AUSTRALIAN SOLID FUEL TESTING

3 Garden Street, Morwell Vic 3840
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Prepared for

PIVOT STOVE AND HEATING

PARTICULATE EMISSIONS, POWER OUTPUT AND THERMAL EFFICIENCY TESTING OF THE CHARNWOOD ISLAND III FREE-STANDING SOLID FUEL APPLIANCE

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by

Steve Marland

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Revision Details

Revision	Date	Comments
0	13/11/2020	Preliminary Issue – pending payment of invoice and engineering drawings
1	16/12/2020	Issue of NATA endorsed test report

EXECUTIVE SUMMARY

The Charnwood Island III Free-Standing solid fuel appliance was tested for particulate emissions power output and efficiency according to the requirements of the joint Australian/New Zealand Standard AS/NZS 4012/4013 (2014).

Below is a summary of the appliance results;

Primary Air Settings	Average Power (kW)	Average Peak Power (kW)	Efficiency (%)	Average Dry Fuel Consumption Rate (kg/hr)	Average Burn Time (mins)	Particulate Emission Factor (g/kg) Oven Dry Wood
High	8.7	10.6	57	2.7	124	0.8
Medium	6.3		65	1.7	194	0.9
Low	5.0		66	1.3	253	2.8

The appliance particulate emissions factor was 1.5g/kg of hardwood that complies to AS/NZS 4014.1, and the average efficiency of the appliance for all burn rates was 63%.

The Charnwood Island III Free-Standing solid fuel appliance complies with the requirements of AS/NZS 4012/4013 (2014).

Signed	
Name	Steve Marland
Title	*Managing Director – Australian Solid Fuel Testing*
Date	16 December 2020

1 INTRODUCTION

Testing of the Charnwood Island III Free-Standing took place from November 8 to 12, 2020 at the Australian Solid Fuel Testing Laboratory located at 3 Garden Street, Morwell, Victoria. The testing was performed by Mr S. Marland and Mr G. Mooney.

Particulate emissions, power output and thermal efficiency testing of the appliance was performed according to the requirements of the joint Australian/New Zealand Standard AS/NZS 4012/4013 (2014).

The appliance was tested using hardwood as the test fuel. This test fuel was used after conforming to the requirements of the joint AS/NZS 4014.1 (1999).

2 INSTALLATION OF THE APPLIANCE

The appliance firebox was measured according to the method described in the joint standard AS/NZS 4012. The appliance fuel load, fuel length and number of wood pieces were then calculated as per section 5 of AS/NZS4012.

Prior to testing, the appliance was burnt for a minimum of 16 hours (two × 8 hours) as per section 6.1.2 of AS/NZS4012:2014.

Testing was conducted according to the manufacturer's verbal or written instructions (joint AS/NZS 4013 Paragraph 8.20[c]).

3 PROCEDURE

The appliance firebox was measured according to the method described in the joint standard AS/NZS 4012. The appliance fuel load, fuel length and number of wood pieces were then calculated as per section 5 of AS/NZS4012. The test fuel was loaded according to the manufacturer's instructions.

Appendix 1 shows photographs of the appliance under test and a typical fuel load and loading geometry.

3.1 Power Output and Thermal Efficiency (AS/NZS4012)

Australian Solid Fuel Testing uses a calorimetry room which is an insulated room (75 mm thick polystyrene lined on walls, floor and ceiling) of internal dimensions 3.0 m × 3.0 m × 2.4 m high.

Air flow into the room is via a 300 mm diameter duct from a manually controlled variable speed fan. Air flow out of the room is via a 300 mm diameter duct also connected to a variable speed fan. The outlet duct air pressure is kept at 57Pa (recorded on Dywer digital 607D-11 manometer) while the inlet air fan speed is adjusted via the variable speed drive to keep the calorimeter room at atmospheric pressure. (by use of a Dwyer digital DP 607D-02 manometer)

Air flow temperatures are measured by three type K thermocouples (batch calibrated by ECE Fast report 14705) in both the inlet and outlet ducts. The Appliance being tested sits on a 0 –600 kg digital

platform scales (Ohaus VE1500RA). The flue system consists of an insulated silicone oil bath that isolates the weight of the appliance from the remainder of the flue. The flue, where it exits from the room, passes into an insulated flue casing. Total flue length above the top of the scales is set at 4.6±0.1 m.

Temperatures and transducer signals are fed to a National Instruments DAQMX that is connected to a computer. A digital signal from the scales is also sent to the computer. The ASFT Labview/SQL designed computer program records all data and desplys realtime results as they are collected.

The calorimeter room heat losses through the walls have been measured and accounted for by calibration from a electrical resistance heater of known output (NATA certified kWhr meter).

