJ/Kg is then calculated and recorded with the fuel's % moisture content.
- The results are determined as Calorific Value (GCV)/Higher Heating Value (HHV) in oven dried fuel or, the Gross Heating Value (GHV) in fuel at its actual % moisture content.



Results are then reported to the customer.

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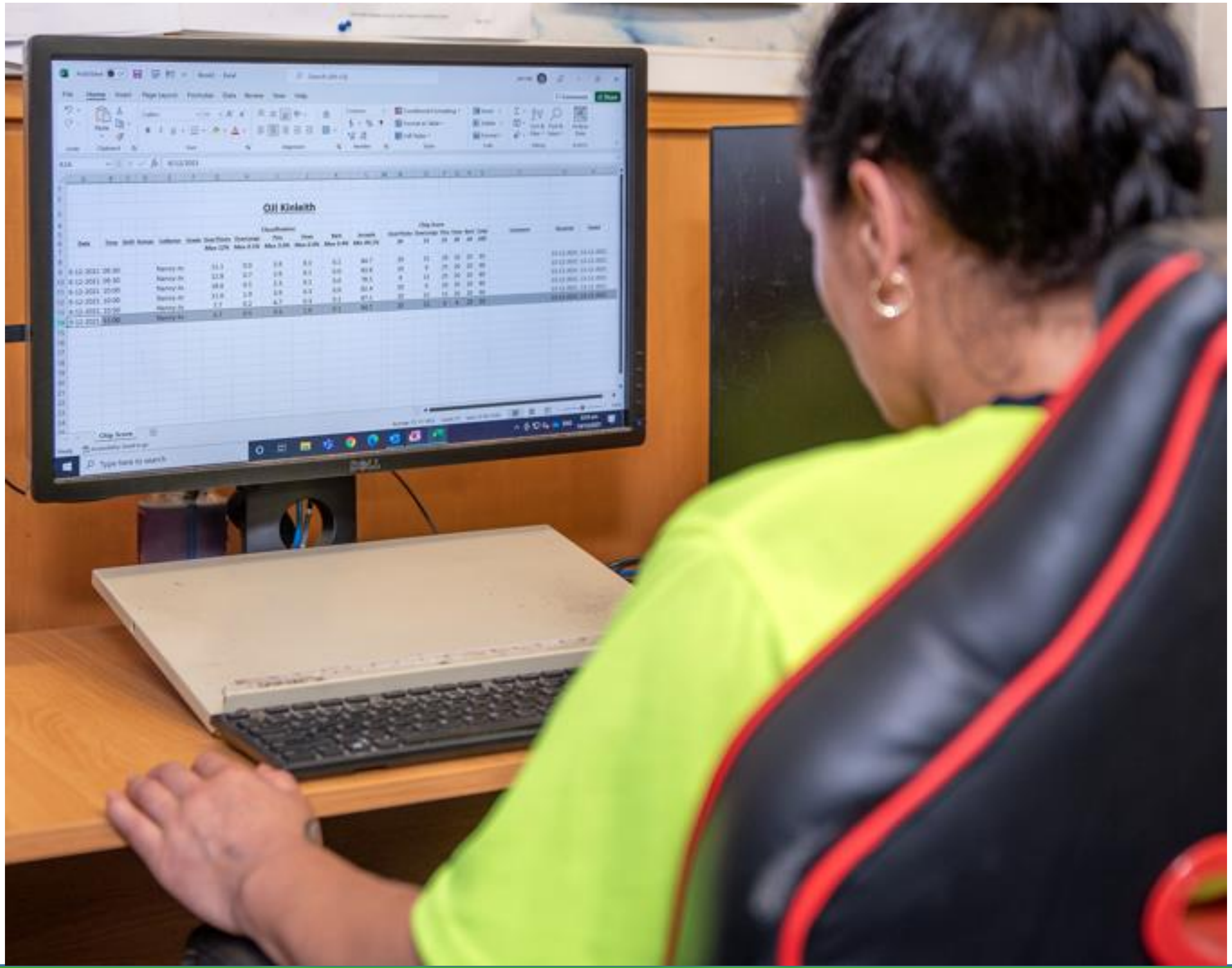

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How is the calorific value determined?

Steps in the process

- Fuel is chipped and or ground down to a fine particle size.
- About 1.0000 gram of the biofuel is placed in the crucible.
- Fuse wire is placed to touch the fuel in combustion crucible.

How is the calorific value determined?

Steps in the process

- Oxygen BOMB is closed securely.
- BOMB filled with oxygen then purged.
- Then filled with pure oxygen so environment in the oxygen BOMB is 99.8%v/v oxygen.

How is the calorific value determined?

Steps in the process

- Oxygen BOMB is placed in the water bath.
- Ignition leads are inserted.
- Lid is placed on water bath.
- Lid has a stirrer and thermocouple as part of assembly.
- Wait for the temperature to stabilize in the water bath.
- Fuse wire is burnt to start combustion reaction.
- Temperature rise is recorded over time.

How is the calorific value determined?

Steps in the process

- Temperature rise is recorded at 15 second intervals.
- Temperature will start rising about 30 seconds after the fuse wire is burnt.
- Temperature will continue to rise for about 6 to 8 minutes after the fuse wire is burnt then stabilize.