Canterbury method 1 for testing of ultra-low emission wood burners

Contents

1 Introduction

1.1 Intent

The Canterbury Method 1 is intended to provide sufficient flexibility to allow both conventional and radically different designs of wood burner to be tested for consideration under Environment Canterbury's Ultra Low Emission Burner (ULEB) authorisation procedures.

The detail of the test method outlined is based on testing of very low emission conventional wood burners; however, test laboratories are not obliged to follow the procedures exactly provided that the intent of the method is adhered to, i.e. testing must be done with realistic firewood, emissions must be monitored during start-up, for periods of high heat output and low heat output; and the method used to collect emissions and determine heat output must be sound.

Any proposed variations in the test method should be discussed with Environment Canterbury prior to testing so that appropriate consideration can be given to the differences and uncertainties in the methodology.

NOTE:
Testing of appliances using this draft method has been carried out in wood burner test laboratories. Matters arising from the tests and observations are noted throughout this version of the method. The method may be subjected to further changes as a result of further testing and feedback received from the laboratories and applicants.

1.2 Scope

The Canterbury Method 1 applies to stick-fuelled wood burners of up to 40kW maximum heat output (i.e. is not intended to cover burners fuelled by wood pellets, wood chips, coal or briquettes).

The method may be applied to wood burners intended for central heating applications using air or water for heat distribution; however it should be noted that burners with maximum heat outputs exceeding 25kW (based on measured power over a minimum of 6 minutes at high burn rate) cannot be tested using AS/NZS 4013:2014 dilution tunnel method for measurements of emissions (refer AS/NZS 4013:2014 clauses 1.2.3(b) and 1.4.3).

1.3 Limitation

The method deals only with the measurement of particle emissions and burner efficiency. It does not address installation or other safety issues which are covered by other legislation.

2 Test facilities

2.1 Emission measurement

Emission testing may be carried out using appropriate stack sampling methods or a calorimeter room and dilution tunnel meeting the requirements of AS/NZS4012/4013:2014.

2.1.1 Dilution Tunnel Method

Where the calorimeter room and dilution tunnel facilities are used:

- the calibration and tunnel preparation requirements of AS/NZS4012/4013:2014 apply;
- requirements for filter preparation and post sampling collection of condensates in the sample probe apply;
- the specified dilution tunnel flow rate applies;
- calorimeter air and wall surface temperature limits apply;
- the dilution tunnel shall be maintained above 25ºC once this temperature has been achieved at start-up.
- filter temperatures shall be maintained in the range 15ºC to 32ºC at all times during sampling;
- the sample flow rate shall be 10 x 10^{-3} standard cubic metres per minute ±10% Note: this is approximately double the sample rate required in AS/NZS4013:2014

2.1.2 Stack Sampling Methods

Other emission measurement techniques may be used provided particle emission factors and efficiencies can be determined with accuracies comparable to the AS/NZS4012/4013:2014 method. For reference purposes for example, collection of the filterable fraction of the emissions using USEPA Method 5 and the condensable fraction of the emission using US EPA Method 202 may be appropriate. Where facilities other than a calorimeter room and dilution tunnel are to be used the test laboratory shall advise Environment Canterbury of the measurement approach before commencing testing so that appropriate consideration can be given to the differences and uncertainties in the methodology.

Note: the firewood and burner operating procedures set out in this Method apply, regardless of the facility used to measure particulates (condensables) and heat output.

2.1.3 Flue Temperature measurement

The flue gas temperature shall be measured using a thermocouple with an accuracy of better than ±3ºC. The measurement point shall be in the flue at a point where an exposed flue would exit a 2.4 metre stud room or as close as is practical to this point and for an enclosed flue such as with an insert fire or horizontal discharge flue through a wall, at a distance of 500mm from the flue connection to the burner.

2.2 Heat output measurement

The useful heat output may be measured by one of the following ways.

(i) Calorimeter Room

If using a calorimeter room, heat output shall be determined using the mass flow rate and temperature difference between incoming and outgoing air, as for AS/NZS4012:2014 except that the innermost walls or wall shields of the calorimeter room shall be not less than 15ºC at the beginning of the test and within the range of 20ºC to 45ºC throughout the ensuing test.

The average heat output for each burn phase shall be reported. The average efficiency as measured by a calorimeter room method shall only be reported for a full day's testing once the calorimeter room has cooled to ambient temperature (see clauses 5.6 and 6.2).

If the burner is fitted with a wet back, the heat transferred to the water shall be calculated using the method outlined in Appendix B. The heat transferred to water shall be added to the heat transferred to the air in the calorimeter room and used for calculation of overall efficiency.