3.2 Particulate Emissions (AS/NZS4013)

The emissions equipment consists of a dilution tunnel, collection hood, pitot tube and NATA certified digital manometer (Dwyer digital DP 607D-02) for air flow measurement and sampling train/probe.

The sampling train/probe consists of a sample probe, double filter assembly, including thermocouple, a gas drier, vacuum pump and NATA certified gas meter (Landis & Gyr).

Grade 333, forty-seven millimetre glass fibre filters are pre-weighed (by way of Ohaus PA114C balance)and are mounted in the filter assembly.

Data from thermocouples, manometer and dry gas meter is fed to a National Instruments DAQMX and ASFT's labview/SQL designed computer program. The particulate emissions information is collected at the same time as data from the calorimeter room.

At the completion of a burn cycle, the filters are removed from the filter holders and placed in a desiccator for drying. Condensed and entrapped emissions from the sample probe are washed with acetone into a glass beaker. A rifle cleaning rod is used to clean the inside of the sampling probe. The cleaning rod is then washed with acetone (into the glass beaker). The acetone washing is allowed to vaporise to dryness and the residue weight determined. The two dried filters are re-weighed.

Emission weight is then determined by totalling the filter weight increases from the two filters and the residue from acetone washings.

4 DETAILS OF APPLIANCE

The test results reported directly relate to the appliance provided by the manufacturer for testing. The details of the appliance given in this section include features which may affect the particulate emissions, power output and thermal efficiency. Any change in the design/construction of this appliance may invalidate this report. Engineering diagrams were sighted and checked by Australian Solid Fuel Testing against test appliance measurements recorded in the table below. (joint AS/NZS 4013 Paragraph 8.2 [d]).

Appliance Model Name: **Island III**		Serial No: **CZE 100614**
Manufacturer: **Charnwood**		
Overall Height: **760mm**	Overall Depth: **455mm**	Overall Width: **770mm**
Top Plate Width: **770mm**	Top Plate Depth: **425mm**	Top Plate Thickness: **10mm**
Appliance Legs Height: **105mm**	Depth: **40-65mm**	Width: **40-65mm**
Usable Firebox Height: **205-310mm**	Width: **545-644mm**	Depth: **228-265mm**
Usable Firebox Volume: **40.09 Litres**		
Firebox Material Type/Seam Fully Welded: **Fully welded 5mm steel**		
Firebrick Type: **30mm compressed vermiculite**		
Main Door Opening Height: **355mm**	Width: **553mm**	
Left Door Height: **510mm** Right Door Height: **510mm**	Width: **300mm** Width: **315mm**	Depth: **25mm** Depth: **25mm**
Door glass Height: **315mm**	Width: **228mm × 2 doors**	
Primary Air Location: **Rear of appliance below firebox**		
Dimension of Primary Air: **3 flaps, 1 @ 50 x65mm, 1 @ 120 x 65mm, 1 @ 50 x 65mm (slide closed flap = 45 x 25mm**		
Area of Primary (mm^2): **8300mm^2(flaps restrict free flow to full air intake (1125mm^2 air slide fully closed)**		
Secondary/Tertiary Air Location: **Rear of firebox, 45mm below baffle**		
Dimension of Secondary/Tertiary Air: **12 holes @ 5mm**		
Area of Secondary/Tertiary Air (mm^2): **235.65mm^2**		
Baffle Plate size: **640×210×6mm**		
Flue Dimensions: **152mm**		
Spigot Dimensions:	OD: **194mm**	ID: **184mm**
Spigot to Rear of Appliance: **80mm**		
Rear Internal to External Heat Shield: **50mm**		
Firebox to Side External Heat Shield: **N/A**		
Heat Shield Material Type: **1.6mm steel**		
Water Heater Fitted: **No**		
Fan Location/Speeds: **N/A**		
Catalytic Combustor fitted: **No**		
Grate: **Yes, Two ash pans**		
NOTE: Accuracy of measurement is ±5% of the measured value		

4.1 Test Fuel

The appliance was fired using the fuel type specified in the table below;

Fuel Type	Hardwood
Common Name	Redgum
Scientific name	Eucalyptus Camaldulensis
Average Fuel load	6.5kg
Average moisture content	14.7%
Dry density	0.86kg/L
Fuel length	201mm
No. of pieces	6
Method of loading (fuel placement)	Front to rear, 1 on 5
Calorific Value (Gross Dry)	20.5MJ/kg
Ash Content	<0.1% db

5 RESULTS

5.1 High Burn Cycles

The appliance was fully fired in accordance with Section 6.3(a) of the joint AS/NZS 4012. Below is a table of the appliance setting for the high burn cycles;

Primary air setting	Average Fuel load	Fan Setting
48mm (8300mm²)	6.5kg	N/A

5.2 Low Burn Cycles

The appliance was fired in accordance with Section 6.3(b) of the joint AS/NZS 4012. Below is a table of the appliance setting for the Low burn cycles;

