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PARTICULATE EMISSIONS, POWER OUTPUT AND EFFICIENCY TESTING OF THE NEO 2.5 FREE-STANDING SOLID FUEL APPLIANCE

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by
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PARTICULATE EMISSIONS POWER OUTPUT AND EFFICIENCY TESTING OF THE NEO 2.5 FREE-STANDING SOLID FUEL APPLIANCE

Report

The Neo 2.5 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).

The appliance particulate emissions factor was 1.0g/kg of hardwood that complies to AS/NZS 4014.1, and the average efficiency of the appliance for all burn rates was 82%.

The Neo 2.5 Free-Standing solid fuel appliance complies with the requirements of AS/NZS 4012/4013 (2014).

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Checked by: A. Reid

Signed:..... Approved:.....

A. Reid
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1. INTRODUCTION

HRL Technology was requested to assess the Neo 2.5 Free-Standing solid fuel burning appliance. Particulate emissions power output and efficiency testing was performed according to the joint Australian/New Zealand Standards (AS/NZS) 4012/4013.

This report provides details of the tests performed at the Solid Fuel Heater Testing and Research Laboratory of HRL Technology, Morwell. The test program was conducted from February 16 to 20, 2015 by Mr A. Reid, Mr A. Wood & Mr S. Marland. The testing was commissioned by Pacific Energy Frieplace Products and the test results remain the property of this company.

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. DETAILS OF APPLIANCE

The test results reported below apply only to the appliance model tested. The details of the appliance given in this section include features which may affect particulate emissions and thermal efficiency results. Any change in the construction or design of this appliance model could invalidate this report. Engineering diagrams were sighted and checked with HRL Technology internal test appliance measurements (joint AS/NZS 4013 Paragraph 8.2 [d]).

Appendix 1 gives appliance construction details.

3. INSTALLATION OF THE APPLIANCE

The appliance firebox was measured according to the method described in the joint AS/NZS 4012. The appliance fuel load, fuel length and number of wood pieces were then calculated. The appliance was burnt for at least 16 hours (two x 8 hours) to fully cure appliance paint and reduce firebrick moisture content.

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

The test fuel was loaded according to the manufacturer's instructions. The appliance was operated initially with a small amount of fuel, and when the bed of embers was 24-26% of the single fuel load, the scale was tared and a pre-burn cycle was commenced. The calorimeter room and associated test equipment and sample weighing method are described in Appendix 2. The emissions test equipment and sample weighing method are described in Appendix 3. Appendix 4 shows photographs of a typical fuel load and the appliance under test.

3.1 High Burn Cycles

The appliance was fully fired in accordance with Section 6.3(a) of the joint AS/NZS 4012.

The average fuel load for initiating High Burn Cycles was 10.9kg. The primary air slide was fully open for each high burn cycle.

The appliance fan was set to High Auto.

3.2 Low Burn Cycles

The appliance was fired in accordance with Section 6.3(b) of the joint AS/NZS 4012.

The average fuel load for initiating Low Burn Cycles was 10.8kg. The first 20% of the test fuel mass was burnt with the primary air slide fully open (as per High Burn Cycles). The primary air slide was then reduced to an opening of 50mm. This is the minimum air slide setting.

The appliance fan was set to High Auto.

3.3 Medium Burn Cycles

The appliance was fired in accordance with Section 6.3(c) of the joint AS/NZS 4012.

The average fuel load for initiating Medium Burn Cycles was 10.8kg. The first 20% of the test fuel mass was burnt with the primary slide fully open (as per High Burn Cycles). The primary air slide was then reduced to an opening of 85mm.

The appliance fan was set to High Auto.

3.4 Test Fuel

The appliance was fired using hardwood with an average moisture content of 14.3% as the test fuel. Each cylindrical firewood piece was 285 ± 10 mm long with a diameter of between 75 mm and 110 mm. Seven pieces of wood were used for each test cycle. The average density of the hardwood was 0.85kg/l (dry basis). The specific energy of the hardwood was 20.73MJ/kg (oven dry basis). The ash content of the hardwood was 0.3% (dry basis).

4. RESULTS

4.1 Uncertainty of Measurement Statement

a) The uncertainty of temperature measurement during the entire test period was ± 2.2°C (at the 95% confidence level).

b) The uncertainty of power measurement was ± 4.6%.

c) The uncertainty of the outlet air pressure was ± 0.2 Pa.