(ii) By stack loss method

If a stack-loss method is used for indirect measurement of heat output the method must allow for the chemical energy lost through incomplete combustion in gaseous and condensed compounds as well as sensible heat loss. If a wet back or other water heating device is fitted to a burner when using the stack loss method for measuring heat output the heat transferred to the water should be measured using the method outlined in Appendix B. Since the stack loss method measures total sensible and chemical energy loss the balance of the energy is transferred to both the air and water. Thus, the heat transferred to the water shall be used to calculate the heat transferred to air by subtraction.

The use of Canadian Standard CSA B415.1, EN303-5 or other alternative methods for assessing heat output and efficiency from stack losses should be discussed with Environment Canterbury pirior to commencement of testing.

3 Firewood specifications

3.1 Wood species

Softwood shall be *Pinus radiata* logs purchased from a commercial firewood supplier that complies with section 3.2, 3.3 and 3.4 and intended for immediate use. The pieces shall include bark (where present) and shall include knots, resinous areas, etc. Pieces shall be selected at random from the purchased firewood, without any specific selection for “clean burning” pieces free of knots etc. However the wood used in the test shall be, as far as possible, free from decay and mould.

Hardwood shall be eucalypt sp. logs purchased from a commercial firewood supplier that complies with section 3.2, 3.3 and 3.4 and intended for immediate use. The pieces shall include bark (where present) and shall include knots, resinous areas, etc. Pieces shall be selected at random from the purchased firewood, without any specific selection for “clean burning” pieces free of knots etc. However, the wood used in the test shall be, as far as possible, free from decay and mould.

Note – this specification is for a Canterbury test regime, designed to differentiate burners used in Canterbury. Surveys in Christchurch indicate that pine is the main species of firewood sold and collected; hence it is specified in this test programme. Other regional authorities may wish to specify test regimes using species used in their region.

3.2 Wood moisture

Air dry wood shall have moisture content between 15% ww and 20% ww (wet weight). Partially seasoned wood shall have moisture content between 25% ww and 30% ww.

The moisture content of logs shall be determined as specified in Appendix A.

3.3 Firewood piece length

The maximum firebox dimension “L’ is the maximum length piece of wood with a 20 mm x 20 mm cross section that will fit in the firebox where:

- it is horizontal and parallel to one side of a firebox with a rectangular base measured at the height of the bottom of the fuel loading door; or
- it is perpendicular to the base if the burner is loaded from the top; or
- for irregular shaped fireboxes, it is placed either parallel or perpendicular to the base at the height of the bottom of the fuel loading door.

Measurements of the maximum firebox dimension shall be made with all components of the firebox fitted, including firebricks, baffles and grate(s) where applicable.

If the ash lip adjacent to the fuel loading door is less than 25 mm, the space between the ash lip and the door shall not be used when determining the maximum dimension.

The length of firewood pieces used in the tests shall be either:

a) As recommended by the manufacturer in the instruction manual for the burner and providing this size is considered by Environment Canterbury to be readily available;
or

(b) For burners with a maximum firebox dimension L of 430 mm or greater, the length of each piece of wood (including kindling) shall be 300 mm ±10 mm.

For burners with a maximum firebox dimension L greater than 300 mm and less than 430 mm, the length of each piece of wood (including kindling) shall be 250 mm ±10 mm.

For burners with a maximum firebox dimension L of 300 mm or less, the length of each piece of wood (including kindling) shall be 75% of the maximum dimension ±10 mm.

For burners with firebox hoppers or automated fuelling systems that feed logs into the combustion chamber, the firewood piece size shall be that recommended in the operating instructions.

3.4 Firewood mass

Firewood mass is based on the wet weight of the firewood (i.e. the actual weight of logs not the oven dry weight which is used for calculating the emission factor).

The mass specifications for fuel loads described in clauses 5.1 to 5.5 are as follows.

Large fireboxes
For fireboxes with a maximum dimension L of 430 mm or longer,
(i) The kindling load shall comprise not more than 20 pieces with a total mass of 1.5kg ± 10%
(ii) Intermediate 1 load (Int1) shall comprise 5 pieces with a total mass of 1.5 kg ± 150g
(iii) Intermediate 2 load (Int2) shall comprise 4 pieces with a total mass of 3.0 kg ± 150g
(iv) The main load (M) shall comprise three pieces with a total mass of 4 kg ± 150g

Intermediate and small fireboxes
For fireboxes with a maximum dimension L of less than 430 mm,
(i) The kindling load shall comprise not more than 16 pieces with a total mass of 1000 g ± 10%
(ii) Intermediate 1 load (Int1) shall comprise 4 pieces with a total mass of 1.2 kg ± 120g
(iii) Intermediate 2 load (Int2) shall comprise 4 pieces with a total mass of 2.5 kg ± 120g
(iv) The main load (M) shall comprise three pieces with a mass 3 kg ± 120g

For all loads, including kindling, the mass of any individual piece shall not be more than 20% above or below the average mass per piece for that load.