Primary air setting for first 20% fuel reduction	Primary air setting after 20% fuel reduction	Average Fuel load	Fan Setting
48mm (8300mm²)	0mm - fully closed (1125mm²)	6.5kg	N/A

5.3 Medium Burn Cycles

The appliance was fired in accordance with Section 6.3(c) of the joint AS/NZS 4012. Below is a table of the appliance setting for the Medium burn cycles;

Primary air setting for first 20% fuel reduction	Primary air setting after 20% fuel reduction	Average Fuel load	Fan Setting
48mm (8300mm²)	11mm – first setting	6.6kg	N/A

5.4 Leak Test Results

The appliance passed the post-conditioning air flow test with a flue velocity of 0.80m^3/min at 25 Pa (<1 m^3/min required in Standard).

The appliance passed the post-burn air flow test with a flue velocity of 0.85m^3/min at 25 Pa (<1 m^3/min required in Standard).

The appliance conforms with clause 6.10 of AS/NZS 4012 (2014).

5.5 Particulate Emissions Factor

The table below shows the particulate emissions values for each burn cycle and the resultant appliance particulate emission factor.

Primary Air Setting	Total Emission Weight (mg)	Sample Dilution Tunnel Ratio	Particulate Emission Factor (g/kg) Oven Dry Wood
High No 1	3.6	971.9	0.6
High No 2	4.5	939.6	0.8
High No 3	5.1	968.7	0.9
Average			0.8
Medium No 1	5.4	1008.2	1.0
Medium No 2	4.2	975.0	0.7
Medium No 3	5.5	959.4	0.9
Average			0.9
Low No 1	15.5	1041.0	2.9
Low No 2	15.1	1010.2	2.8
Low No 3	15.5	1014.5	2.8
Average			2.8

The Appliance Particulate Emissions Factor is 1.5g/kg of hardwood that complies to AS/NZS 4014.1.

5.6 Efficiency/Power Results

The tables below shows the summary of the appliance average power, dry fuel consumption rate and burn time for each burn cycle.

Primary Air Settings	Average Power (kW)	Average Peak Power (kW)	Efficiency (%)	Average Dry Fuel Consumption Rate (kg/hr)	Average Burn Time (mins)
High	8.7	10.6	57	2.7	124
Medium	6.3		65	1.7	194
Low	5.0		66	1.3	253

Appliance Combined Efficiency is 63% when tested with hardwood that complies to AS/NZS 4014.1.

Primary Air Setting	Commencement Date and Time	Cycle Time (mins)	Average Power (kW)	Wet Wood Mass (kg)	Wood Moisture Content (wt%)	Power Efficiency (%)	Peak Power (kW)	Dry Fuel Consumption Rate (kg/hr)
High No 1	09/11/2020 11:05	119	8.98	6.55	13.6	55.4	10.93	2.85
High No 2	09/11/2020 13:11	128	8.39	6.55	14.6	56.2	10.31	2.62
High No 3	09/11/2020 15:22	125	8.77	6.50	14.9	57.9	10.48	2.66
Medium No 1	11/11/2020 06:49	191	6.53	6.50	15.7	66.7		1.72
Medium No 2	11/11/2020 10:05	194	5.83	6.55	15.1	59.5		1.72
Medium No 3	11/11/2020 13:22	198	6.51	6.60	15.4	67.5		1.69
Low No 1	10/11/2020 07:29	248	4.97	6.55	14.4	64.4		1.35
Low No 2	10/11/2020 11:29	236	5.12	6.50	15.0	64.0		1.41
Low No 3	10/11/2020 15:39	276	4.82	6.55	13.9	68.9		1.23

5.7 Uncertainty of Measurement Statement

a) The uncertainty of temperature measurement during the entire test period was ± 1.5°C (at the 95% confidence level).

b) The uncertainty of power measurement was ± 5%.

c) The uncertainty of the outlet air pressure was ± 0.6 Pa.

d) The uncertainty of the dilution tunnel pressure was ± 1 Pa.

e) The uncertainty of particulate emission weights was ± 0.4 mg.

g) The uncertainty of the test fuel mass was ± 50 gm (on appliance balance).

6 CONCLUSION

The Charnwood Island III Free-Standing solid fuel burning appliance produced an appliance particulate emissions factor of 1.5g/kg and an average efficiency of 63% for all burn rates, using hardwood that complies to AS/NZS 4014.1, when tested according to joint AS/NZS 4012, AS/NZS 4013 (2014).

The Charnwood Island III Free-Standing solid fuel burning appliance complies with the requirement of a combined effieiency of not less than 60% and a particulate emissions factor of not greater than 1.5g/kg of hardwood that complies to AS/NZS4014.

APPENDIX 1

Figure 1: Appliance during testing.

Figure 2: Test fuel load.