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

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

f) The uncertainty of acetone dish and "O" ring weights was ± 1 mg.

g) The uncertainty of the test fuel mass was ± 20 gm (on appliance balance).

4.2 Leak Test Results

The appliance passed the post-conditioning air flow test with a flue velocity of $0.4m^3$/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 $0.3m^3$/min at 25 Pa (<1 m^3/min required in Standard).

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

4.3 Operating Conditions

Table 1 shows the operating conditions for the appliance.

4.4 Efficiency/Power Results

Table 2 shows the power efficiency results for the appliance. Table 3 shows a summary of average power, dry fuel consumption rate and burn time for each burn cycle. The average efficiency for all burn cycles was 82%.

4.5 Particulate Emissions Factor

Table 4 shows the particulate emissions values for each burn cycle and the resultant appliance particulate emission factor of 1.0g/kg of hardwood that complies to AS/NZS 4014.1.

5. CONCLUSION

The Neo 2.5 Free-Standing solid fuel burning appliance produced an appliance particulate emissions factor of 1.0g/kg and an average efficiency of 82% 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 Neo 2.5 Free-Standing solid fuel burning appliance complies with the requirement of a combined efficiency of greater than 55% and a particulate emissions factor of not greater than 2.5g/kg of hardwood that complies to AS/NZS4014.1 in AS/NZS4012 (2014) and AS/NZS4013 (2014).

Table 1: Operating Conditions for the Neo 2.5 Free-Standing Solid Fuel Appliance

CONDITION	COMMENTS
Fire Box Volume	66 Litres
Wood Type	Hardwood (Redgum)
Number of Wood Pieces	7
Length of Wood Pieces	285mm
Method of Loading	3 on 4, front to rear
Fan/Fan Speed	High Auto for all burn cycles

Table 3: Summary of Average Power, Combined Efficiency, Burn Rate and Burn Time

Primary Air Settings	Average Power (kW)	Average Peak Power (kW)	Efficiency (%)	Average Dry Fuel Consumption Rate (kg/hr)	Average Burn Time (mins)
High	9.9	14.2	74	2.3	240
Medium	7.3		82	1.5	359
Low	5.6		89	1.1	511

Appliance Combined Efficiency = 82%.

Table 4: Particulate Emissions for the Neo 2.5 Free-Standing Solid Fuel Appliance

Primary Air Setting	Total Emission Weight (mg)	Sample Dilution Tunnel Ratio	Particulate Emission Factor (g/kg) Oven Dry Wood
High No 1	5.8	1096.1	0.7
High No 2	9.5	1090.4	1.1
High No 3	7.2	1074.5	0.8
Average			0.9
Medium No 1	2.8	1105.9	0.3
Medium No 2	10.0	1109.7	1.2
Medium No 3	4.7	1104.7	0.6
Average			0.7
Low No 1	12.2	1112.4	1.4
Low No 2	12.0	1157.5	1.5
Low No 3	11.6	1102.6	1.4
Average			1.4

Appliance Particulate Emissions Factor = 1.0g/kg (oven dry hardwood).

Table 2: Power Efficiency of the Neo 2.5 Free-Standing Solid Fuel Appliance

Primary Air Setting	*Commencement Time/Date*	*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	00:35 16/02/2015	246	9.84	10.89	14.1	74.9	14.77	2.28
High No 2	04:50 16/02/2015	228	10.02	10.76	14.8	72.1	12.93	2.41
High No 3	08:49 16/02/2015	246	9.89	10.91	14.3	75.3	14.79	2.28
Medium No 1	23:10 17/02/2015	358	7.30	10.80	15.2	82.6		1.54
Medium No 2	17:27 18/02/2015	360	7.04	10.87	14.5	78.9		1.55
Medium No 3	23:30 18/02/2015	358	7.60	10.84	15.1	85.5		1.54
Low No 1	02:43 17/02/2015	482	5.76	10.89	13.3	85.1		1.17
Low No 2	10:50 17/02/2015	500	5.88	10.83	14.7	92.1		1.11
Low No 3	19:14 17/02/2015	550	5.25	10.74	12.7	89.2		1.02