Firewood pieces may be split or trimmed, but the overall load shall be representative of the un-split firewood supply, i.e. if bark or smooth surfaces are present in the un-split firewood the some pieces in the fuel load used in the test shall include bark or smooth surfaces.

NOTE:
AS/NZS4012:2014 uses the firebox volume to determine the mass of the fuel load instead of the step approach specified in this method. ECan is interested in feedback on any cases where the step approach appears to disadvantage a particular burner, e.g. the laboratory should advise Environment Canterbury and reach agreement on realistic loads if a burner cannot accommodate the prescribed start-up or main fuel loads during testing.

4 Burner operating procedures

4.1 Burner conditioning

Unless it is evident that the actual burner being tested has been previously operated and bedded in, the wood burner shall be conditioned by operating it at maximum heat output for two 8-hour periods prior to commencing emission tests.

4.2 Automatic controls and ancillary features

If a burner has automatic controls and/or emission cleaning devices, these shall be allowed to operate normally throughout the test.

If a burner requires ancillary features such as electricity (e.g. to operate automatic controls), gas supply (e.g. to achieve low emissions by pre-heating or after-burning) or emission scrubbing (e.g. a water supply or an electrostatic precipitator), such features shall be operated during the test . If the burner can be operated without gas, electricity and/or emission scrubbing or other ancillary features available the full test program shall be repeated without using gas, electricity and/or water and both sets of results reported.

Guidance note: if it is likely, for reasons of cost, convenience, carelessness or ignorance, that the burner would be operated without gas, electricity or water, then the latter test results would be taken into account when assessing the burner's fitness for Consent Approval.

4.3 Multiple controls

If a burner has a separate control for start-up air, primary air and/or secondary air, the controls shall be set in accordance with the manufacturer's written instructions at the start of each burn phase. However, no adjustment of controls during the burn phase is permitted. If the test laboratory is of the view that incorrect use of these controls could lead to higher emissions then this shall be investigated (i.e. some emission tests conducted) and the results reported.

Note: adjustments which require the operator to observe the nature of the fire or sooting of the glass in order to optimise multiple control settings are not acceptable.

4.4 No adjustable combustion air controls

If the burner has no adjustable controls then all tests shall be carried out with the single, fixed setting.

4.5 Convection fan

If the burner has a convection fan, the fan shall be run on its high setting throughout the test; however, any automatic controls on the fan shall be allowed to operate normally.

5 Burner operation during test

The full testing of a burner for the purposes of reporting under this method requires two separate test cycles each comprising a start-up phase, a high burn rate phase, and a low burn rate phase. One cycle shall also include a partially seasoned firewood phase and the other a hardwood phase.

The two test cycles will typically be carried out on two separate days, allowing for the calorimeter room or stack testing rig to return to ambient temperature between the end of one test cycle and the start of the other (see 5.6 and 5.7).

Additional complete test cycles shall not be included in averaging of the overall test results without ECan's prior approval.

Throughout the testing, refuelling shall take place within 2 minutes of the end of the previous burn phase (as determined by the mass of fuel remaining). Filters shall be changed immediately prior to adding fuel for the beginning of a new phase.

When refuelling occurs the door shall not be open for more than 30 seconds.

If it is considered by the laboratory during any of the burning phases that the fire is not burning correctly due to adverse placement of wood logs either from loading or as a result of settling of the fire load, the laboratory operator may rearrange the burning logs with a poker. This may only be carried out once during any burning phase and only after a minimum of 60% of the fuel load for that phase has been consumed and at least 10 minutes have elapsed without fuel consumption for that period being greater than 0.05kg or 1% of the fuel-load whichever is the greater. The adjustment must be carried out within a period of 15 seconds.

NOTE:
Feedback is invited on the prescribed percentages for the residual mass of fuel loads in the firebox that act as trigger points for refuelling or changing air settings. Preliminary testing of one particular burner with a relatively small firebox and automatically controlled combustion rate has found that that the firebox chokes with residual fuel when those percentages are adhered to. A simpler tare weighing approach with reduced fuel loads is being trialled for that burner.

