



3 Garden Street, Morwell Vic 3840
ABN: 46 610 154 768

Prepared for
Pacific Energy Fireplace Products



**PARTICULATE EMISSIONS, POWER OUTPUT AND
THERMAL EFFICIENCY TESTING OF THE
ALDERLEA T6 LE/SUMMIT LE FREE-STANDING
SOLID FUEL APPLIANCE**

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by
Steve Marland

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Revision Details

Revision	Date	Comments
0	24/11/2023	Preliminary Issue – pending payment of invoice and engineering drawings showing model modifications

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EXECUTIVE SUMMARY

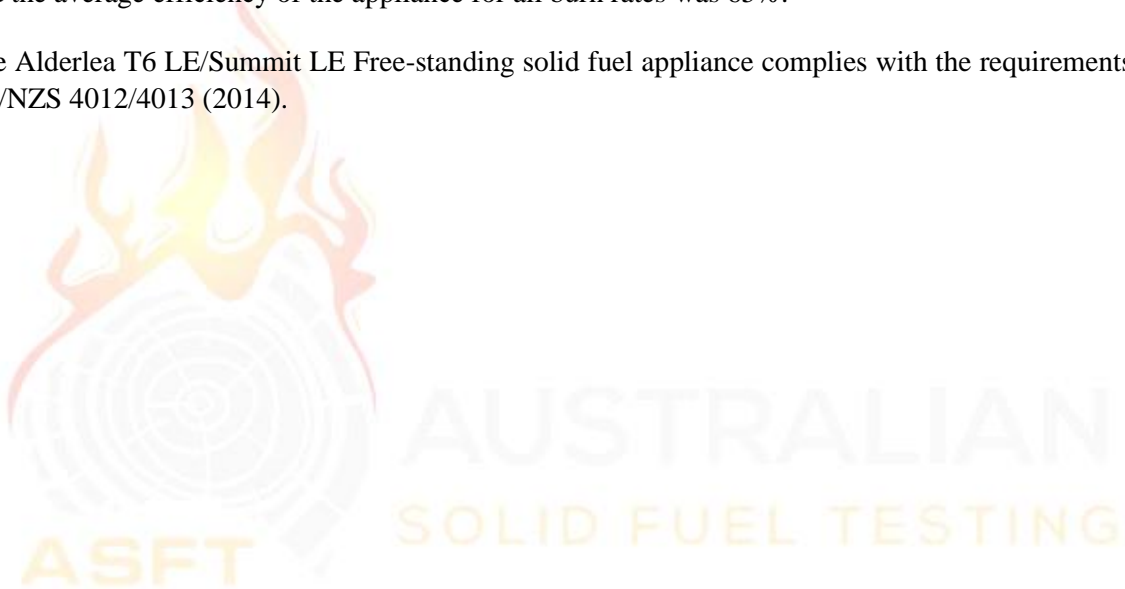
The Alderlea T6 LE/Summit LE Free-standing solid fuel appliance was tested for particulate emissions power output and efficiency according to the requirements of the joint Australian/New Zealand Standard AS/NZS 4012/4013 (2014).

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	7.1	12.6	63	2.1	342	0.5
Medium	5.7		65	1.6	441	0.4
Low	4.9		67	1.4	522	0.4

The appliance particulate emissions factor was 0.4g/kg of hardwood that complies to AS/NZS 4014.1, and the average efficiency of the appliance for all burn rates was 65%.

The Alderlea T6 LE/Summit LE Free-standing solid fuel appliance complies with the requirements of AS/NZS 4012/4013 (2014).



Signed	
Name	Steve Marland
Title	<i>Managing Director – Australian Solid Fuel Testing</i>
Date	24 November 2023

1 INTRODUCTION

Testing of the Alderlea T6 LE/Summit LE took place from October 31 to November 22, 2023 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 Dwyer 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 displays 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: Summit		Serial No: 3080010186
Manufacturer: Pacific Energy Fireplace Products		
Overall Height: 745mm	Overall Depth: 720mm	Overall Width: 650mm
Top Plate Width: 650mm	Top Plate Depth: 590mm	Top Plate Thickness: 10mm
Appliance Legs Height: 230mm	Depth: 30-110mm	Width: 30-110mm
Usable Firebox Height: 310mm	Width: 510mm	Depth: 500mm
Usable Firebox Volume: 79.05 Litres		
Firebox Material Type/Seam Fully Welded: Fully welded steel		
Firebrick Type: 30mm Ceramic		
Main Door Opening Height: 271mm	Width: 475mm	
Door Height: 325-343mm	Width: 545mm	Depth: 30mm
Door glass Height: 220-230mm	Width: 430mm	
Primary Air Location: Below firebox		
Dimension of Primary Air: 1 hole @ 48mm + 1 hole @ 7.5mm + 2holes @ 13mm dia		
Area of Primary (mm ²): 1809.79 + 44.18 + 265.5= 2119.47mm²		
Secondary/Tertiary Air Location: Incorporated into baffle, 18 holes @ 6mm facing Front and 29 holes @ 4.5mm facing down		
Dimension of Secondary/Tertiary Air: 18 holes @ 6mm + 29 holes @ 4.5mm		
Area of Secondary/Tertiary Air (mm ²): 509.0 + 461.28 = 970.28mm²		
Boost Air Location: Below door		
Dimensions of Boost Air: 6 holes @ 9.5mm		
Area of Boost Air: 425.35mm²		
Baffle Plate size: 507x395x25-38mm with 12mm Ceramic Fibre sheet on top		
Flue Dimensions: 152mm		
Spigot Dimensions:	OD: 157mm	ID: 150mm
Spigot to Rear of Appliance: 130mm		
Rear Internal to External Heat Shield: mm		
Firebox to Side External Heat Shield: mm		
Heat Shield Material Type:		
Water Heater Fitted: No		
Fan Location/Speeds: N/A		
Catalytic Combustor fitted: No		
Grate: No		
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	Greybox
Scientific name	Eucalyptus Microcarpa
Average Fuel load	13.7kg
Average moisture content	14.2%
Dry density	0.89kg/L
Fuel length	420mm
No. of pieces	6
Method of loading (fuel placement)	Front to Rear, 2 on 4
Calorific Value (Gross Dry)	19.6MJ/kg
Ash Content	0.6% db