APPENDIX 1:
SOLID FUEL BURNING APPLIANCE CONSTRUCTION DETAILS

Appliance Model Name:	***Neo 2.5 Free-Standing***		
Manufacturer:	Pacific Energy Fireplace Products		
Serial Number:	50230677		
Overall Width:	692mm		
Overall Depth:	700mm		
Overall Height:	990mm		
Top Plate Width:	735mm		
Top Plate Depth:	545mm		
Top Plate Thickness:	8mm		
Firebox Description:	*Height:305mm*	*Width: 510mm*	*Depth: 440mm*
Firebox Material Type/ Seam Fully Welded:	5.0mm steel, seams fully welded		
Firebrick Size:	Firebox is fully lined with bricks		
Main Door Opening:	*Height*: 275mm	*Width*: 470mm	
Door: **Door Glass**:	*Height: 374mm* *Height: 250mm*	*Width: 556mm* *Width: 440mm*	*Depth: 45mm (max)*
Primary Air Location:	Under firebox		
Dimension of Primary Air:	1 hole @ 41mm dia + 1 hole @ 17mm dia + 1 hole @ 8mm dia		
Area of Primary (mm^2)	1597mm^2		
Secondary/Tertiary Air Location:	Incorporated into baffle plate		
Dimension of Secondary/Tertiary Air:	31 holes @ 4mm dia + 21 holes @ 4.7mm dia + 12 holes @ 6.6mm dia		
Area of Secondary/Tertiary Air (mm^2):	1152mm^2		
Flue Dimensions:	152mm OD		
Spigot Dimensions:	160mm OD	152mm ID	
Spigot to Rear of Appliance:	78mm		
Rear Internal to External Heat Shield:	62mm		
Side Internal to External Heat Shield:	50mm		
Heat Shield Material Type:	Stainless steel		
Water Heater Fitted:	NO		
Fan Location/Speeds:	Variable speed with thermostat control at rear of appliance		
Catalytic Combustor:	NO		
Grate:	No, does have ashpan with removeable brick to fill		
Diagrams:	Over the page		

Note the accuracy of measurements in Appendix 2 are ± 5% of the recorded value

Signed: ..... **Date**: 13/3/15

APPENDIX 2:
CALORIMETER ROOM

The HRL Technology Pty Ltd calorimetry room is an insulated room (75 mm thick polystyrene lined on walls, floor and ceiling) of internal dimensions 3.0 m x 3.0 m x 2.4 m high.

Air flow into the room is through 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. Both inlet and outlet air fans are connected to the same speed controller. A baffle over the air entry into the inlet fan controls calorimetry room pressure (equivalent with external room pressure).

Air flow temperatures are measured by three type K thermocouples in both the inlet and outlet ducts. Air velocity of the outlet is measured by a pitot tube connected to a NATA certified inclined manometer.

The solid fuel appliance sits on Mercury 0 –300 kg digital scales. The flue system consists of an insulated silicone oil bath that isolates the weight of the stove 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 Data Electronic DT500 data logger that is connected to a personal computer. A digital signal from the scales is also sent to the computer.

The calorimeter room heat losses through the walls have been measured from electrical resistance heaters of known output.

During operation, airflow into the room is adjusted to maintain the air pressure in the room at atmospheric pressure (baffle over inlet air). Data is collected from thermocouples, air flow and scales weight and dry gas flow rate every two minutes.

APPENDIX 3:
EMISSIONS TEST EQUIPMENT AND SAMPLE WEIGHING METHOD

The emissions equipment consists of a dilution tunnel including collection hood, pitot tube and NATA certified inclined manometer for air flow measurement, sampling train and an in-line variable speed centrifugal extraction fan.

The sampling train consists of a sample probe, double filter assembly, including thermocouple gas drier, vacuum pump, dry gas meter and flow meter (pulsed light 5 pulses/litre).

Forty-seven millimetre glass fibre filters (ex Gelman Sciences) that have been weighed are mounted in the filter assembly.

Data from thermocouples, transducer and dry gas meter is fed to a Data Electronic DT500 data logger that is connected to a personal computer. This information is collected at the same time as data from the calorimeter room.

Towards the end of the pre-burn cycle (>10 minutes before end of pre-burn cycle) the dilution tunnel extraction fan is turned on and the dilution tunnel hood is swung over the appliance flue.

When a new cycle commences, the sample vacuum pump turns on automatically until the end of the cycle when the sample pump automatically stops once <0.05 kg test fuel mass is detected. Sample flow rate and dilution tunnel flow rate is manually controlled within specified ranges.

Sample flow rate is measured by a 1 litre/rev dry gas meter which is coupled to the computer by means of a light detector giving a pulsed output.

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 reweighed.

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

APPENDIX 4:

Photograph 1: Appliance Under Test

Photograph 2: Test Fuel Load