5.1 Start-up phase

5.1.1 Preparation

The burner shall be installed in the test room with the burner and the room at ambient temperature (15ºC to 25ºC). Any unburned wood or charcoal remaining from any previous burn shall be removed and a layer of wood ash approximately 25mm thick shall be spread across the base of the firebox. If the heater utilises a grate, the ash shall be placed in the ash removal tray. If the firebox has firebricks across its base no ash layer shall be applied, and all ash remaining from any previous burn shall be removed prior to start-up. If the test facilities do not use a calorimeter room, the burner and its surrounds shall be at ambient temperature (15ºC to 25ºC).

The firewood used for the start-up phase shall be air-dry *Pinus radiata*.

The sampling train shall be fully prepared and started with filters in place prior to commencing the start-up phase. If a dilution tunnel is used, the dilution tunnel shall also be operating prior to commencing the start-up phase.

5.1.2 Approved start-up procedure

The start-up method shall either be as recommended by the manufacturer, and as described in the operator's manual, or the default method in clause 5.1.3.

NOTE:
If the burner is to be started by a method other than the default method, that method may only be used with the prior approval of ECan. The details and reasons for any alternative method and fire-starting

materials shall be fully described in the laboratory's reports and included in the operating instructions for the burner. For example:

- If the physical design of the burner prevents the default method being used.

- If a burner has a firebox that is too small to accommodate the default start-up fuel loads, the laboratory should advise Environment Canterbury and reach agreement on loads that are more realistic.

Except that if a burner has an unusually large firebox mass the test laboratory may increase the start-up kindling load and time before adding the first intermediate load. Any variation to the test procedure shall be reported together with evidence that the burner has unusually high mass.

.

5.1.3 Default Method

Firewood used for the default start-up method shall conform to the mass specifications for kindling, Intermediate Load 1 (Int1) and Intermediate Load 2 (Int2) in clause 3.4.

Controls shall be set to maximum heat output throughout the start-up phase. The burner shall be set by placing whole pieces of newspaper (full double page broadsheet) loosely crumpled into balls near the centre of the firebox base. The pieces of kindling (as specified in section 3.4 shall be placed over the newspaper in a criss-cross geometry. Up to two firelighters may be used instead of newspaper.

The paper or firelighter are then lit and the door is fully closed. If the manufacturer's written instructions recommend that the burner is lit and the door is left slightly ajar this shall be done (in many burner models the handle can be in the closed position but not latched leaving it slightly ajar).

When the kindling is judged to be well alight the flame conditions in the burner shall be observed and approximately one minute after the maximum flame an intermediate load (Int1) shall be added by placing logs roughly parallel to the long axis of the firebox base with at least two logs forming a second layer of logs. The fuel loading door shall be fully closed (the door is to be fully closed at this stage irrespective of manufacturer's instructions).

When the weight of the fuel load drops to 50% of the mass of kindling plus Int1, intermediate 2 load (Int2) shall be added at a slight angle to the Int1 logs with at least one log forming a second layer to the Int2 load. The fuel loading door shall be fully closed.

The start-up phase is complete when the fuel load drops to 45% of the Int2 mass. When this point is reached, the filters in the sample train shall be changed.

If the fire goes out at any stage during the start-up phase, the testing shall be restarted using a larger mass of kindling as determined appropriate by the test laboratory. All other aspects of the start-up phase should remain unchanged. The need for more kindling shall be reported.

5.2 High burn rate phase

The firewood used for the high burn rate phase shall be air-dry *Pinus radiata*.

As soon as the start-up phase is complete and the filters changed, the first main (M) firewood load for the high burn phase shall be added and controls left on maximum heat output. The logs are placed near the centre of the firebox roughly parallel to the long axis of the firebox base on top of burning wood and coals from previous loads. The fire shall not be stoked prior to adding the main firewood load unless it is necessary to provide space for the addition of the main load.

When the mass of fuel in the firebox drops to 50% of the mass of the main load (M) the burner shall be refuelled with the second main load (M) for the high burn phase with controls left on maximum heat output.

The high burn rate phase is complete when the mass of fuel in the burner drops to 45% of the second main load (M) for the high burn phase with controls set at maximum heat output.

NOTE:
If the fuel feed is automatic or continuous, high burn rate phase shall be carried out at the maximum output setting for a period of 2 hours.

Immediately on completion of the high burn rate phase, the filters in the sample train shall be changed.

5.3 Low burn rate phase

The firewood used for the low burn rate phase shall be air-dry *Pinus radiata*.