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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
Fully Open (2119.5mm ²)	13.7kg	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
Fully Open (2119.5mm ²)	15mm (309mm ²)	13.6kg	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
Fully Open (2119.5mm ²)	25mm	13.8kg	N/A

5.4 Leak Test Results

The appliance passed the post-conditioning air flow test with a flue velocity of 0.79m³/min at 25 Pa (<1 m³/min required in Standard).

The appliance passed the post-burn air flow test with a flue velocity of 0.84m³/min at 25 Pa (<1 m³/min required in Standard).

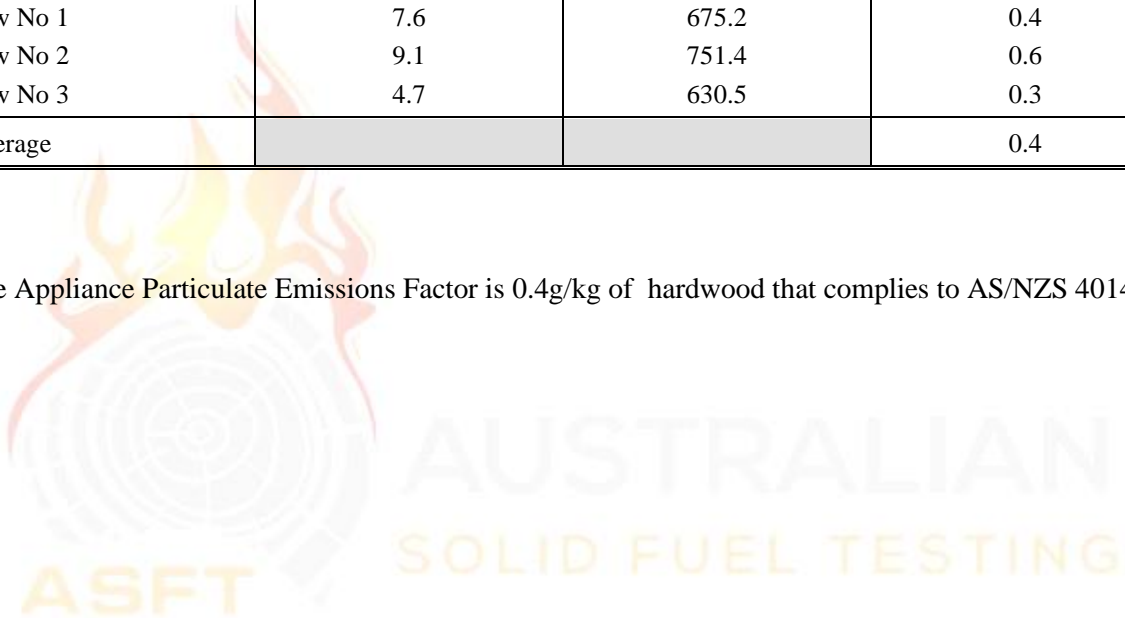
The appliance conforms with clause 6.10 of AS/NZS 4012 (2014).

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	4.4	971.5	0.4
High No 2	8.1	830.3	0.6
High No 3	5.3	934.9	0.4
Average			0.5
Medium No 1	6.4	693.7	0.4
Medium No 2	4.7	717.2	0.3
Medium No 3	7.3	628.4	0.4
Average			0.4
Low No 1	7.6	675.2	0.4
Low No 2	9.1	751.4	0.6
Low No 3	4.7	630.5	0.3
Average			0.4

The Appliance Particulate Emissions Factor is 0.4g/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	7.1	12.6	63	2.1	342
Medium	5.7		65	1.6	441
Low	4.9		67	1.4	522

Appliance Combined Efficiency is 65% 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	31/10/2023 15:11	378	6.72	13.70	12.8	65.1	11.59	1.90
High No 2	01/11/2023 10:20	303	7.68	13.65	15.7	61.9	13.38	2.28
High No 3	01/11/2023 15:28	346	6.83	13.70	15.2	62.3	12.74	2.01
Medium No 1	21/11/2023 16:44	433	5.74	13.85	15.0	64.7		1.63
Medium No 2	22/11/2023 00:10	429	5.64	13.75	14.2	62.8		1.65
Medium No 3	22/11/2023 14:00	462	5.68	13.70	13.5	67.8		1.54
Low No 1	16/11/2023 10:21	514	4.81	13.70	15.0	65.0		1.36
Low No 2	17/11/2023 09:54	509	5.13	13.60	12.9	67.5		1.40
Low No 3	20/11/2023 15:18	543	4.76	13.60	13.2	67.0		1.31

5.7 Uncertainty of Measurement Statement

- a) The uncertainty of temperature measurement during the entire test period was $\pm 1.5^{\circ}\text{C}$ (at the 95% confidence level).
- b) The uncertainty of power measurement was $\pm 5\%$.
- 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 Alderlea T6 LE/Summit LE Free-standing solid fuel burning appliance produced an appliance particulate emissions factor of 0.4g/kg and an average efficiency of 65% 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 Alderlea T6 LE/Summit LE Free-standing solid fuel burning appliance complies with the requirement of a combined efficiency 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.