The low burn rate phase may be carried out by one of the following options depending on the control method for obtaining a reduced heat output. The method used shall be generally in agreement with the method recommended by the manufacturer in the instruction manual for obtaining a reduced heat output if this is available:

Option A- Where the reduced output is obtained by combustion air control

As soon as the high burn rate phase is complete and the filters changed, the first main firewood load (M) for the low burn phase shall be added and controls immediately adjusted to the minimum heat output setting. The logs shall be placed near the centre of the firebox roughly parallel to the long axis of the firebox base on top of burning wood and coals from previous loads.

When the mass of fuel in the firebox drops to 40% of the mass of the main load (M) the burner shall be refuelled with the second main load (M) for the low burn phase with controls left on minimum heat output.

The low burn rate phase is complete when the mass of fuel in the burner drops to 45% of the second main fuel load (M) for the low burn phase with controls set at minimum heat output.

Option B – Where there is no reduced heat output phase possible (i.e. non-adjustable combustion air supply).

The low burn phase shall be carried out as a repeat of the high burn phase.

Option C- Where the fuel feed is automatic or continuous
If the fuel feed is automatic or continuous, low burn rate phase shall be carried out at the minimum output setting for a period of 2 hours.

Immediately on completion of the low burn rate phase, the filters in the sample train shall be changed.

5.4 Partially seasoned firewood phase

For one day of testing, as soon as the low burn rate phase has ended and the filters changed, the appliance shall be reloaded with a main load (M) of partially seasoned firewood and the controls set to maximum heat output. When the mass of fuel drops to 75% of the main load, the controls shall be set

to the minimum heat output if the combustion air controls are adjustable, and the burner shall then be operated at low setting for 30 minutes with controls left on minimum heat output.

Emission sampling shall then cease. The combustion air control shall then be set to high burn rate and the burner allowed to burn the remaining fuel while the calorimeter room (or other heat output/efficiency facility) continues to operate in accordance with clause 5.6 or 5.7.

If the combustion air is non-adjustable, the burner shall be operated continuously for 1 hour and sampling shall then cease. The burner shall be allowed to burn the remaining fuel and the calorimeter room (or other heat output/efficiency facility) continues to operate in accordance with clause 5.6.

NOTE:
The method requires two complete sequences of tests from light-up to cold; the two sequences of tests are identical except for the final burn phase which uses partially seasoned firewood for one sequence and hardwood for the other.

5.5 Hardwood firewood phase

For the other day of testing, as soon as the low burn rate phase has ended and the filters changed, the appliance shall be reloaded with a main load (M) of hardwood firewood and the controls set to maximum heat output. When the mass of fuel drops to 75% of the main load, the controls shall be set to the minimum heat output if the combustion air controls are adjustable, and the burner shall then be operated at low setting for 30 minutes with controls left on minimum heat output.

Emission sampling shall then cease. The combustion air control shall then be set to high burn rate and the burner allowed to burn the remaining fuel while the calorimeter room (or other heat output/efficiency facility) continues to operate in accordance with clause 5.6 or 5.7.

If the combustion air is non-adjustable, the burner shall be operated continuously for 1 hour and sampling shall then cease. The burner shall be allowed to burn remaining fuel and the calorimeter room (or other heat output/efficiency facility) continues to operate in accordance with clause 5.6.

5.6 Heat Output and Efficiency using a Calorimeter Room

If a calorimeter room is used to determine efficiency of the burner, the calorimeter room shall be at ambient temperature (15^0C to 25^0C) at the start and finish of each of the two separate test cycles described in section 5 above.

The calorimeter room shall continue to operate and be monitored after the partially seasoned firewood phase and the hardwood phase have ceased (i.e. emission sampling will have ceased but the burner will operate with the combustion air control set to high burn rate). Heat output shall be recorded until the output has dropped to less than 0.5% of the maximum heat output or 0.1kW whichever is the lesser. Efficiency of the burner shall be calculated and recorded based on total heat output expressed as a percentage of total gross calorific energy input* in the firewood minus the energy content of residual charcoal, which shall be separated from the residual ash bed and weighed for the purpose of this calculation.

(*of oven dried wood)

NOTE:
This calculation of efficiency over a full day's testing with the calorimeter room starting and ending at ambient temperature is a new approach. Feedback to ECan is invited.

5.7 Heat Output and Efficiency by Stack Losses

If the stack losses are used to calculate heat output and efficiency, the burner and its surrounds shall be at ambient temperature (15^0C to 25^0C) at the start and finish of each of the two separate test cycles described in section 5 above.

If stack losses are used to calculate heat output and efficiency, the stack discharges shall be monitored and measured representatively for that purpose during each of the four operating phases described in clauses 5.1 to 5.5.

6 Laboratory reporting

6.1 Information to be submitted with burner for test

In submitting a burner for test, the manufacturer shall make available to the laboratory:

(i) Such documents that identify the type and model of burner to be tested;
(ii) The names and physical addresses of the manufacturer and the applicant;
(iii) The recommended fuels and specification of the fuels to be used in the burner;
(iv) Design drawings with tolerances stated and a detailed description of the appliance (and water booster if fitted including part identification numbers) as specified in section 8 of the AS/NZS 4013:2014 which match the specifications of the test model to the production model;
(v) Sales brochure if available;
(vi) Current operating and installation instructions;
(vii) Proposed authorisation label.

6.2 Report

The laboratory report shall include the following:

(i) The details as noted in 6.1
(ii) The name and address of the testing agency and the name of the person responsible for the test
(iii) A list of the date and times for the test
(iv) Whether the appliance being tested is a prototype or a production model
(v) A statement that the burner tested complies fully with the scaled assembly drawings
(vi) Whether any variations from the Canterbury Method 1 were required and if so, details of the procedure followed.
(vii) Photographs of the wood used for test showing extent of bark, knots and resin in the wood.

The following data shall be included in the test report for each output setting:

- The charcoal bed weight at each refuelling
- The weight of each fuel load added, in kg
- The average moisture content of the each fuel load, % wet basis
- The flue gas temperature immediately prior to each refuelling, °C
- The average flue gas temperature for each output setting, °C
- The average burn rate for each output setting, kg/h
- Heat output measurements before and after any corrections for calorimeter room thermal mass
- The average heat output for each burn phase
- The maximum heat output for each burn phase
- All data relating to the dilution tunnel and particulate measuring train as required in AS/NZS 4013:2014 (or other sampling parameters as appropriate)
- The total particulate emission, in grams, g/kg fuel (dry weight basis) and g/h for each of start-up, high burn rate, low burn rate, hardwood and partially seasoned softwood phases,

and for the mass weighted average of start-up, high burn rate and low burn rate phases combined, for each day of testing.

- The overall efficiency based on gross calorific value for each day of testing and for both days combined.
- The average emission factor expressed as mg/MJ of total useful heat for each day and for both days combined.
- The estimated uncertainty in emission factor measurements and the basis for the estimate
- The use of any convection fans or automatic devices fitted to the appliance or the use of any ancillary features as described in clauses 4.2 to 4.5.
- Any routine maintenance requirements for the burner.

In an attachment to the main report, the test laboratory shall provide comment on any of the following that are relevant.

a) the potential for tampering with components of the burner that may influence emissions, in particular whether it appears easy for an untrained person to adjust the minimum air supply or draught due to the design of the burner;
b) aspects of the burner design that have tight tolerances and may influence emissions (e.g. narrow slots between two components which are used as primary or secondary air supply);
c) the need for routine maintenance of emission reduction components of the burner, in particular cleaning of emission scrubbing devices (if fitted) or replacement of bottled gas supplies used as part of after-burner or start-up features of the burner (if fitted);
d) the complexity and potential for failure or incorrect use of automatic controls; and
e) other features of the burner that influence emissions and might be subject to failure or poor incorrect use.

Note: The Canterbury Method 1 does not require the laboratory to review the full operating instructions for the burner. However, Environment Canterbury will require the manufacturer to supply complete instructions as part of the approval process. All aspects of appliance installation and operation with relevance to emissions shall be clearly stated.

7 Variation and alternative operation of Tested Appliance

7.1 General

(i) Except as provided in Clause 7.2, an appliance shall be retested whenever any change from the tested appliance is made in the design or method of construction affecting any of the items that in the opinion of the testing agency would adversely affect the emissions of the appliance.
(ii) Except as provided in Clause 7.3 an appliance shall also be tested in compliance with clause 4.2 : Automatic Controls and Ancillary Features .

7.2 Retesting Exemption

If, in the opinion of the testing agency, changes in the test fuel or changes to the appliance design or construction changes or a combination of these will not change or will lower the particulate emission rate (mg/MJ), the appliance may not need retesting. Any such opinion shall be made by the original testing agency and be given in writing and provide –

a. Details of the changes made to the appliance
b. Detailed opinions as to why such changes or alternatives shall not be expected to result in an increase in the original emission results.

7.3 Testing Exemption

If in the opinion of the testing agency, the operation of the appliance without the use of electricity, gas, and or water where these would normally be used in the appliance operation would not result in any

change or will lower the particulate emission rate (mg/MJ), the appliance may not need repeat testing in this mode.
Any such opinion shall be made by the testing agency and be given in writing and provide detailed opinions as to why such operation would not be expected to result in an in increase in the original emission results.

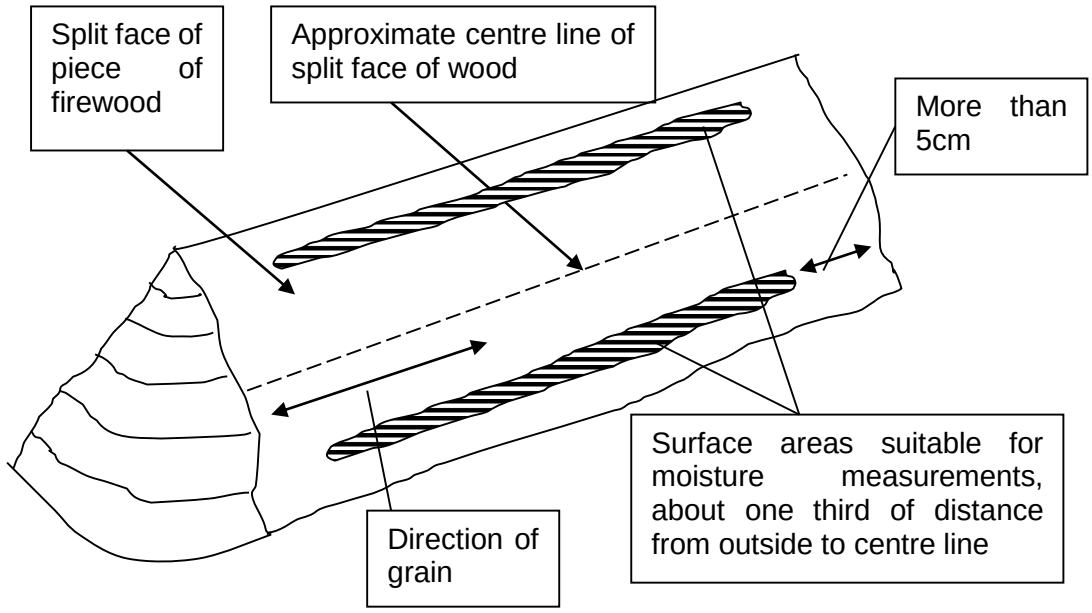
Appendix A Moisture measurement of firewood

Each batch of purchased firewood shall be sampled with one log in 10 tested for moisture using a calibrated electrical resistance moisture meter. Temperature corrections shall be made to moisture readings unless the moisture meter used is a model with automatic temperature correction.

a) The person making the moisture measurements shall be familiar with the operating instructions for the model of moisture meter being used.
b) Each piece of firewood selected for moisture measurement shall be split along the grain, approximately through the centre of the piece of firewood. This may be done with an axe or firewood splitter.
c) The moisture readings shall be made within 30 minutes of splitting the logs.
d) Moisture measurements should be made more than 5cm from the ends of the piece of firewood.
e) The moisture measurements shall be made approximately one third of the distance between the outer surface of the piece of firewood and its centre line (see Figure A.1).
f) Measurements shall not be made where there are knots, cracks, visible evidence of decay or visible evidence of insect activity.
g) The two pins on the moisture meter shall be positioned along the grain of the wood.
h) The pins shall be pressed into the wood hard enough to leave a visible indentation or hole.
i) Four (4) measurements shall be made for each piece of firewood. It is acceptable to just use one half of the split firewood piece. Two measurements should be made on each side of the centre line. Each measurement shall be recorded. The moisture content of the sampled log is the average of the four measurements.

Once moisture measurements have been completed the batch of firewood under consideration shall be used within 48 hours or it shall be sealed in a labelled airtight bag/container until it is to be used.

Figure A.1: Schematic diagram indicating areas where moisture readings should be taken



The electrical resistance moisture meter shall be calibrated by making measurements on seasoned and partially seasoned pieces of firewood which are then oven dried at 100 to 105ºC to constant weight to determine the free moisture content of the wood.

The moisture meter should be accurate to ± one percentage point moisture.

Appendix B Measurement of heat output from a wetback

B1 SCOPE This Appendix provides a method for determination of the heat extracted in the form of hot water for domestic solid fuel burning appliances fitted with a water-heating facility when testing an appliance in accordance with the Canterbury Method 1.

B2 PRINCIPLE For an appliance incorporating a water heating facility, or if the manufacturer provides or offers instructions for installing an optional water heating facility, then the facility shall be in position and have water passing through it when tested to the Canterbury Method 1. The energy captured by in the water-heating facility may be calculated and reported using the method described in this Appendix.

Appliances intended solely for water heating may also be tested using the method described in this Appendix.

B3 EQUIPMENT AND FACILITES

Guidance note: the equipment and facilities described below are suitable for add-on wet backs for heating a domestic water supply. Some water heating systems that are built into wood burners have specific requirements for water flow and inlet water temperatures. In these cases the test laboratory shall follow manufacturers operating/installation instructions (see Section 2 of the main Canterbury Method 1 text).

B3.1 Water temperature measurement system A system that measures water temperature in the range 20 to 65^{o}C with an accuracy of $\pm$3^{o}C.

Note: This method relies on measurement of the temperature difference between two water flows. The temperature difference should be measured to an accuracy of $\pm$0.2^{o}C.

B3.2 Water flow measurement system A system that measures water flow in the range 0.1 to 2L/min with an accuracy of $\pm$0.01L/min.

Note: a calibrated container and stop watch is adequate for this purpose.

B3.3 Water supply Water from a reticulated supply complying with drinking water quality standards (or equivalent) may be used.

B4 INSTALLATION The appliance, with water-heating facility fitted, shall be installed in the calorimeter room or other test space where appropriate. The water-heating facility water inlet and outlet fittings shall be connected to flexible hoses supported in such a way that varying water flows and temperatures influence the measured fuel load weight by less than ±0.5% of the test fuel load mass. The hoses may be linked to rigid pipes at an appropriate distance from the appliance. The flexible hoses and pipes shall be insulated with a minimum thickness of 12.5mm thick pipe insulating foam (or equivalent); except that the flexible pipe within 500mm of the water-heating facility inlet and outlet need not be insulated.

Temperature measuring devices shall be fitted within 100mm of the water-heating facility inlet and outlet. Temperature measurements shall be made in the water flow. A fitting to house the temperature measuring probes may be installed between the water-heating facility inlet and outlet and the flexible hoses.

The points where hoses or pipes pass through the calorimeter room walls shall be sealed to prevent any air flow.

Water flow measurement shall take place outside the calorimeter room.

B5 APPLIANCE OPERATION The appliance shall be operated in accordance with Section 6 of this method. The determination of water heating power shall be made for all burn cycles at each reported burn rate.

B6 WATER FLOW RATE AND TEMPERATURE The inlet water temperature shall be maintained in the range 25 to 30^{o}C throughout the test. The temperature rise of the water across the water-heating facility shall be maintained in the range 25 to 30^{o}C throughout the test. Water inlet and outlet temperatures shall be measured and recorded at intervals of not less than 2min.

The water flow rate shall be adjusted to ensure water temperature conditions are maintained. Water flow rates shall be measured at intervals of not less than 15 minutes and before and after any adjustment to water flow rates.

B7 CALCULATION The water heating energy shall be calculated at 2 minute intervals using equation B1.

$$E_i = 2 \times WFR \times TD \times 4.18 \quad \ldots \quad B1$$

Where: E_i is the energy extracted in the two minute interval (kJ)
WFR is the water flow rate expressed as litres per minute
TD is the difference in water temperature between the inlet and outlet (^{o}C)

Drafting Note: the above equation assumes a water density of 1kg/L. It will be necessary to carry out an error analysis to see whether a temperature correction applied to the water volume (flow rate). Such a correction, if required, can be incorporated in the above equation.

The energy is summed over all two minute recording and calculation intervals in the burn cycle to give the total energy collected in the water-heating facility over the test burn cycle E_t.

The average power (kW) of the water heating facility for one burn cycle (P_{bc}) is

$$P_{bc} = E_t \ / (60 \times \text{burn cycle time (min)} \times 1000 \times 3.6) \quad \ldots \quad B2$$

The average power (kW) of the water-heating facility at a given burn rate is

$$P_{br} = \text{Sum } \{P_{bc} \text{ for each valid burn cycle}\} / \text{number of valid burn cycles} \quad \ldots \quad B3$$

B8 REPORTING The power (energy extraction rate) shall be reported as an average power at a given appliance burn rate. The power may be reported for selected burn rates provided the report makes it clear that the result(s) only applies to the selected burn rate(s). An overall water-heating facility power may be calculated by averaging the average power for each of the burn cycles.

The report shall identify the make and model of appliance used in the test and sufficient information to identify the design and/or make and model of the water-heating facility.

The report shall identify the Test Laboratory, the dates of the test and the person responsible for the test.